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**Thermodynamic and Related Properties of  
Parahydrogen From the Triple Point to 100 °K  
At Pressures to 340 Atmospheres**



**U.S. DEPARTMENT OF COMMERCE  
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H. M. Roder, L. A. Weber, and R. D. Goodwin



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# Thermodynamic and Related Properties of Parahydrogen from the Triple Point to 100 °K at Pressures to 340 Atmospheres

H. M. Roder, L. A. Weber, and R. D. Goodwin

Experimental programs on parahydrogen at this laboratory have provided pressure-density-temperature relations and heat capacities at temperatures from 15 to 100 °K and at pressures from 2 to 350 atm. The two types of data have been correlated to yield a consistent set of functions. The properties tabulated for selected isobars and isochores are temperature, volume or pressure, the isotherm derivative  $(\partial P/\partial \rho)_T$ , the isochore derivative  $(\partial P/\partial T)_\rho$ , internal energy, enthalpy, entropy, the specific heats at constant volume and at constant pressure, and the velocity of sound. Also presented are the derived Joule-Thomson inversion curve and some comparisons with normal hydrogen near 100 °K.

Key words: density, enthalpy, entropy, equation of state, fixed points (PVT), hydrogen, Joule-Thomson data, latent heat, melting curve, parahydrogen, properties of fluids, specific heat, vapor pressure, velocity of sound.

## 1. Introduction

The current large-scale use of liquid parahydrogen [1]<sup>1</sup> has led to the experimental determination of volumetric properties and specific heats at this laboratory. The results are used here for the computation of tables of thermodynamic and related functions. Provisional tables of some of these properties have been issued previously [2], computed by means of a modified Benedict-Webb-Rubin equation of state; however, this equation did not describe the volumetric properties within experimental accuracy. In the present report, therefore, polynomials representing isotherms and isochores are combined with numerical methods of computation for the purpose of improving accuracy, in particular for the derivatives of the  $P$ - $\rho$ - $T$  surface.

About 1200 closely spaced  $P$ - $\rho$ - $T$  points have been measured for parahydrogen between 15 and 100 °K and between 2 and 350 atm [3, 4]. The  $P$ - $\rho$ - $T$  surface was approximated by a large number of polynomials at high densities, while virial expansions were used at low densities, to allow extrapolation to pressures below 2 atm.

The virial coefficients were extrapolated below 24 °K to permit computations for the vapor down to the triple point. The results for the compressed liquid at temperatures below 17 °K are based on limited experimental data.

The representation of the  $P$ - $\rho$ - $T$  surface, and the specific heats of the ideal gas derived from spectroscopic data [5, 6] yield thermal properties for the vapor at temperatures below critical, and for all states at temperatures above critical. Experimental specific heats [7] not only served as a check on results above critical temperatures, but were also used as primary data for the compressed liquid states at subcritical temperatures. Consistency in this latter region was examined by means of derived heats of vaporization [8] and the specific heats of the saturated liquid [9]. Other relations such as the isothermal and adiabatic compressibilities can be computed from the various tabulated properties.

Results near 100 °K were also compared with those for normal hydrogen from other laboratories [5, 10, 11, 12].

## 2. Symbols and Units

The symbols and units used in this paper are listed below. Values for fixed points, parameters, and conversion factors are given where applicable.

|     |                                                                                                             |
|-----|-------------------------------------------------------------------------------------------------------------|
| $R$ | gas constant; 82.0597 cm <sup>3</sup> atm/g mole °K                                                         |
| $P$ | pressure, atm                                                                                               |
|     | $P_{\text{sat}}$ vapor pressure                                                                             |
|     | $P_{\text{melt}}$ melting pressure                                                                          |
|     | $P_c$ critical pressure, 12.759 atm                                                                         |
|     | $P_t$ triple point pressure, 0.0695 atm                                                                     |
| $V$ | specific volume, cm <sup>3</sup> /g mole                                                                    |
| $T$ | absolute temperature, degrees Kelvin, where the triple point of water is 273.16 °K; experimental values are |

based on the NBS-1955 scale for platinum resistance thermometers;

$T_c$  critical temperature, 32.976 °K  
 $T_t$  triple point temperature, 13.803 °K

|                        |                                                                             |
|------------------------|-----------------------------------------------------------------------------|
| $\rho$                 | density, g/mole cm <sup>3</sup>                                             |
| $\rho_c$               | critical density, 0.01559 g mole/cm <sup>3</sup>                            |
| $\rho_t$               | density of liquid at triple point, 0.038207 g mole/cm <sup>3</sup>          |
| $\rho_{\text{sat L}}$  | saturated liquid density                                                    |
| $\rho_{\text{sat G}}$  | saturated vapor density                                                     |
| $\rho_{\text{melt L}}$ | density of liquid along the liquid-solid boundary                           |
| $\rho_l$               | a selected density in the compressed liquid 0.037821 g mole/cm <sup>3</sup> |

$(\partial P/\partial \rho)_T$  isotherm derivative, atm cm<sup>3</sup>/g mole

<sup>1</sup> Figures in brackets indicate the literature references on p. 12.

$(\partial P/\partial T)_\rho$  isochore derivative, atm/°K

$A_i$  generalized coefficients in approximating polynomials; numerical values are distinct for each equation

$B$  the second virial coefficient, cm<sup>3</sup>/g mole

$C$  the third virial coefficient, [cm<sup>3</sup>/g mole]<sup>2</sup>

$C_v(T, \rho)$  heat capacity at constant volume at  $T$  and  $\rho$ , J/g mole °K;  $C_v^\circ$ , heat capacity at constant volume of the ideal gas

$C_p(T, \rho)$  heat capacity at constant pressure at  $T$  and  $\rho$ , J/g mole °K

$S(T, \rho)$  entropy at  $T$  and  $\rho$ , J/g mole °K;  $S^\circ$ , entropy of the ideal gas at 1 atm

$H(T, \rho)$  enthalpy at  $T$  and  $\rho$ , J/g mole;  $H^\circ$  enthalpy of the ideal gas at 1 atm

$U(T, \rho)$  internal energy at  $T$  and  $\rho$ , J/g mole

$C_{sat}$  heat capacity of the saturated liquid, J/g mole °K

$W$  velocity of sound, meter/sec;  $W_0$  velocity of sound in the ideal gas

Molecular weight, 2.01572 g/g mole\*

1 calorie equals 4.184 joules

### 3. Representation of the $P$ - $\rho$ - $T$ Data

An accurate wide-range equation of state for parahydrogen is not yet available. A modified Benedict-Webb-Rubin equation has previously been used [2] to obtain thermodynamic functions over wide temperature and pressure ranges. This equation of state has also been used in this laboratory in obtaining thermodynamic functions for several other fluids. A comparison of these previous calculations for parahydrogen with the present calculations and the experimental specific heats [7] leads to the following generalizations:

a. The modified Benedict-Webb-Rubin equation [2] approximates the  $P$ - $\rho$ - $T$  surface reasonably well, but not within the experimental accuracy. The deviations between experimental data and calculated values are as high as 2 percent in pressure or density.

b. The derived properties which depend on the first derivatives of the surface, such as entropy, can be established well enough for most engineering purposes by the equation of state in [2]. The maximum deviations in entropy when compared to the present calculations are on the order of 3 percent.

c. The representation by the equation of state from [2] of those derived properties which depend on the second derivatives of the surface, such as the specific heats, is not at all successful. Errors as large as 20 percent are encountered near the critical point, and also at temperatures near 33 °K with pressures from critical to nearly 300 atm.

d. The application of the equation of state from [2] may be justified and successful with accuracies approaching the experimental precision, if the surface to be described is restricted to temperatures somewhat above critical. The  $P$ - $\rho$ - $T$  surface defined by this equation gives neither a good representation near critical temperatures, nor will it reproduce the saturation boundaries well.

Attempts to fit an equation of state of the Hirschfelder-McGee-Sutton type to several other gases

[13] at this laboratory were not as successful as using the modified Benedict-Webb-Rubin equation.

The purpose of the present calculations is to obtain the best possible values for the derived functions. The  $P$ - $\rho$ - $T$  surface is therefore approximated by a large number of polynomials along lines of constant temperature, along lines of constant density, and along the two-phase boundaries. It should be emphasized that the polynomials are used merely as empirical interpolating devices. If several algebraic expressions approximate a set of data within experimental error, the expression selected gives the best results in terms of the derived properties. It might have been possible to place restraints on the derivatives to obtain a smooth transition at points of change in the representation. Instead, the discontinuities that do occur in the derivatives and thus in the derived properties, described in detail later in the paper, are taken as one measure of the errors in the derived properties.

The application of a polynomial approximation of such high degree is perhaps unconventional. As an alternate procedure the "spline-fit" [14] was considered. The basic technique (a cubic polynomial between two adjacent points) was tested on the specific heat data of the ideal gas and on the experimental points of the 33 °K isotherm. In both cases interpolations were obtained with deviations to one part in 1000. The "spline-fit" technique resulted in good interpolations between adjacent points, provided that the initial entries were smooth. However, "spline-fit" did not appear to be a satisfactory way of smoothing experimental data, which is subject to random errors. This technique may place an unacceptable inflection point between two experimental points. Also, the "spline-fit" imposes linear changes in curvature between two adjacent points while rapid changes in curvature are encountered in the precise definition of the specific heats. The "spline-fit" method was also combined with a least squares technique. The cubic polynomials

\*2.01594 on the  $C^{12}$ =12.000 scale to be adopted.

were least squared over several ranges of approximately seven data points each with appropriate restrictions on the derivatives of the adjacent ranges. In the case of the 33 °K, isotherm this amounts to at least six ranges, none of which have constant curvature. The number of arbitrary constants used in this procedure is very nearly equal to the 15 used in the polynomial approximation, and while the first objection above may have been overcome, the second still applies.

*Isotherms.* The experimental  $P$ - $\rho$ - $T$  data provided 39 isotherms, which, as described in [4], have been represented by

$$P = RT\rho + \sum_i A_i \rho^{(i+1)}, \text{ where } i = 1, 2, 3 \dots 15. \quad (1)$$

The maximum value of  $i$  is 15 for the 33 °K isotherm. The value is smaller for all other isotherms, ranging down to 4 for the 17 °K isotherm and 5 for the 100 °K isotherm. Additional isotherms at 13.8, 14, 15, and 16 °K were established from a more limited number of experimental points and from the properties on the saturation boundaries. The functional form of these isotherms is also that of eq (1). Coefficients for all isotherms are given in table I, while representative deviations for selected isotherms are shown in table II. The deviations are within the experimental precision as described in [4]. The coefficients were obtained from the data given in table 1 of [4], applying the slight shift in densities as described in [4]. The coefficients will reproduce table 2 of [4], but care must be taken to avoid round-off errors. This is particularly true of the 33 °K isotherm. The form of eq (1) is such that  $A_1$  will reproduce  $RTB$  within 0.3 percent, while  $A_2$  approximates  $RTC$ , where  $B$  and  $C$  are the second and third virial coefficients, respectively. The other coefficients in the power series have no significance.

*Isochores.* The isotherm polynomials permitted calculation of pressures at even increments of density as given in table 2 of [4]. The pressure-temperature pairs so obtained for a given density, including the intersections at the appropriate lines of saturation, were fitted by a least squares procedure to

$$P = A_1 T^2 + A_2 T + A_3 + A_4/T + A_5/T^2. \quad (2)$$

A total of 90 sets of coefficients for (2) describes the lines of constant density between 0.0005 and 0.0450 g mole/cm<sup>3</sup>. Numerical values for the coefficients of (2) are given in table III, while representative deviations in pressure are shown in table IV.

*Low density.* At densities of 0.0070 g mole/cm<sup>3</sup> and less, the isochore polynomials (2) were replaced by the truncated virial expansion

$$P = RT\rho + RTB\rho^2 + RTC\rho^3. \quad (3)$$

Values of  $RTB$  and  $RTC$  were obtained from the low-density data on all isotherms from 24 to 100 °K as described in [3]. The virial coefficients were approximated by

$$RTB = A_1 T + A_2 + A_3/T + A_4/T^2 \quad (4a)$$

and

$$RTC = A_1 T^2 + A_2 T + A_3 + A_4/T + A_5/T^2 + A_6/T^3. \quad (4b)$$

One set of coefficients for (4b) was used between 13.8 °K and  $T_c$ , a second set between  $T_c$  and 55 °K, while between 55 °K and 100 °K the relation used was

$$RTC = RTA_1 e^{A_2/T} [1 - e^{A_3[1 - (T/A_4)^{A_5}]}]. \quad (4c)$$

A number of functions can be found which will fit the  $RTC$  data within experimental accuracy; however, relations (4b) and (4c) were selected on the basis of the behavior of their first and second derivatives. Values for the coefficients for eqs (4a), (4b), and (4c), are found in table V.

*Two-phase boundaries.* The densities of the saturated liquid and vapor, respectively, have been represented by

$$\rho_{\text{sat L}} = \rho_c + A_1(T_c - T)^{0.380} + A_2(T_c - T) + A_3(T_c - T)^{4/3} + A_4(T_c - T)^{5/3} + A_5(T_c - T)^2, \quad (5a)$$

and

$$\rho_{\text{sat G}} = \rho_c + A_1(T_c - T)^{0.370} + A_2(T_c - T) + A_3(T_c - T)^{0.7} + A_4(T_c - T)^{0.8}, \quad (5b)$$

as given in [8]. However, the saturated vapor densities below the normal boiling point are calculated from (3), (4a), (4b), and the vapor pressure equation rather than by (5b).

The melting pressures are given by Goodwin [15] as

$$P_{\text{melt}} = P_t + (T - T_t)[A_1 e^{-\alpha/T} + A_2 T], \quad (6)$$

while the saturated liquid densities along the liquid-solid boundary from [16] are approximated by

$$\rho_{\text{melt L}} = \rho_t + \rho_t A_1 [1 - e^{-\delta(T - T_t)/T_t}]. \quad (7)$$

TABLE V. Coefficients for equations 4a, 4b, 4c

|                                          | A-1                       | A-2                        | A-3                        | A-4                         | A-5                        | A-6                         |
|------------------------------------------|---------------------------|----------------------------|----------------------------|-----------------------------|----------------------------|-----------------------------|
| Equation 4a                              | 1.9397741×10 <sup>3</sup> | -1.9279522×10 <sup>5</sup> | -2.2890051×10 <sup>6</sup> | 1.1094088×10 <sup>7</sup>   |                            |                             |
| Equation 4b $T < T_c$                    | 1.0541776×10 <sup>5</sup> | -1.6597141×10 <sup>7</sup> | 1.0431411×10 <sup>9</sup>  | -3.2538718×10 <sup>10</sup> | 5.1405848×10 <sup>11</sup> | -3.3123453×10 <sup>12</sup> |
| Equation 4b $T_c < T < 55^\circ\text{K}$ | 1.6971294×10 <sup>3</sup> | -5.0854223×10 <sup>5</sup> | 6.7284118×10 <sup>7</sup>  | -3.8045171×10 <sup>9</sup>  | 1.0789413×10 <sup>11</sup> | -1.1515642×10 <sup>12</sup> |
| Equation 4c                              | 388.682                   | 45.5                       | 0.60                       | 20.0                        | 4.0                        |                             |

*Additional data.* The vapor pressure equation from [17], the heats of vaporization and critical parameters as given by [8], and the properties of

the ideal gas at 1 atm [5, 6] have been used either directly or as supplemental information for comparisons and tests.

#### 4. Calculation of Thermodynamic Properties

A computer program has been developed which will determine a value of density corresponding to arguments of temperature and pressure. An interpolation scheme utilizes the isotherm equations, the isochore equations, and the functions representing the saturation boundaries. Both the isotherm derivative  $(\partial P/\partial \rho)_T$  and the isochore derivative  $(\partial P/\partial T)_\rho$  are obtained and used in this interpolation scheme. In the region near the critical point, direct differences in the table of pressures [4] are used rather than the isochore polynomials. After the point on the  $P$ - $\rho$ - $T$  surface is thus defined, the program calculates the remaining properties.

*Thermodynamic properties, regions.* Thermodynamic functions have been calculated for regions I and II as defined in figure 1. Region I covers the gas at densities typical of the vapor at temperatures above saturation. It also includes gas at higher densities above 46 °K and up to a pressure of 350 atm. Region II covers the fluid at liquid densities, up to 46 °K, and to the same limit in pressure. For values in region I, the computations proceed from the properties of the ideal gas at 1 atm [5, 6] as the line of reference. In region II, or on the liquid-solid boundary, an auxiliary table of smoothed experimentally determined values of  $C_v$ , for a particular constant density ( $\rho_1=0.037821$  g mole/cm<sup>3</sup>), is utilized as the line of reference; these values are presented in table VI. The properties on the vapor pressure curve are determined with the appropriate densities for the saturated liquid or saturated vapor.

*Equations.* The integrations indicated in the equations below are accomplished in closed form in the low-density region, that is, for densities up to 0.0070 g mole/cm<sup>3</sup>. For higher densities the ap-

propriate derivatives of the isochores are calculated at all intermediate tabulated densities [4], and the integration is performed numerically by employing the trapezoidal rule. In the region near the critical point (at temperatures from 32 to 37 °K, and at densities from 0.007 to 0.0210 g mole/cm<sup>3</sup>) the isochore derivatives are found by direct differences from the table of pressures reported in [4] rather than from the isochore equations.

The following isothermal equations are used in region I:

$$C_v(T, \rho) = C_v^\circ - T \int_0^\rho \frac{1}{\rho^2} \left( \frac{\partial^2 P}{\partial T^2} \right)_\rho d\rho, \quad (8)$$

$$S(T, \rho) = S^\circ - R \ln \left( \frac{RT\rho}{P_0} \right) + \int_0^\rho \left[ \frac{R}{\rho} - \frac{1}{\rho^2} \left( \frac{\partial P}{\partial T} \right)_\rho \right] d\rho, \quad (9)$$

where  $P_0=1$  atm;

$$H(T, \rho) = H^\circ + \frac{P}{\rho} - RT + \int_0^\rho \left[ \frac{P}{\rho^2} - \frac{T}{\rho^2} \left( \frac{\partial P}{\partial T} \right)_\rho \right] d\rho. \quad (10)$$

The values of  $C_v^\circ$ ,  $S^\circ$ , and  $H^\circ$  are obtained from [5, 6].

TABLE VI. Heat capacity at constant density

( $\rho_1=0.037821$  g mole/cm<sup>3</sup>)

| Temperature | $C_v$       | Temperature | $C_v$       |
|-------------|-------------|-------------|-------------|
| °K          | J/g mole °K | °K          | J/g mole °K |
| 13.5        | 9.355       | 30.5        | 12.970      |
| 14.0        | 9.544       | 31.0        | 13.029      |
| 14.5        | 9.728       | 31.5        | 13.088      |
| 15.0        | 9.904       | 32.0        | 13.142      |
|             |             | 32.5        | 13.196      |
| 15.5        | 10.075      | 33.0        | 13.247      |
| 16.0        | 10.238      | 33.5        | 13.297      |
| 16.5        | 10.397      | 34.0        | 13.347      |
| 17.0        | 10.548      | 34.5        | 13.397      |
| 17.5        | 10.694      | 35.0        | 13.443      |
| 18.0        | 10.832      |             |             |
| 18.5        | 10.966      | 35.5        | 13.489      |
| 19.0        | 11.092      | 36.0        | 13.535      |
| 19.5        | 11.213      | 36.5        | 13.581      |
| 20.0        | 11.326      | 37.0        | 13.623      |
|             |             | 37.5        | 13.665      |
| 20.5        | 11.435      | 38.0        | 13.703      |
| 21.0        | 11.539      | 38.5        | 13.736      |
| 21.5        | 11.640      | 39.0        | 13.770      |
| 22.0        | 11.736      | 39.5        | 13.799      |
| 22.5        | 11.832      | 40.0        | 13.832      |
| 23.0        | 11.916      |             |             |
| 23.5        | 12.000      | 40.5        | 13.862      |
| 24.0        | 12.083      | 41.0        | 13.895      |
| 24.5        | 12.163      | 41.5        | 13.924      |
| 25.0        | 12.238      | 42.0        | 13.958      |
|             |             | 42.5        | 13.991      |
| 25.5        | 12.314      | 43.0        | 14.025      |
| 26.0        | 12.385      | 43.5        | 14.058      |
| 26.5        | 12.456      | 44.0        | 14.092      |
| 27.0        | 12.527      | 44.5        | 14.125      |
| 27.5        | 12.598      | 45.0        | 14.159      |
| 28.0        | 12.665      |             |             |
| 28.5        | 12.732      | 45.5        | 14.192      |
| 29.0        | 12.795      | 46.0        | 14.226      |
| 29.5        | 12.853      |             |             |
| 30.0        | 12.912      |             |             |

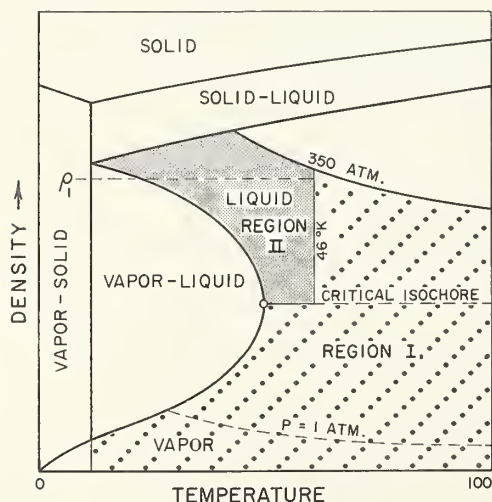


FIGURE 1. Regions for thermodynamic computations.

For region II the values of the thermodynamic properties at  $T=46^\circ\text{K}$  and  $\rho_1$  serve as the starting point. Property differences are first calculated along the path of constant density to the desired temperature, and then along an isothermal path to the desired density. Considering first the increments along the line of constant density, no increment is calculated for  $C_v(T, \rho_1)$ , which is interpolated directly from table VI. The entropy is

$$S(T, \rho_1) = S(46^\circ, \rho_1) + \int_{46^\circ}^T [C_v(T, \rho_1)/T] dT, \quad (11)$$

while the enthalpy is computed through the internal energy as  $H = U + P \cdot V$ .

Thus,

$$H(T, \rho_1) = U(46^\circ, \rho_1) + \int_{46^\circ}^T C_v(T, \rho_1) dT + P(T, \rho_1)/\rho_1. \quad (12)$$

Finally, the isothermal contributions are calculated as follows:

$$C_v(T, \rho) = C_v(T, \rho_1) - T \int_{\rho_1}^{\rho} [(\partial^2 P / \partial T^2)_\rho / \rho^2] d\rho, \quad (13)$$

$$S(T, \rho) = S(T, \rho_1) - \int_{\rho_1}^{\rho} [(\partial P / \partial T)_\rho / \rho^2] d\rho, \quad (14)$$

and

$$H(T, \rho) = H(T, \rho_1) + \int_{\rho_1}^{\rho} [P - T(\partial P / \partial T)_\rho] / \rho^2 d\rho + P/\rho - P(T, \rho_1)/\rho_1. \quad (15)$$

In both regions the internal energy and the specific heat at constant pressure are computed from

$$U(T, \rho) = H(T, \rho) - P/\rho, \quad (16)$$

and

$$C_p(T, \rho) = C_v(T, \rho) + T(\partial P / \partial T)_\rho^2 / \rho^2 (\partial P / \partial \rho)_T. \quad (17)$$

The derivative  $(\partial P / \partial \rho)_T$  was found when interpolating for density, while  $(\partial P / \partial T)_\rho$ , at the desired temperature  $T$ , is the isochore slope linearly interpolated from the two tabulated isochores bracketing the density  $\rho$ .

## 5. Related Functions

Two related functions are treated in this report, the velocity of sound, and the Joule-Thomson inversion curve. Other related properties such as adiabatic and isothermal compressibilities may be derived from the tabulations where values of isotherm and isochore derivatives have been included to facilitate such computations.

*The velocity of sound.* The velocity of sound,  $W$ , was calculated by means of (17) and the

relation

$$W^2 = K C_p (\partial P / \partial \rho)_T / C_v. \quad (18)$$

The constant of proportionality,  $K$ , is 50.26 where  $W$  is in meter/sec,  $C_p$  and  $C_v$  are in J/g mole  $^\circ\text{K}$ ,  $P$  is in atm, and  $\rho$  is in g mole/cm<sup>3</sup>. Figure 2 illustrates the variation of velocity with temperature along a few selected isobars, while tables VII and XV give a comparison with other sources. The detailed discussion of this comparison will be found in the appendix. The agreement between the calculated velocities and the other sources considering the errors discussed in section 9, is favorable, and is taken as a further indication of the internal consistency between the  $P$ - $\rho$ - $T$  surface, the various derivatives, and the specific heats.

TABLE VII. Comparison of calculated and experimental velocities of sound in normal hydrogen

| $T$              | $P$ | $\rho$ | $\frac{W}{W_0}$ [Normal]<br>(other sources) | $\frac{W}{W_0}$ [Normal]<br>(calc., this<br>research) | $\frac{W}{W_0}$ [Para]<br>(this research) |
|------------------|-----|--------|---------------------------------------------|-------------------------------------------------------|-------------------------------------------|
| $^\circ\text{K}$ | atm | amagat | Ref. [30]                                   |                                                       |                                           |
| 70.13            | 20  |        | 1.026                                       | 1.015                                                 | 1.012                                     |
| 70.13            | 40  |        | 1.067                                       | 1.056                                                 | 1.052                                     |
| 70.13            | 60  |        | 1.133                                       | 1.126                                                 | 1.120                                     |
| 70.13            | 70  |        | 1.171                                       | 1.170                                                 | 1.164                                     |
| 77.25            | 20  |        | 1.029                                       | 1.019                                                 | 1.016                                     |
| 77.25            | 40  |        | 1.065                                       | 1.056                                                 | 1.051                                     |
| 77.25            | 60  |        | 1.117                                       | 1.114                                                 | 1.107                                     |
| 77.25            | 70  |        | 1.156                                       | 1.149                                                 | 1.141                                     |
| 90.10            | 20  |        | 1.029                                       | 1.022                                                 | 1.019                                     |
| 90.10            | 40  |        | 1.060                                       | 1.056                                                 | 1.050                                     |
| 90.10            | 60  |        | 1.103                                       | 1.102                                                 | 1.092                                     |
| 90.10            | 70  |        | 1.127                                       | 1.132                                                 | 1.117                                     |
|                  |     |        | Ref. [11]                                   |                                                       |                                           |
| 98.15            |     | 80     | 1.085                                       | 1.037                                                 | 1.030                                     |
| 98.15            |     | 200    | 1.125                                       | 1.126                                                 | 1.115                                     |
| 98.15            |     | 280    | 1.211                                       | 1.210                                                 | 1.197                                     |
| 98.15            |     | 360    | 1.322                                       | 1.320                                                 | 1.307                                     |
| 98.15            |     | 440    | 1.460                                       | 1.453                                                 | 1.440                                     |
| 98.15            |     | 520    | 1.628                                       | 1.618                                                 | 1.608                                     |
| 98.15            |     | 600    | 1.810                                       | 1.805                                                 | 1.800                                     |
|                  |     |        | Ref. [33]                                   |                                                       |                                           |
| 30.00            |     | 91     | 0.889                                       | 0.869                                                 | 0.869                                     |
| 40.00            |     | 219    | 0.933                                       | 0.929                                                 | 0.929                                     |
| 50.00            |     | 491    | 1.41                                        | 1.430                                                 | 1.430                                     |
| 100.00           |     | 303    | 1.24                                        | 1.242                                                 | 1.227                                     |

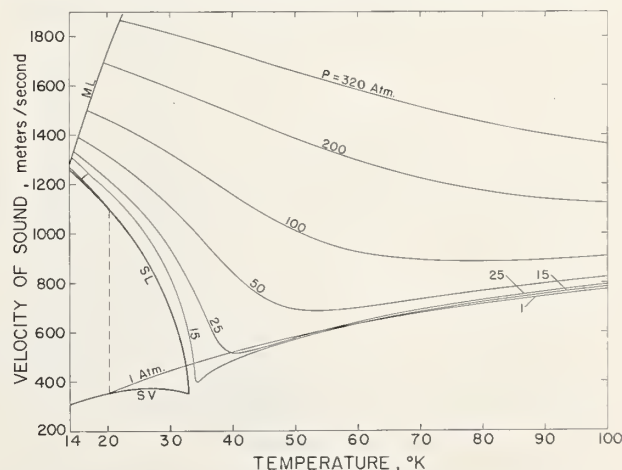


FIGURE 2. Velocity of sound in parahydrogen as a function of temperature on selected isobars.

SL and SV represent saturated liquid and saturated vapor, respectively. ML represents liquid at the melting line.

The Joule-Thomson inversion curve. The locus of the maxima of the isenthalpic curves with respect to temperature has been calculated from the  $P$ - $\rho$ - $T$  data and the definition of the Joule-Thomson coefficient,  $\mu=(\partial T/\partial P)_H$ . When  $\mu=0$ , the relation

$$T(\partial P/\partial T)_\rho = \rho(\partial P/\partial \rho)_T \quad (19)$$

defines the  $P$ - $\rho$ - $T$  coordinates of the inversion curve. The results are presented in table VIII. The fourth column in table VIII, labeled uncertainty, is the uncertainty in the inversion curve due to an assumed uncertainty of 0.5 percent in either the isotherm or the isochore derivatives. The calculated curve satisfies the criterion, pointed out by Brown [18], that the inversion curve should intersect each isochore only once. The inversion curve represented in table VIII is in fair agreement with the results given by Brown [18], which are based on earlier measurements of the inversion curve of normal and para-hydrogen. Quantitative comparison is difficult, however, due to the small scale of the graphs generally presented to illustrate this property in the literature. Koeppe [19], using the data for normal hydrogen of Johnston et al. [20], calculated the intersection of the inversion curve with the vapor pressure curve to be 27.05 °K. Our value of  $27.08 \pm 0.04$  °K is in excellent agreement with that result.

## 6. Results

The results of the calculations are presented in tables IX, X, and XI. The comparison of the experimental versus the calculated specific heats at constant volume is shown in table XII. Units have been indicated in section 2, and are also entered in the column headings of the tables. The number of digits in any given column is not intended to represent accuracy; digits were

TABLE VIII. Joule-Thomson inversion curve for para-hydrogen

| Temperature | Pressure | Density                | Uncertainty* |
|-------------|----------|------------------------|--------------|
| °K          | atm      | g mole/cm <sup>3</sup> | atm          |
| 28.000      | 9.87     | 0.03006                | 0.12         |
| 29.000      | 15.05    | .02990                 | .12          |
| 30.000      | 20.08    | .02973                 | .13          |
| 31.000      | 25.01    | .02956                 | .15          |
| 32.000      | 29.85    | .02940                 | .16          |
| 33.000      | 34.61    | .02923                 | .17          |
| 34.000      | 39.16    | .02905                 | .19          |
| 35.000      | 43.66    | .02888                 | .20          |
| 36.000      | 48.06    | .02870                 | .21          |
| 37.000      | 52.34    | .02852                 | .23          |
| 38.000      | 56.52    | .02834                 | .24          |
| 39.000      | 60.60    | .02817                 | .26          |
| 40.000      | 64.59    | .02799                 | .27          |
| 42.000      | 72.23    | .02763                 | .31          |
| 44.000      | 79.46    | .02726                 | .34          |
| 46.000      | 86.33    | .02689                 | .37          |
| 48.000      | 92.79    | .02652                 | .41          |
| 50.000      | 98.93    | .02616                 | .45          |
| 55.000      | 112.70   | .02523                 | .56          |
| 60.000      | 124.42   | .02430                 | .67          |
| 65.000      | 134.24   | .02337                 | .80          |
| 70.000      | 142.24   | .02243                 | .94          |
| 75.000      | 148.7    | .02151                 | 1.1          |
| 80.000      | 153.5    | .02058                 | 1.3          |
| 85.000      | 156.9    | .01965                 | 1.5          |
| 90.000      | 159.3    | .01875                 | 1.7          |
| 95.000      | 161.1    | .01791                 | 1.9          |
| 100.000     | 161.4    | .01704                 | 2.2          |

\*The uncertainty in the inversion pressure due to an assumed uncertainty of 0.5% in either  $(\partial P/\partial \rho)_T$  or  $(\partial P/\partial T)_\rho$ .

selected for publication in consideration of the errors discussed in section 9, and to facilitate interpolation.

The results are presented graphically in the form of a temperature-entropy chart in figure 3, in the form of an enthalpy-entropy chart in figure 4, while the general behavior of the specific heat at constant pressure is illustrated in figure 5.

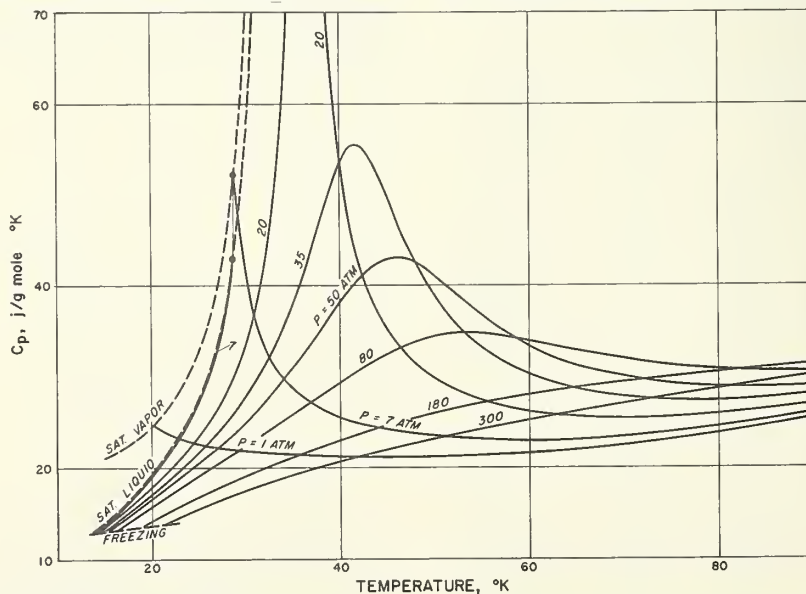


FIGURE 5. The specific heat at constant pressure as a function of temperature on selected isobars.

## 7. Normal Versus Parahydrogen Near 100 °K

The present tabulations are compared to the results of others which are, however, restricted to normal hydrogen. Only the temperature range near 100 °K is considered here, as the deviation between the  $P$ - $\rho$ - $T$  behavior of the two modifications is expected to increase with lowered temperatures. The values for parahydrogen are computed at the temperature and pressure reported by the other authors and are compared as follows:

1. Along the 98.15 °K isotherm to the smoothed

$P$ - $\rho$ - $T$  values and the derived properties of Michels et al. [10, 11];

2. Along the 100 °K isotherm to the smoothed  $P$ - $\rho$ - $T$  values and the derived properties of Woolley et al. [5];

3. Along the 100 °K isotherm to the smoothed  $P$ - $\rho$ - $T$  values of Johnston and White [12].

In the case of Michels et al. and Woolley et al., the comparisons are at approximately integral amagat densities.

## 8. Internal Comparisons and Tests

Values for  $Z=PV/RT$  are compared directly in figure 6a, and are seen to differ by no more than 4 parts in 1000. The heat capacity from Michels can also be compared directly. The differences in heat capacities are shown in figure 6b; they vary little from the difference in the ideal gas, 4.226 J/g mole °K, calculated from spectroscopic data. For entropy and enthalpy the two modifications have different numerical values in the ideal gas state; furthermore, different authors prefer different reference states. For entropy and enthalpy, therefore, isothermal increments were calculated from the lowest density of comparison. The differences between the entropy increments are shown in figure 6c; the maximum difference between all sources is 0.084 J/g mole °K. The differences between enthalpy increments are as high as 14.6 J/g mole and are plotted in figure 6d.

The differences in the derived functions can probably be related directly to the differences in  $Z$ . The difference in the  $P$ - $\rho$ - $T$  behavior, however, cannot be unambiguously assigned to the different modifications of the gas, but must be attributed to differences in the experimental determinations.

*Experimental versus calculated  $C_v$ .* This comparison is among the more stringent tests that may be applied. Error estimates in  $C_v$  allow direct computation of errors in entropy, and indicate the quality of the calculated thermodynamic properties. The discussion that follows is a summary of the results presented in table XII.

Using eq (8),  $C_v$  was computed at the 121 experimental points published by Younglove and Diller [7] for temperatures greater than  $T_c$ . Deviations ( $C_{v\text{ exp}} - C_{v\text{ calc}}$ ) have been plotted in figure 7 as

FIGURE 6. Normal versus parahydrogen.\*

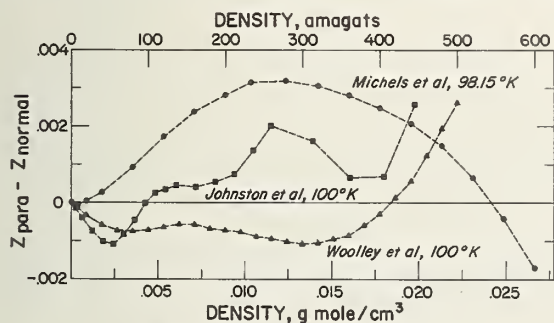


FIGURE 6a. Differences in  $Z=PV/RT$ .

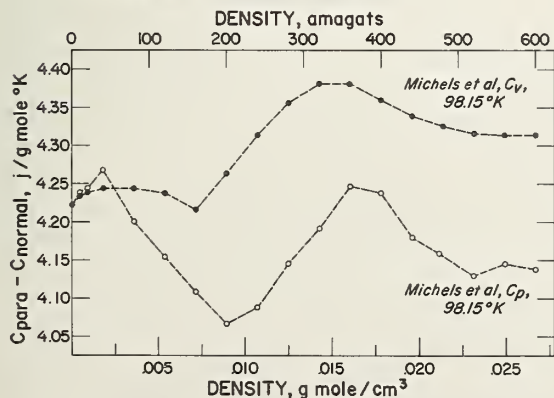


FIGURE 6b. Differences in the heat capacities.

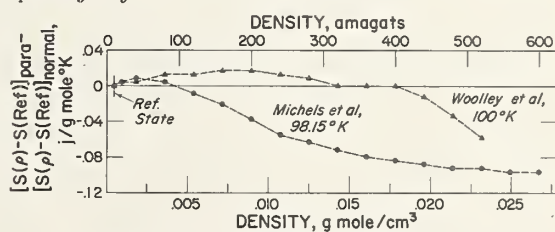


FIGURE 6c. Differences in entropy increments.

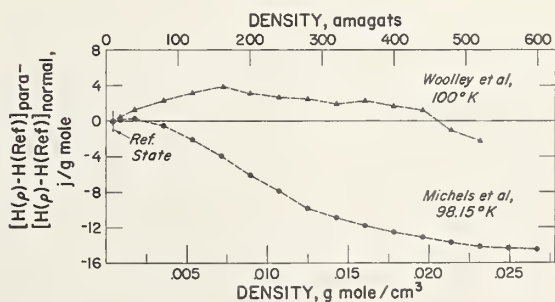


FIGURE 6d. Differences in enthalpy increments.

\*Values for parahydrogen are derived from the present measurements. For normal hydrogen values are taken from the references as follows: ● and ○ from [10] or [11], ▲ from [5], and ■ from [12].

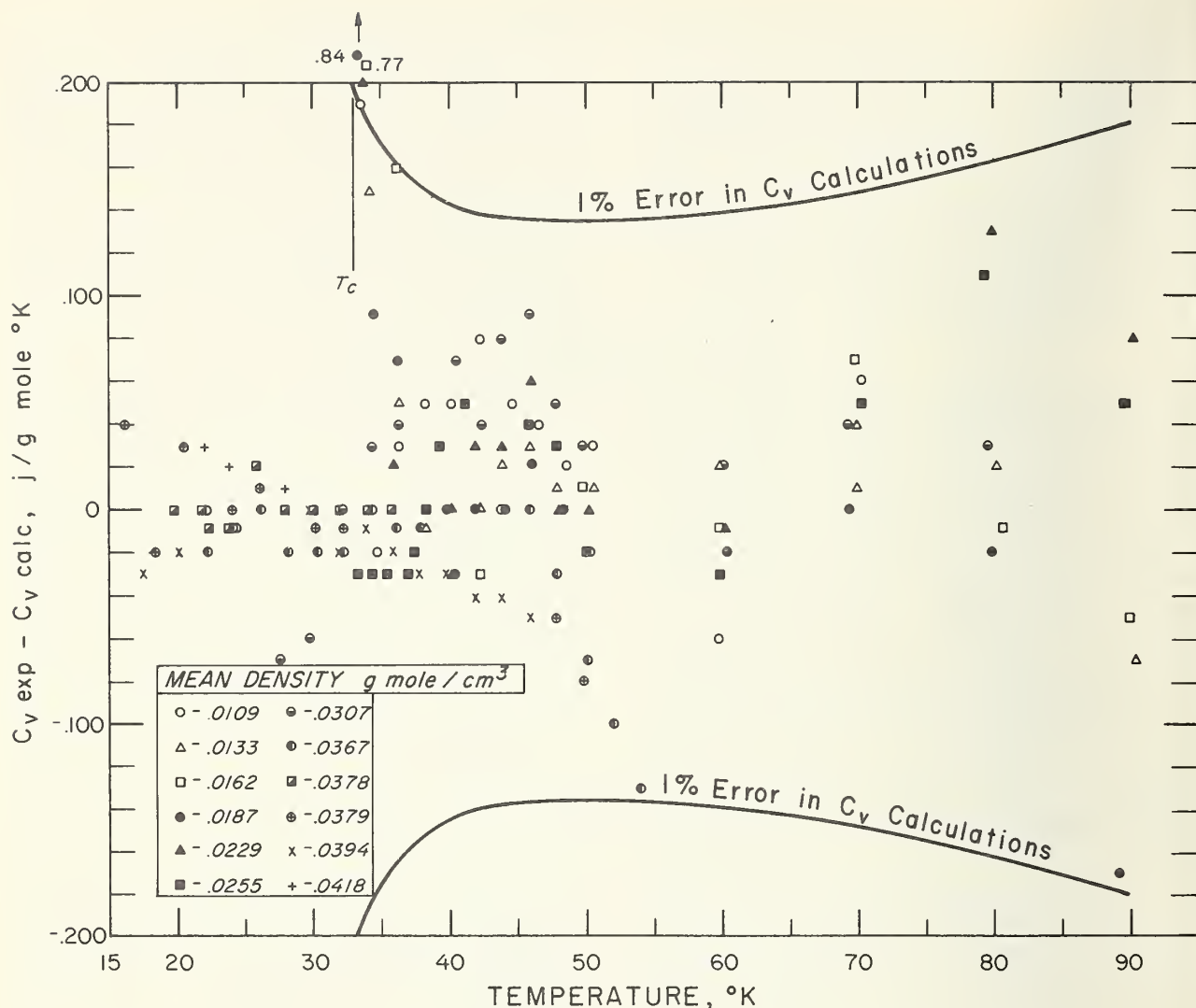


FIGURE 7. Difference between experimental and calculated heat capacities at constant volume vs. temperature.

a function of temperature for 12 densities. Mean deviation for all 121 experimental points is 0.071 J/g mole °K, or about twice the error estimated by the experimenters. The 20 points nearest the critical temperature contribute heavily to the overall mean deviation, ranging up to 4 percent error in  $C_v$ . Errors of this magnitude illustrate the difficulty of obtaining accurate second derivatives from the  $P$ - $\rho$ - $T$  data near the critical point. For the remaining 101 points above  $T_c$ , all of which lie at temperatures above 36.1 °K, the maximum errors correspond to 1 percent in  $C_v$ , with a mean deviation of 0.042 J/g mole °K which is the estimated error in the experimental values of  $C_v$ . The statistically calculated contribution ( $C_v^s$ ) is approximately 90 percent of the total value of  $C_v$  and the contribution from the  $P$ - $\rho$ - $T$  integral about 10 percent. The  $P$ - $\rho$ - $T$  contribution to  $C_v$  involving second derivatives of the smoothed  $P$ - $\rho$ - $T$  data can be computed within 7 percent; the error in this contribution becomes as large as 15 percent near the critical point.

At temperatures below  $T_c$  in region II a smoothed table of  $C_v$  (table VI) was used as the line of reference. The values of  $C_v$  computed at experimental conditions merely show the internal consistency among the various calorimetric runs, as the  $P$ - $\rho$ - $T$  contribution is small. The deviations, experimental minus calculated  $C_v$ , are also plotted in figure 7. The maximum deviation in this range is twice that estimated for the experimental values; however, the mean deviation for the 42 points in this range is less than 0.017 J/g mole °K.

**Heats of vaporization.** The heats of vaporization have been derived from the saturated liquid and vapor densities and the derivative of the vapor pressure ( $dP/dT$ ) using the Clapeyron equation and are reported in [8]. Values so calculated are listed in column 2 of table XIII. The heats of vaporization obtained in the present method are listed in column 3 of table XIII as enthalpy differences between saturated vapor and liquid, and in column 4 as entropy differences multiplied

TABLE XIII. *Heats of vaporization and entropy differences along the saturated liquid line*

| Temperature<br>°K | Heats of vaporization, J/g mole |                  |                          |                       | Entropies, J/g mole °K |                                                                               |            |
|-------------------|---------------------------------|------------------|--------------------------|-----------------------|------------------------|-------------------------------------------------------------------------------|------------|
|                   | Clapeyron<br>equation           | $\Delta H_{vap}$ | $T \cdot \Delta S_{vap}$ | Maximum<br>difference | Saturated<br>liquid    | $(S_{T,P} \equiv 10.016) + \int_{T.F.}^T \left( \frac{C_{sat}}{T} \right) dT$ | Difference |
| 13.803            | 907.1                           | 905.6            | 905.8                    | 1.5                   | 10.000                 | 10.016                                                                        | -0.016     |
| 14                | 908.3                           | 906.5            | 906.9                    | 1.8                   | 10.188                 | 10.201                                                                        | -.013      |
| 15                | 913.4                           | 910.8            | 910.9                    | 2.6                   | 11.138                 | 11.125                                                                        | .013       |
| 16                | 914.2                           | 913.2            | 913.2                    | 1.0                   | 12.079                 | 12.054                                                                        | .025       |
| 17                | 913.8                           | 913.5            | 913.6                    | 0.3                   | 13.012                 | 12.987                                                                        | .025       |
| 18                | 911.7                           | 911.6            | 911.7                    | .1                    | 13.945                 | 13.920                                                                        | .025       |
| 19                | 907.1                           | 907.3            | 907.4                    | -.3                   | 14.882                 | 14.862                                                                        | .020       |
| 20                | 900.4                           | 900.2            | 900.4                    | .2                    | 15.828                 | 15.811                                                                        | .017       |
| 20.268            | 898.7                           | 898.3            | 898.6                    | .4                    | 16.079                 | 16.067                                                                        | .012       |
| 21                | 889.1                           | 890.6            | 890.9                    | -1.8                  | 16.778                 | 16.769                                                                        | .009       |
| 22                | 876.5                           | 877.3            | 877.8                    | -1.3                  | 17.740                 | 17.736                                                                        | .004       |
| 23                | 860.2                           | 860.5            | 861.0                    | -0.8                  | 18.719                 | 18.719                                                                        | .000       |
| 24                | 840.1                           | 839.7            | 840.3                    | .4                    | 19.719                 | 19.719                                                                        | .000       |
| 25                | 815.9                           | 814.6            | 815.1                    | 1.3                   | 20.740                 | 20.740                                                                        | .000       |
| 26                | 785.8                           | 784.3            | 784.8                    | 1.5                   | 21.794                 | 21.794                                                                        | .000       |
| 27                | 749.8                           | 748.0            | 748.4                    | 1.8                   | 22.891                 | 22.891                                                                        | .000       |
| 28                | 705.8                           | 704.3            | 704.7                    | 1.5                   | 24.041                 | 24.041                                                                        | .000       |
| 29                | 651.9                           | 651.3            | 651.6                    | 0.6                   | 25.267                 | 25.267                                                                        | .000       |
| 30                | 586.2                           | 585.6            | 585.8                    | .6                    | 26.610                 | 26.602                                                                        | .008       |
| 31                | 501.2                           | 500.6            | 500.8                    | .6                    | 28.146                 | 28.112                                                                        | .034       |
| 32                | 379.9                           | 379.6            | 379.7                    | .3                    | 30.083                 | 29.966                                                                        | .117       |

by the appropriate temperatures. A comparison of columns 3 and 4 indicates that the present method is thermodynamically consistent, while a comparison of columns 2 and 3 shows that the heats of vaporization derived by the two different methods agree within 0.3 percent.

*Entropy along the saturated liquid line.* A comparison of the entropies of the saturated liquid calculated by the present method with the integral

$$\int_{T_i}^T (C_{sat}/T) dT$$

shows the internal consistency of two distinct calorimetric experiments [7, 9]. The comparison suggests a value of 10.016 J/g mole °K as entropy of the liquid at the triple point. Values and differences are given in table XIII as a function of temperature. It is seen that the agreement is excellent, with deviations ranging up to 0.025 J/g mole °K except near the critical point. The

error near the critical point was anticipated by Younglove and Diller [9], who represented  $C_{sat}$  by

$$C_{sat} = \frac{A_1 T}{(T_c - T)^n} + A_2 + A_3 T + A_4 T^2 + A_5 T^3 + A_6 T^4 + A_7 T^5. \quad (20)$$

The authors used  $n=0.1$  to give the best average representation of the experimental data, whereas  $n=0.6$  is required to yield the proper value of the integrated function near the critical point.

*Preliminary calculations.* In a preliminary tabulation of thermodynamic functions the  $P$ - $\rho$ - $T$  surface was described by an equation of state [2]; assuming the equation to be thermodynamically correct, the present method was compared to these earlier results. No gross inconsistencies were detected as all deviations corresponded closely to the errors anticipated in the preliminary computation.

## 9. Discussion of Errors

The magnitude of the absolute error in entropy can be determined by completing a closed-loop calculation utilizing the Third Law. As will be seen, the detailed computation is complex. We examine only the entropy for one particular point in the phase diagram, calculated on two different paths. Ideally the resulting entropies should be the same. The point selected for the comparison is 100 percent para, saturated vapor at a pressure of 1 atm and a temperature of 20.268 °K. One path assumes zero entropy for the ideal crystal at 0 °K, and utilizes the heat capacity of the solid, the experimental value of the heat of fusion, and

tabulated values of entropy for saturated liquid and vapor. The second path includes the entropy of the ideal gas at 20.268 °K calculated from statistical mechanics, and the small correction for the difference between real and ideal gas at 20.268 °K. The value obtained in following the latter path is the one given by this tabulation. It should be recalled that values tabulated are for 100 percent parahydrogen under the assumption that the  $P$ - $\rho$ - $T$  surface for 100 percent parahydrogen is identical with that determined experimentally for 99.79 percent parahydrogen.

The entropy contributions in J/g mole °K are as follows:

|                                                    |               |
|----------------------------------------------------|---------------|
| (a) Solid, from 0 °K to 13.803 °K-----             | 1.647 ± .016  |
| (b) Fusion, (28.03 cal/g mole at 13.803 °K) _      | 8.496 ± .045  |
| (c) Liquid, from 13.803 to 20.268 °K-----          | 6.079 ± .048  |
| (d) Vaporization, at 20.268 °K-----                | 44.334 ± .080 |
| <hr/>                                              |               |
| (e) Entropy, first path-----                       | 60.556        |
| (f) Entropy, second path, value from table IX----- | 60.41 ± .042  |
| <hr/>                                              |               |
| Discrepancy in entropy-----                        | 0.146         |
| <hr/>                                              |               |
| RMS combination of individual uncertainties-----   | ± .113        |

Contribution (a) was derived from the experimental heat capacities of the solid given by Ahlers [21] who indicated an uncertainty of 1 percent in the experimental values. A slight correction was applied to account for the orthohydrogen present in the sample ( $0.0021 R \ln 3$ ). Contribution (b) is based on the heat of fusion measured by several workers [5, 21, 22], while the uncertainty in this contribution is that calculated by Johnston et al. [22]. Contribution (c) is the entropy difference between the liquid at the boiling point and the triple point, as given in table IX. The corresponding uncertainty was chosen to reflect the entropy differences shown in table XIII and also the experimental uncertainty in  $C_{\text{sat}}$  given by Younglove and Diller [7]. Contribution (d) is the entropy difference between values for saturated liquid and vapor at 20.268 °K in table IX. This contribution is in agreement with the experimental heat of vaporization of Johnston et al. [22], and its uncertainty is that indicated by the experimenters. The uncertainty in the calculation of the entropy of the ideal gas [5] is given on line (f).

The actual discrepancy, 0.146 J/g mole °K, is in reasonable agreement with the statistical combination of the uncertainties in the individual contributions. The agreement is interpreted to mean that no physical anomaly has been overlooked, as only a slightly nonrandom addition of the individual uncertainties is required to account for the observed discrepancy. The discrepancy is in accord with the values for errors in entropy given in table XIV.

A rigorous calculation of other errors has not been attempted. As a guide to the user, "nominal" and "maximum" errors are specified in table XIV. These errors have been established from internal closed loop calculations, and from calculations of discontinuities along the critical isochore and critical isotherm; they are based on the internal checks of section 8, and in part on the comparison to normal hydrogen. However, the author's best judgment was also a consideration. In this context a "nominal" error is a mean or average error. The "nominal" errors include the discontinuities discussed below, and may occur anywhere in the phase diagram. A "maximum" error occurs only in areas of special difficulty such as near the critical point, or the triple point in the liquid, or along the saturated vapor boundary.

TABLE XIV. "Nominal" and "maximum" errors in the thermodynamic properties

| Variable                             | Errors                   |                        | Remarks                                                                                                        |
|--------------------------------------|--------------------------|------------------------|----------------------------------------------------------------------------------------------------------------|
|                                      | Nominal                  | Maximum*               |                                                                                                                |
| Temperature-----                     | 0.001 °K-----            | 0.02 °K-----           | The maximum is the uncertainty in the platinum thermometer scale.                                              |
| Volume-----                          | 0.02 percent-----        | 0.1 percent-----       | Maximum near critical and along the saturated vapor boundary. Originally estimated at 0.1 percent in ref. [3]. |
| Pressure-----                        | 0.001 atm-----           | 0.2 atm-----           | Not better than 0.01 percent.                                                                                  |
| $(\partial P/\partial \rho)_T$ ----- | 0.5 percent-----         | 5 percent-----         | See discussion (sec. 9).                                                                                       |
| $(\partial P/\partial T)_\rho$ ----- | 0.3 percent-----         | 1 percent-----         | See discussion (sec. 9).                                                                                       |
| Internal energy and enthalpy.        | 0.6 J/g mole-----        | 2.6 J/g mole-----      | Maximum near critical and along saturated vapor boundary.                                                      |
| Entropy-----                         | 0.016 J/g mole °K-----   | 0.170 J/g mole °K----- | Maximum near liquid triple point, critical point, and along saturated vapor boundary.                          |
| $C_v$ -----                          | Less than 1 percent----- | 4 percent-----         | Maximum near critical point and at low temperatures along saturated vapor boundary.                            |
| $C_p$ -----                          | 1 percent-----           | $\infty$ -----         | Not defined near critical, see discussion.                                                                     |
| Velocity of sound-----               | 0.5 percent-----         | 4 percent-----         | See discussion (sec. 9).                                                                                       |

\*Occurs only in areas of special difficulty such as near the critical point, or the triple point in the liquid, or along the saturated vapor boundary.

The isotherm derivatives  $(\partial P/\partial \rho)_T$  and the isochore derivatives  $(\partial P/\partial T)_\rho$  are accurate within 0.5 percent and 0.3 percent respectively in the interior of the region defined by the experiments. These uncertainties probably increase to 2 percent and 1 percent respectively near the upper limits of temperature and pressure. In the compressed liquid below 17 °K the isotherm derivatives may be in error by as much as 5 percent due to the scarcity of data points. The isochore first derivatives at the saturated liquid boundary have an uncertainty of about  $\pm 0.05$  atm/°K except as noted below. On the vapor side of the two-phase boundary, the uncertainty is about 1 percent.

It is perhaps inevitable that discontinuities will occur whenever the numerical representation of the  $P$ - $\rho$ - $T$  surface is changed. While each region has been selected to give the best overall fit, the derivatives at the various boundaries were not constrained to match. Such a discontinuity occurs along the boundary of region I and II, as described in figure 1, where near the critical temperature, the enthalpy is discontinuous by 0.93 J/g mole, the entropy by 0.024 J/g mole °K, and  $C_v$  by 0.226 J/g mole °K. This discontinuity decreases to zero at 46 °K. Another discontinuity arises along the 55 °K isotherm where the representation of the third virial coefficient,  $RTC$ , changes from eq (4b) to (4c). As the density increases to 0.007 g mole/cm<sup>3</sup>, the discontinuity in enthalpy increases to 0.58 J/g mole and remains

constant to higher densities, while the discontinuities in entropy and  $C_v$  are negligible. Figure 6b shows a minimum  $C_v$  near 0.007 g mole/cm<sup>3</sup>. This discontinuity exists only in  $C_v$  and  $C_p$ , and is attributed to the change in second derivatives between the virial expansion and the isochore representation, a change which cannot be detected in comparison to experimental values at 90 °K. For the saturated liquid, between densities 0.0210 and 0.0215 g mole/cm<sup>3</sup>, there is a discontinuity in the isochore derivative which amounts to 0.115 atm/°K, or 4 percent. This in turn causes discontinuities of 3.7 percent and 8 percent in the velocity of sound and  $C_p$ , respectively. These discontinuities are caused by a change in the representation of the  $P$ - $\rho$ - $T$  surface. They decrease rapidly in the compressed liquid and amount to only half of the above values at 33 °K. The discontinuities in these quantities are a measure of their uncertainties in this region. The uncertainty in the isochore derivative at saturation drops from a maximum at density 0.0215 g mole/cm<sup>3</sup> to about 0.1 percent at the critical point. For the same reason there is a 4.4 percent discontinuity in  $C_v$  of the saturated vapor at 32 °K.

Errors in the specific heats and the isotherm and isochore derivatives contribute to the error in the velocity of sound. Due to the form of eqs (17) and (18), however, the errors involved are partially compensating. The calculated velocities are estimated to be accurate within 0.5 percent, with the exceptions noted below. Near the high-pressure boundary (340 atm) the uncertainty increases to about 1 percent; thus the entries for 340 atm below 40 °K have a random scatter of 0.3 percent about a smooth curve, while the entries for the melting curve scatter by about 1 percent at the higher pressures. Uncertainties are larger for the saturated liquid and also in the compressed liquid below 20 °K. These problems are discussed further in the appendix. In tables

X and XI the velocity values approach the ideal gas values at zero pressure due to the nature of the functions used. The uncertainty in the value of 350 meter/sec assigned to the critical point is proportional mainly to the uncertainty in  $C_p$ . This value of  $C_v$  was taken to be 19.87 J/g mole °K, and its accuracy is difficult to estimate since it involves an uncertain extrapolation of the experimental heat capacities. Several recent publications [23, 24, 25] have brought up the possibility that  $C_v$  may become infinite at the critical point. As a result the velocity of sound could have a value of zero. Our data on parahydrogen seem to be in contradiction to this possibility. Our calculations show that  $C_v$ , at critical temperature, has a maximum at somewhat less than critical density. This same behavior has been observed for isopentane by Young [26] and for carbon dioxide by Michels et al. [27].

The entire set of tables has been subjected to checks by differencing; and the derivatives  $(\partial P/\partial \rho)_T$ ,  $(\partial P/\partial T)_\rho$ , and  $(\partial^2 P/\partial T^2)_\rho$  were tested for the proper sign. For a small region near the critical point, at densities from 0.0150 to 0.0160 g mole/cm<sup>3</sup> and temperatures from 32.975 to 32.984 °K, the interpolation of  $(\partial P/\partial \rho)_T$  results in the wrong sign. Calculation of  $C_p$  near the critical point is subject to large errors, and values of  $C_p$  over 200 J/g mole °K should be treated as uncertain.

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## 10. Appendix

*Calculated velocities of sound compared to results of others.* In general, published experimental measurements of the velocity of sound in hydrogen below 100 °K have been restricted to the saturated liquid and to the gas at pressures below one atmosphere. Van Itterbeek, Van Dael, and Forrez [28] measured the velocity in saturated liquid para and normal hydrogen from 14 to 20.4 °K. Between 14 and 16 °K our calculations agree with their experimental values within 1 percent. From 17 to 20 °K, however, our values are consistently 2 percent lower. This may perhaps be attributed to the relatively few  $P$ - $\rho$ - $T$  and  $C_v$  data points measured in the liquid below 20 °K. The agreement at 14 and 15 °K is probably fortuitous. The experimental work in progress at this laboratory on the velocity in the compressed liquid may resolve these differences.

A more recent publication by Van Itterbeek, Van Dael, and Cops [29] contains experimental

velocities in the compressed liquid from 14.85 to 20.50 °K. Table XV gives a comparison with our

TABLE XV. Comparison of experimental and calculated velocities of sound in parahydrogen\*

| Temperature | Pressure | $\frac{100(W_{\text{exp}} - W_{\text{calc}})}{W_{\text{exp}}}$ |
|-------------|----------|----------------------------------------------------------------|
| °K          | ATM      |                                                                |
| 14.85       | 4.26     | 0.01                                                           |
| 14.85       | 11.18    | -0.05                                                          |
| 14.85       | 19.74    | -0.07                                                          |
| 16.09       | 5.76     | 1.23                                                           |
| 16.09       | 29.18    | 0.78                                                           |
| 16.09       | 58.55    | 0.74                                                           |
| 18.25       | 8.03     | 2.11                                                           |
| 18.25       | 76.42    | 0.95                                                           |
| 18.25       | 132.60   | 0.78                                                           |
| 20.50       | 11.42    | 2.08                                                           |
| 20.50       | 97.46    | 0.77                                                           |
| 20.50       | 228.40   | 0.06                                                           |

\*Experimental values from reference [29].

values at a few points selected to cover the region of the experimental work.

Van Itterbeek et al. [30] have published experimental data for normal hydrogen at pressures up to 70 atm along three isotherms, 70.13 °K, 77.25 °K, and 90.10 °K. Their results are compared with ours at selected pressures in the first section of table VII. The values are more easily compared when reduced by the velocity in the ideal gas,  $W_0$ , which is, in general, not the same for normal and parahydrogen. In table VII, column 4 is the reduced velocity taken from smoothed curves published by Van Itterbeek et al. Column 5 is the reduced velocity in normal hydrogen calculated from our results for parahydrogen on the assumption that the two ortho-para forms have the same  $P$ - $\rho$ - $T$  behavior. This assumption is reasonable at least for temperatures above 50 °K. Column 6 is the reduced velocity in parahydrogen calculated from our data. Comparison of columns 4 and 5 shows that the values from [30] are consistently higher than ours. This difference increases to about 1 percent at the lower pressures. In addition their data, extrapolated to zero pressure, yields values which are about 1 percent higher than the calculated ideal gas values.

Van Itterbeek and Vermaelen [31] have published velocities for normal hydrogen gas at pressures less than one atmosphere from 50 to 100 °K. Comparison with our results is not useful here, however, since both are within 0.3 percent of the respective ideal gas values. Van Itterbeek and Keesom [32] measured the velocity in normal hydrogen at 20.42 °K from 0.15 atm to 0.92 atm. Extrapolation of their results to 1 atm leads to a value of 357.6 meter/sec, whereas we calculate 356.9 meter/sec. The ideal gas value is 374.4 meter/sec for both normal and para at this temperature.

Michels et al. [11] have calculated velocities in normal hydrogen from  $PVT$  data in the range  $-175$  °C to  $150$  °C. Their results are compared with ours in the second section of table VII at  $-175$  °C (98.15 °K). The deviations are all less than 0.6 percent.

Brown [33] has calculated the velocity in compressed normal hydrogen up to a density of 500 amagat, using the  $PVT$  data from Woolley, Scott, and Brickwedde [5]. His results are compared with ours at four points in the last section of table VII. The agreement is quite good except in the region of the critical point.

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|                                 |                                 |                                 |                                                                |
|---------------------------------|---------------------------------|---------------------------------|----------------------------------------------------------------|
| T = 13.803                      |                                 |                                 |                                                                |
| -2.7362469000 X10 <sup>5</sup>  | 1.1626831000 X10 <sup>7</sup>   | -5.4569215000 X10 <sup>8</sup>  | 1.0693073000 X10 <sup>10</sup>                                 |
| T = 14.000                      |                                 |                                 |                                                                |
| -2.7253626000 X10 <sup>5</sup>  | 7.2864442000 X10 <sup>6</sup>   | -3.1514784000 X10 <sup>8</sup>  | 7.6284550000 X10 <sup>9</sup>                                  |
| T = 15.000                      |                                 |                                 |                                                                |
| -2.6699190000 X10 <sup>5</sup>  | 1.0029355000 X10 <sup>7</sup>   | -4.5885587000 X10 <sup>8</sup>  | 9.4900031000 X10 <sup>9</sup>                                  |
| T = 16.000                      |                                 |                                 |                                                                |
| -2.6148537000 X10 <sup>5</sup>  | 8.1543086000 X10 <sup>6</sup>   | -3.5944479000 X10 <sup>8</sup>  | 8.1514178000 X10 <sup>9</sup>                                  |
| T = 17.000                      |                                 |                                 |                                                                |
| 1.3927202795 X10 <sup>6</sup>   | -1.2086392365 X10 <sup>8</sup>  | 3.0043639751 X10 <sup>9</sup>   | -2.1091736290 X10 <sup>10</sup>                                |
| T = 18.000                      |                                 |                                 |                                                                |
| 8.2979422927 X10 <sup>6</sup>   | -8.5412708605 X10 <sup>8</sup>  | 3.2183413067 X10 <sup>10</sup>  | -5.3645475253 X10 <sup>11</sup> 3.4086445220 X10 <sup>12</sup> |
| T = 19.000                      |                                 |                                 |                                                                |
| 1.3754949312 X10 <sup>6</sup>   | -1.3860879159 X10 <sup>8</sup>  | 4.4768285585 X10 <sup>9</sup>   | -5.9781177810 X10 <sup>10</sup> 3.3417579045 X10 <sup>11</sup> |
| T = 20.000                      |                                 |                                 |                                                                |
| -4.2265860500 X10 <sup>7</sup>  | 5.4885225906 X10 <sup>9</sup>   | -2.8552308790 X10 <sup>11</sup> | 7.4078018995 X10 <sup>12</sup> -9.5744663179 X10 <sup>13</sup> |
| 4.9410854979 X10 <sup>14</sup>  |                                 |                                 |                                                                |
| T = 21.000                      |                                 |                                 |                                                                |
| 3.1391805297 X10 <sup>6</sup>   | -4.0065538099 X10 <sup>8</sup>  | 1.9626480997 X10 <sup>10</sup>  | -4.8727924224 X10 <sup>11</sup> 6.2549943067 X10 <sup>12</sup> |
| -3.2326148724 X10 <sup>13</sup> |                                 |                                 |                                                                |
| T = 22.000                      |                                 |                                 |                                                                |
| -7.8495402170 X10 <sup>6</sup>  | 1.0294182978 X10 <sup>9</sup>   | -5.4711094212 X10 <sup>10</sup> | 1.4427061021 X10 <sup>12</sup> -1.8769317543 X10 <sup>13</sup> |
| 9.7296745261 X10 <sup>13</sup>  |                                 |                                 |                                                                |
| T = 23.000                      |                                 |                                 |                                                                |
| 6.6081943799 X10 <sup>6</sup>   | -8.6995122325 X10 <sup>8</sup>  | 4.4898977607 X10 <sup>10</sup>  | -1.1633247847 X10 <sup>12</sup> 1.5245167439 X10 <sup>13</sup> |
| -7.9908905042 X10 <sup>13</sup> |                                 |                                 |                                                                |
| T = 24.000                      |                                 |                                 |                                                                |
| -2.2703167414 X10 <sup>5</sup>  | 1.1029755943 X10 <sup>7</sup>   | -4.6014059410 X10 <sup>9</sup>  | 7.6797978893 X10 <sup>11</sup> -5.6832274951 X10 <sup>13</sup> |
| 2.2210004348 X10 <sup>15</sup>  | -4.7917093894 X10 <sup>16</sup> | 5.4321544187 X10 <sup>17</sup>  | -2.5374445754 X10 <sup>18</sup>                                |
| T = 25.000                      |                                 |                                 |                                                                |
| -2.1845298801 X10 <sup>5</sup>  | 4.0041483547 X10 <sup>6</sup>   | -8.2011529356 X10 <sup>8</sup>  | 2.3387866020 X10 <sup>11</sup> -2.1691510581 X10 <sup>13</sup> |
| 9.5739108732 X10 <sup>14</sup>  | -2.2214987520 X10 <sup>16</sup> | 2.6449547900 X10 <sup>17</sup>  | -1.2813225060 X10 <sup>18</sup>                                |
| T = 26.000                      |                                 |                                 |                                                                |
| -2.1564931312 X10 <sup>5</sup>  | 5.8371388186 X10 <sup>6</sup>   | -1.2147135809 X10 <sup>9</sup>  | 2.3126337737 X10 <sup>11</sup> -1.8341887072 X10 <sup>13</sup> |
| 7.3708533789 X10 <sup>14</sup>  | -1.5898029097 X10 <sup>16</sup> | 1.7755403232 X10 <sup>17</sup>  | -8.1112233168 X10 <sup>17</sup>                                |
| T = 27.000                      |                                 |                                 |                                                                |
| -2.1051262962 X10 <sup>5</sup>  | 4.5024526855 X10 <sup>6</sup>   | -5.4837631192 X10 <sup>8</sup>  | 1.3039311502 X10 <sup>11</sup> -1.1222941596 X10 <sup>13</sup> |
| 4.6496663610 X10 <sup>14</sup>  | -1.0060419823 X10 <sup>16</sup> | 1.1118468638 X10 <sup>17</sup>  | -4.9896063641 X10 <sup>17</sup>                                |
| T = 28.000                      |                                 |                                 |                                                                |
| -2.0762939800 X10 <sup>5</sup>  | 6.0281970017 X10 <sup>6</sup>   | -1.0832171742 X10 <sup>9</sup>  | 2.0891232542 X10 <sup>11</sup> -1.7089932257 X10 <sup>13</sup> |
| 7.0813046116 X10 <sup>14</sup>  | -1.5732074258 X10 <sup>16</sup> | 1.8097591250 X10 <sup>17</sup>  | -8.5189154881 X10 <sup>17</sup>                                |
| T = 29.000                      |                                 |                                 |                                                                |
| -2.0399829665 X10 <sup>5</sup>  | 6.0944290049 X10 <sup>6</sup>   | -9.9903507122 X10 <sup>8</sup>  | 1.8406649802 X10 <sup>11</sup> -1.4767020559 X10 <sup>13</sup> |
| 6.0389139144 X10 <sup>14</sup>  | -1.3244607901 X10 <sup>16</sup> | 1.5039641025 X10 <sup>17</sup>  | -6.9892408619 X10 <sup>17</sup>                                |

TABLE I. COEFFICIENTS A<sub>i</sub> FOR ISOTHERMS IN EQUATION (1)-CONTINUED \*

| T = 30.000                      |                                 |                                 |                                 |                                 |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| -1.9930510098 X10 <sup>5</sup>  | 4.2467782509 X10 <sup>6</sup>   | 1.3753519803 X10 <sup>8</sup>   | -1.0285127394 X10 <sup>11</sup> | 2.1030356489 X10 <sup>13</sup>  |
| -1.9496018335 X10 <sup>15</sup> | -9.8476712280 X10 <sup>16</sup> | -2.9098704020 X10 <sup>18</sup> | 5.0573267198 X10 <sup>19</sup>  | -4.8103183375 X10 <sup>20</sup> |
| 1.9378706506 X10 <sup>21</sup>  |                                 |                                 |                                 |                                 |
| T = 31.000                      |                                 |                                 |                                 |                                 |
| -1.9649180312 X10 <sup>5</sup>  | 5.5458899410 X10 <sup>6</sup>   | -6.1607831288 X10 <sup>8</sup>  | 1.3517651163 X10 <sup>11</sup>  | -2.3596665785 X10 <sup>13</sup> |
| 3.3893888131 X10 <sup>15</sup>  | -3.2529478608 X10 <sup>17</sup> | 1.9767194733 X10 <sup>19</sup>  | -7.6800027760 X10 <sup>20</sup> | 1.9123637559 X10 <sup>22</sup>  |
| -2.9624543910 X10 <sup>23</sup> | 2.6058297626 X10 <sup>24</sup>  | -9.9609263365 X10 <sup>24</sup> |                                 |                                 |
| T = 32.000                      |                                 |                                 |                                 |                                 |
| -1.9350503328 X10 <sup>5</sup>  | 6.9373186417 X10 <sup>6</sup>   | -1.6636348493 X10 <sup>9</sup>  | 5.0637612670 X10 <sup>11</sup>  | -9.3704055906 X10 <sup>13</sup> |
| 1.1178838140 X10 <sup>16</sup>  | -8.7528036354 X10 <sup>17</sup> | 4.5583209515 X10 <sup>19</sup>  | -1.5877799116 X10 <sup>21</sup> | 3.6586697848 X10 <sup>22</sup>  |
| -5.3582912630 X10 <sup>23</sup> | 4.5217607620 X10 <sup>24</sup>  | -1.6753822146 X10 <sup>25</sup> |                                 |                                 |
| T = 33.000                      |                                 |                                 |                                 |                                 |
| -1.8723476775 X10 <sup>5</sup>  | 1.4999719858 X10 <sup>6</sup>   | 2.3160600394 X10 <sup>9</sup>   | -1.0063395316 X10 <sup>12</sup> | 2.5153228712 X10 <sup>14</sup>  |
| -3.9905387556 X10 <sup>16</sup> | 4.2648040664 X10 <sup>18</sup>  | -3.1716062755 X10 <sup>20</sup> | 1.6685452289 X10 <sup>22</sup>  | -6.2399228830 X10 <sup>23</sup> |
| 1.6469852417 X10 <sup>25</sup>  | -2.9974796223 X10 <sup>26</sup> | 3.5787896341 X10 <sup>27</sup>  | -2.5226536953 X10 <sup>28</sup> | 7.9569173817 X10 <sup>28</sup>  |
| T = 34.000                      |                                 |                                 |                                 |                                 |
| -1.8488862691 X10 <sup>5</sup>  | 4.3215606863 X10 <sup>6</sup>   | -1.3896810114 X10 <sup>8</sup>  | 4.4586371816 X10 <sup>10</sup>  | -9.6325801836 X10 <sup>12</sup> |
| 1.3984833795 X10 <sup>15</sup>  | -1.2701931661 X10 <sup>17</sup> | 7.2530968934 X10 <sup>18</sup>  | -2.6570375597 X10 <sup>20</sup> | 6.2683647514 X10 <sup>21</sup>  |
| -9.2424628854 X10 <sup>22</sup> | 7.7691902499 X10 <sup>23</sup>  | -2.8473520151 X10 <sup>24</sup> |                                 |                                 |
| T = 35.000                      |                                 |                                 |                                 |                                 |
| -1.8177532310 X10 <sup>5</sup>  | 4.4133408513 X10 <sup>6</sup>   | -5.5172063887 X10 <sup>7</sup>  | -9.6827596798 X10 <sup>9</sup>  | 3.6024158141 X10 <sup>12</sup>  |
| -3.8251315113 X10 <sup>14</sup> | 2.0115412292 X10 <sup>16</sup>  | -5.9233883954 X10 <sup>17</sup> | 1.0080261600 X10 <sup>19</sup>  | -9.3573929400 X10 <sup>19</sup> |
| 3.6981942728 X10 <sup>20</sup>  |                                 |                                 |                                 |                                 |
| T = 36.000                      |                                 |                                 |                                 |                                 |
| -1.7814838737 X10 <sup>5</sup>  | 4.1419954249 X10 <sup>6</sup>   | 2.6146841235 X10 <sup>7</sup>   | -2.1749048736 X10 <sup>10</sup> | 4.5849213321 X10 <sup>12</sup>  |
| -4.4034967366 X10 <sup>14</sup> | 2.2993337230 X10 <sup>16</sup>  | -7.0033300830 X10 <sup>17</sup> | 1.2653522663 X10 <sup>19</sup>  | -1.2716989561 X10 <sup>20</sup> |
| 5.5193689680 X10 <sup>20</sup>  |                                 |                                 |                                 |                                 |
| T = 37.000                      |                                 |                                 |                                 |                                 |
| -1.7461960892 X10 <sup>5</sup>  | 3.8868326028 X10 <sup>6</sup>   | 1.0718345926 X10 <sup>8</sup>   | -3.4551414531 X10 <sup>10</sup> | 5.6480262001 X10 <sup>12</sup>  |
| -4.9568945858 X10 <sup>14</sup> | 2.5092683201 X10 <sup>16</sup>  | -7.6047875801 X10 <sup>17</sup> | 1.3842803721 X10 <sup>19</sup>  | -1.4096659837 X10 <sup>20</sup> |
| 6.2098481429 X10 <sup>20</sup>  |                                 |                                 |                                 |                                 |
| T = 38.000                      |                                 |                                 |                                 |                                 |
| -1.7163854649 X10 <sup>5</sup>  | 4.1633946821 X10 <sup>6</sup>   | -2.3910768749 X10 <sup>7</sup>  | -5.2847387223 X10 <sup>9</sup>  | 1.9075874444 X10 <sup>12</sup>  |
| -2.0942215086 X10 <sup>14</sup> | 1.1562533830 X10 <sup>16</sup>  | -3.6087256402 X10 <sup>17</sup> | 6.6412609945 X10 <sup>18</sup>  | -6.8407236618 X10 <sup>19</sup> |
| 3.0739794580 X10 <sup>20</sup>  |                                 |                                 |                                 |                                 |
| T = 39.000                      |                                 |                                 |                                 |                                 |
| -1.6853963905 X10 <sup>5</sup>  | 4.2284416296 X10 <sup>6</sup>   | -6.8717583816 X10 <sup>7</sup>  | 6.5602342483 X10 <sup>9</sup>   | 1.8489675946 X10 <sup>11</sup>  |
| -6.5908219083 X10 <sup>13</sup> | 4.3958693044 X10 <sup>15</sup>  | -1.4045183669 X10 <sup>17</sup> | 2.5238994618 X10 <sup>18</sup>  | -2.5364583628 X10 <sup>19</sup> |
| 1.1357792965 X10 <sup>20</sup>  |                                 |                                 |                                 |                                 |
| T = 40.000                      |                                 |                                 |                                 |                                 |
| -1.6470836396 X10 <sup>5</sup>  | 3.3724181266 X10 <sup>6</sup>   | 2.8005063552 X10 <sup>8</sup>   | -6.6549522430 X10 <sup>10</sup> | 9.0755118597 X10 <sup>12</sup>  |
| -7.4291866142 X10 <sup>14</sup> | 3.7724755667 X10 <sup>16</sup>  | -1.1980572394 X10 <sup>18</sup> | 2.3364368948 X10 <sup>19</sup>  | -2.5698554428 X10 <sup>20</sup> |
| 1.2219937944 X10 <sup>21</sup>  |                                 |                                 |                                 |                                 |
| T = 42.000                      |                                 |                                 |                                 |                                 |
| -1.5861053957 X10 <sup>5</sup>  | 3.1690123817 X10 <sup>6</sup>   | 3.7246165872 X10 <sup>8</sup>   | -8.8317988960 X10 <sup>10</sup> | 1.1829375334 X10 <sup>13</sup>  |
| -9.5484987495 X10 <sup>14</sup> | 4.8235399945 X10 <sup>16</sup>  | -1.5334536603 X10 <sup>18</sup> | 2.9978262958 X10 <sup>19</sup>  | -3.3008822365 X10 <sup>20</sup> |
| 1.5678208548 X10 <sup>21</sup>  |                                 |                                 |                                 |                                 |

TABLE 1. COEFFICIENTS A<sub>i</sub> FOR ISOTHERMS IN EQUATION (1)-CONTINUED \*

| T = 44.000                      |                                 |                                 |                                 |                                 |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| -1.5359475951 X10 <sup>5</sup>  | 4.0962442274 X10 <sup>6</sup>   | -4.5687429380 X10 <sup>7</sup>  | 4.8988136428 X10 <sup>9</sup>   | -1.6995649473 X10 <sup>11</sup> |
| -4.2694098185 X10 <sup>12</sup> | 5.4293030962 X10 <sup>14</sup>  | -1.2691095952 X10 <sup>16</sup> | 9.3047212366 X10 <sup>16</sup>  |                                 |
| T = 46.000                      |                                 |                                 |                                 |                                 |
| -1.4815999058 X10 <sup>5</sup>  | 4.1880803906 X10 <sup>6</sup>   | -6.3062218182 X10 <sup>7</sup>  | 6.5286749863 X10 <sup>9</sup>   | -3.1304070275 X10 <sup>11</sup> |
| 6.3268984317 X10 <sup>12</sup>  | 1.2090559054 X10 <sup>14</sup>  | -4.6460374419 X10 <sup>15</sup> | 3.4224387722 X10 <sup>16</sup>  |                                 |
| T = 48.000                      |                                 |                                 |                                 |                                 |
| -1.4289709695 X10 <sup>5</sup>  | 4.3430704313 X10 <sup>6</sup>   | -1.0015478474 X10 <sup>8</sup>  | 1.0671721772 X10 <sup>10</sup>  | -5.7717251094 X10 <sup>11</sup> |
| 1.7476035113 X10 <sup>13</sup>  | -1.6511955271 X10 <sup>14</sup> | -7.7547326168 X10 <sup>14</sup> | 1.3353676047 X10 <sup>16</sup>  |                                 |
| T = 50.000                      |                                 |                                 |                                 |                                 |
| -1.3740743668 X10 <sup>5</sup>  | 4.3079274536 X10 <sup>6</sup>   | -8.9153195730 X10 <sup>7</sup>  | 8.9471762553 X10 <sup>9</sup>   | -4.4685100671 X10 <sup>11</sup> |
| 1.3589982410 X10 <sup>13</sup>  | -1.3818464153 X10 <sup>14</sup> | -2.3391448210 X10 <sup>13</sup> | 2.3127558170 X10 <sup>15</sup>  |                                 |
| T = 55.000                      |                                 |                                 |                                 |                                 |
| -1.2486657792 X10 <sup>5</sup>  | 4.8191921227 X10 <sup>6</sup>   | -2.3851501909 X10 <sup>8</sup>  | 3.1381120132 X10 <sup>10</sup>  | -2.3285019081 X10 <sup>12</sup> |
| 1.0887184062 X10 <sup>14</sup>  | -2.9553113523 X10 <sup>15</sup> | 4.4407171401 X10 <sup>16</sup>  | -2.8618128494 X10 <sup>17</sup> |                                 |
| T = 60.000                      |                                 |                                 |                                 |                                 |
| -1.1290347350 X10 <sup>5</sup>  | 5.2055069485 X10 <sup>6</sup>   | -3.1922673751 X10 <sup>8</sup>  | 4.2432762272 X10 <sup>10</sup>  | -3.2249430353 X10 <sup>12</sup> |
| 1.5544493636 X10 <sup>14</sup>  | -4.4024977985 X10 <sup>15</sup> | 6.8523528062 X10 <sup>16</sup>  | -4.5167937235 X10 <sup>17</sup> |                                 |
| T = 65.000                      |                                 |                                 |                                 |                                 |
| -1.0011710195 X10 <sup>5</sup>  | 4.8350848439 X10 <sup>6</sup>   | -1.7449417289 X10 <sup>8</sup>  | 1.9477145304 X10 <sup>10</sup>  | -1.2034135144 X10 <sup>12</sup> |
| 5.4476389091 X10 <sup>13</sup>  | -1.5147296439 X10 <sup>15</sup> | 2.4297497653 X10 <sup>16</sup>  | -1.7050119592 X10 <sup>17</sup> |                                 |
| T = 70.000                      |                                 |                                 |                                 |                                 |
| -8.7862933060 X10 <sup>4</sup>  | 4.6498736377 X10 <sup>6</sup>   | -9.6987491543 X10 <sup>7</sup>  | 8.3550593088 X10 <sup>9</sup>   | -2.4292007541 X10 <sup>11</sup> |
| 5.6505608371 X10 <sup>12</sup>  | -4.7058568731 X10 <sup>13</sup> |                                 |                                 |                                 |
| T = 75.000                      |                                 |                                 |                                 |                                 |
| -7.7328248508 X10 <sup>4</sup>  | 5.2537801514 X10 <sup>6</sup>   | -1.9358154438 X10 <sup>8</sup>  | 1.7560525895 X10 <sup>10</sup>  | -6.7091986589 X10 <sup>11</sup> |
| 1.5565779024 X10 <sup>13</sup>  | -1.3861537547 X10 <sup>14</sup> |                                 |                                 |                                 |
| T = 80.000                      |                                 |                                 |                                 |                                 |
| -6.5411880737 X10 <sup>4</sup>  | 5.0459744611 X10 <sup>6</sup>   | -1.2449876773 X10 <sup>8</sup>  | 1.0873657127 X10 <sup>10</sup>  | -3.2722428716 X10 <sup>11</sup> |
| 7.0774575355 X10 <sup>12</sup>  | -5.9030985978 X10 <sup>13</sup> |                                 |                                 |                                 |
| T = 85.000                      |                                 |                                 |                                 |                                 |
| -5.2881744772 X10 <sup>4</sup>  | 4.2893700745 X10 <sup>6</sup>   | 8.0046229182 X10 <sup>7</sup>   | -1.0882062428 X10 <sup>10</sup> | 8.5433948768 X10 <sup>11</sup>  |
| -2.4150823228 X10 <sup>13</sup> | 2.6006115503 X10 <sup>14</sup>  |                                 |                                 |                                 |
| T = 90.000                      |                                 |                                 |                                 |                                 |
| -4.1167482811 X10 <sup>4</sup>  | 4.1287617988 X10 <sup>6</sup>   | 1.4742581518 X10 <sup>8</sup>   | -1.8749216672 X10 <sup>10</sup> | 1.3377914908 X10 <sup>12</sup>  |
| -3.8327173765 X10 <sup>13</sup> | 4.1780717716 X10 <sup>14</sup>  |                                 |                                 |                                 |
| T = 95.000                      |                                 |                                 |                                 |                                 |
| -3.1164714559 X10 <sup>4</sup>  | 4.9636724736 X10 <sup>6</sup>   | -4.3883143487 X10 <sup>7</sup>  | 4.4122507201 X10 <sup>9</sup>   | -1.8905239252 X10 <sup>10</sup> |
| T = 100.000                     |                                 |                                 |                                 |                                 |
| -2.0676232668 X10 <sup>4</sup>  | 5.0876801868 X10 <sup>6</sup>   | -4.0904786694 X10 <sup>7</sup>  | 4.4707993548 X10 <sup>9</sup>   | -2.1730880274 X10 <sup>10</sup> |

\* ORDER OF COEFFICIENTS,

A1  
A6  
A11A2  
A7  
A12A3  
A8  
A13A4  
A9  
A14A5  
A10  
A15

TABLE II. REPRESENTATIVE DEVIATIONS FOR SELECTED ISOTHERMS

| T = 18 DEG K |              |      |    | T = 20 DEG K |              |      |    | T = 25 DEG K |              |      |    | T = 32 DEG K |              |      |    |
|--------------|--------------|------|----|--------------|--------------|------|----|--------------|--------------|------|----|--------------|--------------|------|----|
| DENSITY      | OELTA        | P    |    | DENSITY      | OELTA        | P    |    | DENSITY      | OELTA        | P    |    | DENSITY      | OELTA        | P    |    |
| <sup>3</sup> | <sup>3</sup> |      | ** | <sup>3</sup> | <sup>3</sup> |      | ** | <sup>3</sup> | <sup>3</sup> |      | ** | <sup>3</sup> | <sup>3</sup> |      | ** |
| G MOL/CM     | ATMX10       | PCT  |    | G MOL/CM     | ATMX10       | PCT  |    | G MOL/CM     | ATMX10       | PCT  |    | G MOL/CM     | ATMX10       | PCT  |    |
| * 0.03631    | -1.5         | 0.31 |    | * 0.03526    | -0.9         | 0.10 |    | 0.00108      | 0.           | 0.00 |    | 0.00108      | 0.           | 0.00 |    |
| 0.03692      | 14.9         | 0.13 |    | 0.03559      | 4.0          | 0.07 |    | 0.00149      | 0.           | 0.00 |    | 0.00149      | 0.           | 0.00 |    |
| 0.03788      | -24.6        | 0.08 |    | 0.03623      | -0.1         | 0.00 |    | * 0.00199    | 0.           | 0.00 |    | 0.00215      | -0.5         | 0.01 |    |
| 0.03866      | -0.9         | 0.00 |    | 0.03690      | 1.3          | 0.00 |    | * 0.03199    | -9.1         | 0.28 |    | 0.00256      | 0.9          | 0.02 |    |
| 0.03936      | 71.1         | 0.10 |    | 0.03785      | -8.6         | 0.02 |    | 0.03215      | 16.3         | 0.36 |    | 0.00333      | -0.8         | 0.01 |    |
| 0.04000      | -106.5       | 0.12 |    | 0.03864      | -4.7         | 0.01 |    | 0.03322      | 48.4         | 0.32 |    | 0.00398      | 0.8          | 0.01 |    |
| 0.04059      | 66.0         | 0.06 |    | 0.03934      | 34.4         | 0.04 |    | 0.03385      | -29.5        | 0.13 |    | 0.00496      | -1.0         | 0.01 |    |
| 0.04113      | -15.5        | 0.01 |    | 0.03998      | -21.5        | 0.02 |    | 0.03438      | -15.7        | 0.05 |    | 0.00678      | 1.0          | 0.01 |    |
|              |              |      |    | 0.04057      | -15.3        | 0.01 |    | 0.03494      | 36.7         | 0.10 |    | 0.00831      | -0.5         | 0.00 |    |
|              |              |      |    | 0.04111      | 7.7          | 0.01 |    | 0.03553      | -46.8        | 0.10 |    | * 0.00868    | 0.           | 0.00 |    |
|              |              |      |    | 0.04162      | 13.6         | 0.01 |    | 0.03618      | 9.9          | 0.02 |    | * 0.02281    | -2.3         | 0.02 |    |
|              |              |      |    | 0.04210      | -8.4         | 0.00 |    | 0.03684      | -3.3         | 0.00 |    | 0.02383      | 10.1         | 0.09 |    |
|              |              |      |    | 0.04258      | 0.5          | 0.00 |    | 0.03780      | -12.9        | 0.01 |    | 0.02490      | 6.7          | 0.05 |    |
|              |              |      |    |              |              |      |    | 0.03858      | 10.9         | 0.01 |    | 0.02555      | 4.0          | 0.03 |    |
|              |              |      |    |              |              |      |    | 0.03928      | 29.4         | 0.02 |    | 0.02622      | -14.3        | 0.09 |    |
|              |              |      |    |              |              |      |    | 0.03992      | 17.4         | 0.01 |    | 0.02695      | -6.5         | 0.04 |    |
|              |              |      |    |              |              |      |    | 0.04051      | -1.8         | 0.00 |    | 0.02763      | 6.2          | 0.03 |    |
|              |              |      |    |              |              |      |    | 0.04105      | 1.1          | 0.00 |    | 0.02842      | -27.4        | 0.11 |    |
|              |              |      |    |              |              |      |    | 0.04157      | -10.5        | 0.00 |    | 0.02928      | 29.0         | 0.10 |    |
|              |              |      |    |              |              |      |    | 0.04205      | -52.6        | 0.02 |    | 0.03015      | -5.1         | 0.01 |    |
|              |              |      |    |              |              |      |    | 0.04253      | -27.0        | 0.01 |    | 0.03110      | 25.9         | 0.06 |    |
|              |              |      |    |              |              |      |    | 0.04296      | -2.5         | 0.00 |    | 0.03208      | -15.0        | 0.03 |    |
|              |              |      |    |              |              |      |    | 0.04340      | 47.1         | 0.02 |    | 0.03316      | -16.0        | 0.02 |    |
|              |              |      |    |              |              |      |    | 0.04377      | 94.8         | 0.03 |    | 0.03378      | 10.2         | 0.01 |    |
|              |              |      |    |              |              |      |    | 0.04414      | -81.9        | 0.02 |    | 0.03431      | -1.9         | 0.00 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.03487      | 10.1         | 0.01 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.03546      | -14.3        | 0.01 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.03611      | -33.2        | 0.03 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.03677      | 31.8         | 0.02 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.03773      | 11.9         | 0.01 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.03851      | 24.3         | 0.01 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.03921      | -46.8        | 0.02 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.03985      | 27.4         | 0.01 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.04044      | -9.4         | 0.00 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.04098      | -34.9        | 0.01 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.04150      | 12.6         | 0.00 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.04198      | 34.5         | 0.01 |    |
|              |              |      |    |              |              |      |    |              |              |      |    | 0.04246      | -20.0        | 0.01 |    |

| T = 33 DEG K |              |      | T = 40 DEG K |              |      | T = 50 DEG K |              |      | T = 70 DEG K |              |      |
|--------------|--------------|------|--------------|--------------|------|--------------|--------------|------|--------------|--------------|------|
| DENSITY      | DELTA        | P    | DENSITY      | DELTA        | P    | DENSITY      | DELTA        | P    | DENSITY      | DELTA        | P    |
| <sup>3</sup> | <sup>3</sup> | **   | <sup>3</sup> | <sup>3</sup> | **   | <sup>3</sup> | <sup>3</sup> | **   | <sup>3</sup> | <sup>3</sup> | **   |
| G MOL/CM     | ATMX10       | PCT  | G MOL/CM     | ATMX10       | PCT  | G MOL/CM     | ATMX10       | PCT  | G MOL/CM     | ATMX10       | PCT  |
| 0.00108      | 0.           | 0.00 | 0.00108      | 0.1          | 0.00 | 0.00108      | 0.           | 0.00 | 0.00107      | -0.2         | 0.00 |
| 0.00149      | -0.2         | 0.01 | 0.00149      | -0.2         | 0.00 | 0.00149      | 0.           | 0.00 | 0.00148      | 0.6          | 0.01 |
| 0.00215      | 0.           | 0.00 | 0.00215      | -0.1         | 0.00 | 0.00215      | 0.1          | 0.00 | 0.00214      | -0.4         | 0.00 |
| 0.00256      | 0.8          | 0.01 | 0.00256      | 0.4          | 0.01 | 0.00255      | 0.           | 0.00 | 0.00255      | -0.5         | 0.00 |
| 0.00333      | -1.1         | 0.02 | 0.00332      | -0.4         | 0.00 | 0.00332      | -0.6         | 0.01 | 0.00331      | 0.           | 0.00 |
| 0.00398      | 0.6          | 0.01 | 0.00397      | 1.4          | 0.01 | 0.00397      | 0.7          | 0.01 | 0.00396      | -0.5         | 0.00 |
| 0.00496      | -1.0         | 0.01 | 0.00496      | -1.2         | 0.01 | 0.00495      | 0.2          | 0.00 | 0.00494      | 1.0          | 0.00 |
| 0.00678      | 1.6          | 0.01 | 0.00677      | -0.8         | 0.01 | 0.00676      | -0.5         | 0.00 | 0.00675      | 1.9          | 0.01 |
| 0.00830      | -0.1         | 0.00 | 0.00830      | -1.3         | 0.01 | 0.00828      | -0.4         | 0.00 | 0.00826      | 0.5          | 0.00 |
| 0.01015      | -1.2         | 0.01 | 0.01013      | 5.7          | 0.03 | 0.01012      | 0.2          | 0.00 | 0.01009      | -3.7         | 0.01 |
| 0.01182      | -1.1         | 0.01 | 0.01180      | -0.2         | 0.00 | 0.01179      | 0.           | 0.00 | 0.01175      | -1.9         | 0.00 |
| 0.01410      | -1.3         | 0.01 | 0.01408      | -6.1         | 0.02 | 0.01409      | 0.1          | 0.00 | 0.01405      | -1.0         | 0.00 |
| 0.01513      | 0.4          | 0.00 | 0.01412      | -1.8         | 0.01 | 0.01509      | 2.4          | 0.01 | 0.01504      | 0.4          | 0.00 |
| 0.01552      | 2.5          | 0.02 | 0.01511      | 1.4          | 0.01 | 0.01635      | -0.5         | 0.00 | 0.01630      | 1.2          | 0.00 |
| 0.01640      | 2.2          | 0.02 | 0.01551      | -0.1         | 0.00 | 0.01806      | -2.4         | 0.00 | 0.01800      | 3.8          | 0.00 |
| 0.01812      | -1.4         | 0.01 | 0.01638      | -4.5         | 0.02 | 0.01974      | -0.6         | 0.00 | 0.01967      | 3.5          | 0.00 |
| 0.01980      | -11.7        | 0.09 | 0.01638      | 6.1          | 0.02 | 0.02064      | 1.2          | 0.00 | 0.02057      | 8.9          | 0.01 |
| 0.02070      | -7.4         | 0.06 | 0.01809      | 0.1          | 0.00 | 0.02155      | 0.3          | 0.00 | 0.02147      | -0.2         | 0.00 |
| 0.02162      | 1.9          | 0.01 | 0.01978      | 0.3          | 0.00 | 0.02264      | -1.4         | 0.00 | 0.02256      | -0.4         | 0.00 |
| 0.02272      | 8.5          | 0.06 | 0.02068      | 2.9          | 0.01 | 0.02374      | 5.5          | 0.01 | 0.02365      | -5.1         | 0.00 |
| 0.02383      | 10.2         | 0.07 | 0.02159      | 5.2          | 0.01 | 0.02480      | -19.5        | 0.02 | 0.02471      | -9.5         | 0.01 |
| 0.02489      | 17.0         | 0.10 | 0.02269      | 0.8          | 0.00 | 0.02545      | 4.2          | 0.00 | 0.02535      | -7.8         | 0.00 |
| 0.02554      | 8.2          | 0.04 | 0.02379      | -4.9         | 0.01 | 0.02611      | 7.4          | 0.01 | 0.02601      | -7.9         | 0.00 |
| 0.02621      | -24.7        | 0.12 | 0.02485      | 5.4          | 0.01 | 0.02684      | 2.9          | 0.00 | 0.02674      | -7.2         | 0.00 |
| 0.02694      | -17.6        | 0.08 | 0.02550      | -5.3         | 0.01 | 0.02752      | -29.8        | 0.03 | 0.02741      | -79.6        | 0.04 |
| 0.02762      | -5.7         | 0.02 | 0.02617      | -17.8        | 0.03 | 0.02830      | 71.4         | 0.06 | 0.02818      | 95.3         | 0.04 |
| 0.02841      | -25.9        | 0.09 | 0.02690      | -7.2         | 0.01 | 0.02916      | -6.9         | 0.01 | 0.02904      | 36.9         | 0.02 |
| 0.02928      | 24.4         | 0.07 | 0.02758      | 3.9          | 0.01 | 0.03002      | -9.3         | 0.01 | 0.02990      | 44.0         | 0.02 |
| 0.03014      | -2.0         | 0.00 | 0.02836      | 14.6         | 0.02 | 0.03096      | -39.8        | 0.03 | 0.03084      | -66.4        | 0.02 |
| 0.03109      | 21.6         | 0.04 | 0.02923      | 28.2         | 0.04 | 0.03194      | -9.2         | 0.01 | 0.03181      | 30.7         | 0.01 |
| 0.03207      | -3.1         | 0.01 | 0.03008      | 0.3          | 0.00 | 0.03301      | -59.2        | 0.03 | 0.03288      | -153.4       | 0.05 |
| 0.03315      | -24.3        | 0.03 | 0.03103      | -38.1        | 0.04 | 0.03363      | 75.4         | 0.04 | 0.03350      | 145.5        | 0.04 |
| 0.03377      | 21.0         | 0.03 | 0.03202      | 13.7         | 0.01 | 0.03416      | 50.9         | 0.02 | 0.03403      | -28.8        | 0.01 |
| 0.03430      | 3.2          | 0.00 | 0.03309      | -40.2        | 0.03 | 0.03472      | -59.7        | 0.03 |              |              |      |
| 0.03486      | -6.6         | 0.01 | 0.03371      | 49.2         | 0.04 | 0.03531      | 82.7         | 0.03 |              |              |      |
| 0.03545      | -3.9         | 0.00 | 0.03424      | 30.6         | 0.02 | 0.03595      | -34.6        | 0.01 |              |              |      |
| 0.03610      | -43.0        | 0.03 | 0.03480      | -39.6        | 0.03 | 0.03662      | -61.5        | 0.02 |              |              |      |
| 0.03676      | 25.0         | 0.02 | 0.03539      | 5.6          | 0.00 | 0.03757      | 30.3         | 0.01 |              |              |      |
| 0.03772      | 0.           | 0.00 | 0.03603      | -23.9        | 0.01 |              |              |      |              |              |      |
| 0.03850      | 8.1          | 0.00 | 0.03670      | 2.5          | 0.00 |              |              |      |              |              |      |
| 0.03920      | 26.9         | 0.01 | 0.03765      | 32.8         | 0.01 |              |              |      |              |              |      |
| 0.03984      | -28.0        | 0.01 | 0.03843      | 7.0          | 0.00 |              |              |      |              |              |      |
| 0.04043      | -31.4        | 0.01 | 0.03914      | -61.7        | 0.02 |              |              |      |              |              |      |
| 0.04097      | -28.1        | 0.01 | 0.03977      | 50.7         | 0.02 |              |              |      |              |              |      |
| 0.04149      | -58.4        | 0.02 | 0.04037      | -13.3        | 0.00 |              |              |      |              |              |      |
| 0.04197      | 13.6         | 0.00 |              |              |      |              |              |      |              |              |      |
| 0.04245      | -22.6        | 0.01 |              |              |      |              |              |      |              |              |      |

- SATURATION DENSITY
- ABSOLUTE VALUE

TABLE III. COEFFICIENTS  $A_i$  FOR ISOCHORES IN EQUATION (2)

| DENSITY | A1                          | A2                         | A3                          | A4                          | A5                       |
|---------|-----------------------------|----------------------------|-----------------------------|-----------------------------|--------------------------|
| 0.0005  | -8.0377310 $\times 10^{-7}$ | 4.1671141 $\times 10^{-2}$ | -5.7318471 $\times 10^{-2}$ | -3.4852970 $\times 10^{-1}$ | 1.0761355 $\times 10^0$  |
| 0.0010  | 1.2281445 $\times 10^{-6}$  | 8.3815085 $\times 10^{-2}$ | -1.8093034 $\times 10^{-1}$ | -2.3328599 $\times 10^0$    | 9.0125519 $\times 10^0$  |
| 0.0015  | -2.1059322 $\times 10^{-6}$ | 1.2820967 $\times 10^{-1}$ | -4.9784230 $\times 10^{-1}$ | -2.0682478 $\times 10^0$    | -1.6858820 $\times 10^1$ |
| 0.0020  | -3.8373024 $\times 10^{-6}$ | 1.7331713 $\times 10^{-1}$ | -8.8737394 $\times 10^{-1}$ | -3.2165717 $\times 10^0$    | -3.7102804 $\times 10^1$ |
| 0.0025  | -8.7732374 $\times 10^{-6}$ | 2.2031547 $\times 10^{-1}$ | -1.4439885 $\times 10^0$    | -2.6094543 $\times 10^0$    | -8.6642049 $\times 10^1$ |
| 0.0030  | -1.5259414 $\times 10^{-5}$ | 2.6879575 $\times 10^{-1}$ | -2.1308185 $\times 10^0$    | -1.2407244 $\times 10^0$    | -1.5703564 $\times 10^2$ |
| 0.0035  | -2.6335328 $\times 10^{-5}$ | 3.1955518 $\times 10^{-1}$ | -3.0135132 $\times 10^0$    | 3.2160865 $\times 10^0$     | -2.7513041 $\times 10^2$ |
| 0.0040  | -4.1334596 $\times 10^{-5}$ | 3.7255940 $\times 10^{-1}$ | -4.0968010 $\times 10^0$    | 1.1342612 $\times 10^1$     | -4.5130837 $\times 10^2$ |
| 0.0045  | -6.5248416 $\times 10^{-5}$ | 4.2889084 $\times 10^{-1}$ | -5.4553331 $\times 10^0$    | 2.5378825 $\times 10^1$     | -7.0776183 $\times 10^2$ |
| 0.0050  | -9.5611221 $\times 10^{-5}$ | 4.8814042 $\times 10^{-1}$ | -7.0653434 $\times 10^0$    | 4.4994254 $\times 10^1$     | -1.0446450 $\times 10^3$ |
| 0.0055  | -1.3180607 $\times 10^{-4}$ | 5.5015638 $\times 10^{-1}$ | -8.9079311 $\times 10^0$    | 6.9446852 $\times 10^1$     | -1.4487078 $\times 10^3$ |
| 0.0060  | -1.7026696 $\times 10^{-4}$ | 6.1401927 $\times 10^{-1}$ | -1.0891583 $\times 10^1$    | 9.5141850 $\times 10^1$     | -1.8692702 $\times 10^3$ |
| 0.0065  | -2.1873437 $\times 10^{-4}$ | 6.8175290 $\times 10^{-1}$ | -1.3194912 $\times 10^1$    | 1.2866170 $\times 10^2$     | -2.3880154 $\times 10^3$ |
| 0.0070  | -2.5922335 $\times 10^{-4}$ | 7.4882307 $\times 10^{-1}$ | -1.5409693 $\times 10^1$    | 1.5495204 $\times 10^2$     | -2.8067078 $\times 10^3$ |
| 0.0075  | -3.1173105 $\times 10^{-4}$ | 8.2030192 $\times 10^{-1}$ | -1.7982500 $\times 10^1$    | 1.9055501 $\times 10^2$     | -3.3410802 $\times 10^3$ |
| 0.0080  | -3.6397233 $\times 10^{-4}$ | 8.9316323 $\times 10^{-1}$ | -2.0641264 $\times 10^1$    | 2.2540166 $\times 10^2$     | -3.8559030 $\times 10^3$ |
| 0.0085  | -4.2257714 $\times 10^{-4}$ | 9.6889537 $\times 10^{-1}$ | -2.3494803 $\times 10^1$    | 2.6281975 $\times 10^2$     | -4.3843916 $\times 10^3$ |
| 0.0090  | -4.5541749 $\times 10^{-4}$ | 1.0395381 $\times 10^0$    | -2.5827529 $\times 10^1$    | 2.7566446 $\times 10^2$     | -4.5542515 $\times 10^3$ |
| 0.0095  | -5.0527305 $\times 10^{-4}$ | 1.1158471 $\times 10^0$    | -2.8601520 $\times 10^1$    | 3.0073723 $\times 10^2$     | -4.8694049 $\times 10^3$ |
| 0.0100  | -5.4852158 $\times 10^{-4}$ | 1.1918611 $\times 10^0$    | -3.1270310 $\times 10^1$    | 3.1701581 $\times 10^2$     | -5.0390446 $\times 10^3$ |
| 0.0105  | -5.8649584 $\times 10^{-4}$ | 1.2680118 $\times 10^0$    | -3.3868301 $\times 10^1$    | 3.2576079 $\times 10^2$     | -5.0769555 $\times 10^3$ |
| 0.0110  | -6.1718419 $\times 10^{-4}$ | 1.3436317 $\times 10^0$    | -3.6312903 $\times 10^1$    | 3.2333676 $\times 10^2$     | -4.9279847 $\times 10^3$ |
| 0.0115  | -6.4380987 $\times 10^{-4}$ | 1.4195863 $\times 10^0$    | -3.8676869 $\times 10^1$    | 3.1249379 $\times 10^2$     | -4.6275005 $\times 10^3$ |
| 0.0120  | -6.5827104 $\times 10^{-4}$ | 1.4938576 $\times 10^0$    | -4.0770123 $\times 10^1$    | 2.8602308 $\times 10^2$     | -4.0775766 $\times 10^3$ |
| 0.0125  | -6.5781804 $\times 10^{-4}$ | 1.5657673 $\times 10^0$    | -4.2521120 $\times 10^1$    | 2.4109665 $\times 10^2$     | -3.2393895 $\times 10^3$ |

TABLE III. COEFFICIENTS  $A_i$  FOR ISOCHORES IN EQUATION (2)-CONTINUED

| DENSITY | A1                          | A2                      | A3                       | A4                       | A5                       |
|---------|-----------------------------|-------------------------|--------------------------|--------------------------|--------------------------|
| 0.0130  | -6.4924148 $\times 10^{-4}$ | 1.6369293 $\times 10^0$ | -4.4057432 $\times 10^1$ | 1.8228715 $\times 10^2$  | -2.1710548 $\times 10^3$ |
| 0.0135  | -6.2883272 $\times 10^{-4}$ | 1.7064442 $\times 10^0$ | -4.5291856 $\times 10^1$ | 1.0647785 $\times 10^2$  | -8.3495872 $\times 10^2$ |
| 0.0140  | -5.9352177 $\times 10^{-4}$ | 1.7737101 $\times 10^0$ | -4.6171278 $\times 10^1$ | 1.1968543 $\times 10^1$  | 7.8810918 $\times 10^2$  |
| 0.0145  | -5.5021366 $\times 10^{-4}$ | 1.8403582 $\times 10^0$ | -4.6823811 $\times 10^1$ | -9.6472164 $\times 10^1$ | 2.6316170 $\times 10^3$  |
| 0.0150  | -4.9570493 $\times 10^{-4}$ | 1.9056878 $\times 10^0$ | -4.7185354 $\times 10^1$ | -2.2083220 $\times 10^2$ | 4.7142330 $\times 10^3$  |
| 0.0155  | -4.3643903 $\times 10^{-4}$ | 1.9713662 $\times 10^0$ | -4.7400820 $\times 10^1$ | -3.5521484 $\times 10^2$ | 6.9491255 $\times 10^3$  |
| 0.0160  | -3.7869989 $\times 10^{-4}$ | 2.0390411 $\times 10^0$ | -4.7608307 $\times 10^1$ | -4.9429203 $\times 10^2$ | 9.2604127 $\times 10^3$  |
| 0.0165  | -3.2988888 $\times 10^{-4}$ | 2.1107021 $\times 10^0$ | -4.7991765 $\times 10^1$ | -6.3011102 $\times 10^2$ | 1.1524025 $\times 10^4$  |
| 0.0170  | -2.9135311 $\times 10^{-4}$ | 2.1868961 $\times 10^0$ | -4.8607001 $\times 10^1$ | -7.5967443 $\times 10^2$ | 1.3685515 $\times 10^4$  |
| 0.0175  | -2.7009731 $\times 10^{-4}$ | 2.2692860 $\times 10^0$ | -4.9585045 $\times 10^1$ | -8.7793619 $\times 10^2$ | 1.5672403 $\times 10^4$  |
| 0.0180  | -2.7696572 $\times 10^{-4}$ | 2.3605869 $\times 10^0$ | -5.1154888 $\times 10^1$ | -9.7611348 $\times 10^2$ | 1.7362219 $\times 10^4$  |
| 0.0185  | -2.9812312 $\times 10^{-4}$ | 2.4577571 $\times 10^0$ | -5.3068125 $\times 10^1$ | -1.0620580 $\times 10^3$ | 1.8840761 $\times 10^4$  |
| 0.0190  | -3.5004592 $\times 10^{-4}$ | 2.5647236 $\times 10^0$ | -5.5648849 $\times 10^1$ | -1.1236298 $\times 10^3$ | 1.9943022 $\times 10^4$  |
| 0.0195  | -4.2455082 $\times 10^{-4}$ | 2.6795942 $\times 10^0$ | -5.8727770 $\times 10^1$ | -1.1665448 $\times 10^3$ | 2.0737451 $\times 10^4$  |
| 0.0200  | -5.2401202 $\times 10^{-4}$ | 2.8029003 $\times 10^0$ | -6.2332962 $\times 10^1$ | -1.1896026 $\times 10^3$ | 2.1205585 $\times 10^4$  |
| 0.0205  | -6.4125592 $\times 10^{-4}$ | 2.9331360 $\times 10^0$ | -6.6339776 $\times 10^1$ | -1.1965205 $\times 10^3$ | 2.1388423 $\times 10^4$  |
| 0.0210  | -7.8212495 $\times 10^{-4}$ | 3.0713863 $\times 10^0$ | -7.0798392 $\times 10^1$ | -1.1861179 $\times 10^3$ | 2.1278368 $\times 10^4$  |
| 0.0215  | -9.3448052 $\times 10^{-4}$ | 3.2149294 $\times 10^0$ | -7.5474072 $\times 10^1$ | -1.1663516 $\times 10^3$ | 2.0977596 $\times 10^4$  |
| 0.0220  | -1.0934784 $\times 10^{-3}$ | 3.3623746 $\times 10^0$ | -8.0216248 $\times 10^1$ | -1.1427383 $\times 10^3$ | 2.0559050 $\times 10^4$  |
| 0.0225  | -1.2559322 $\times 10^{-3}$ | 3.5129883 $\times 10^0$ | -8.4945172 $\times 10^1$ | -1.1180923 $\times 10^3$ | 2.0065004 $\times 10^4$  |
| 0.0230  | -1.3698538 $\times 10^{-3}$ | 3.6532274 $\times 10^0$ | -8.8378554 $\times 10^1$ | -1.1428658 $\times 10^3$ | 2.0212248 $\times 10^4$  |
| 0.0235  | -1.5478358 $\times 10^{-3}$ | 3.8122308 $\times 10^0$ | -9.3209590 $\times 10^1$ | -1.1103218 $\times 10^3$ | 1.9492025 $\times 10^4$  |
| 0.0240  | -1.7219023 $\times 10^{-3}$ | 3.9723517 $\times 10^0$ | -9.7775742 $\times 10^1$ | -1.0857529 $\times 10^3$ | 1.8829911 $\times 10^4$  |
| 0.0245  | -1.8920438 $\times 10^{-3}$ | 4.1335542 $\times 10^0$ | -1.0205513 $\times 10^2$ | -1.0696396 $\times 10^3$ | 1.8237987 $\times 10^4$  |
| 0.0250  | -2.0561721 $\times 10^{-3}$ | 4.2953206 $\times 10^0$ | -1.0598185 $\times 10^2$ | -1.0641185 $\times 10^3$ | 1.7749108 $\times 10^4$  |

TABLE III. COEFFICIENTS  $A_i$  FOR ISOCHORES IN EQUATION (2)-CONTINUED

| DENSITY | A1                          | A2                      | A3                       | A4                       | A5                       |
|---------|-----------------------------|-------------------------|--------------------------|--------------------------|--------------------------|
| 0.0255  | -2.2143473 $\times 10^{-3}$ | 4.4572955 $\times 10^0$ | -1.0947043 $\times 10^2$ | -1.0733223 $\times 10^3$ | 1.7442580 $\times 10^4$  |
| 0.0260  | -2.4177387 $\times 10^{-3}$ | 4.6326102 $\times 10^0$ | -1.1370972 $\times 10^2$ | -1.0504141 $\times 10^3$ | 1.6669838 $\times 10^4$  |
| 0.0265  | -2.6272401 $\times 10^{-3}$ | 4.8109381 $\times 10^0$ | -1.1770864 $\times 10^2$ | -1.0340018 $\times 10^3$ | 1.5978421 $\times 10^4$  |
| 0.0270  | -2.8467149 $\times 10^{-3}$ | 4.9917539 $\times 10^0$ | -1.2139729 $\times 10^2$ | -1.0264770 $\times 10^3$ | 1.5412988 $\times 10^4$  |
| 0.0275  | -2.9235301 $\times 10^{-3}$ | 5.1482192 $\times 10^0$ | -1.2287832 $\times 10^2$ | -1.0823485 $\times 10^3$ | 1.5529079 $\times 10^4$  |
| 0.0280  | -3.2097408 $\times 10^{-3}$ | 5.3505627 $\times 10^0$ | -1.2737635 $\times 10^2$ | -1.0365624 $\times 10^3$ | 1.4476561 $\times 10^4$  |
| 0.0285  | -3.4133869 $\times 10^{-3}$ | 5.5385032 $\times 10^0$ | -1.3032203 $\times 10^2$ | -1.0349302 $\times 10^3$ | 1.3941732 $\times 10^4$  |
| 0.0290  | -3.4292715 $\times 10^{-3}$ | 5.6917803 $\times 10^0$ | -1.3031157 $\times 10^2$ | -1.1172453 $\times 10^3$ | 1.4340021 $\times 10^4$  |
| 0.0295  | -4.0583221 $\times 10^{-3}$ | 5.9679756 $\times 10^0$ | -1.3843027 $\times 10^2$ | -9.5022563 $\times 10^2$ | 1.2070660 $\times 10^4$  |
| 0.0300  | -4.0351868 $\times 10^{-3}$ | 6.1196071 $\times 10^0$ | -1.3730741 $\times 10^2$ | -1.0518802 $\times 10^3$ | 1.2720182 $\times 10^4$  |
| 0.0305  | -5.2023678 $\times 10^{-3}$ | 6.4955823 $\times 10^0$ | -1.5065102 $\times 10^2$ | -7.3317710 $\times 10^2$ | 9.0641995 $\times 10^3$  |
| 0.0310  | -5.5757572 $\times 10^{-3}$ | 6.7236159 $\times 10^0$ | -1.5333181 $\times 10^2$ | -7.1729678 $\times 10^2$ | 8.6428251 $\times 10^3$  |
| 0.0315  | -6.2069722 $\times 10^{-3}$ | 7.0008332 $\times 10^0$ | -1.5864047 $\times 10^2$ | -6.1916306 $\times 10^2$ | 7.4271301 $\times 10^3$  |
| 0.0320  | -6.8678927 $\times 10^{-3}$ | 7.2845818 $\times 10^0$ | -1.6366492 $\times 10^2$ | -5.2271128 $\times 10^2$ | 6.3105084 $\times 10^3$  |
| 0.0325  | -7.1803709 $\times 10^{-3}$ | 7.5091781 $\times 10^0$ | -1.6426362 $\times 10^2$ | -5.3825987 $\times 10^2$ | 6.3673451 $\times 10^3$  |
| 0.0330  | -7.6073285 $\times 10^{-3}$ | 7.7573489 $\times 10^0$ | -1.6578472 $\times 10^2$ | -5.1531466 $\times 10^2$ | 6.0708932 $\times 10^3$  |
| 0.0335  | -7.9515444 $\times 10^{-3}$ | 7.9939722 $\times 10^0$ | -1.6593847 $\times 10^2$ | -5.1639302 $\times 10^2$ | 6.0532802 $\times 10^3$  |
| 0.0340  | -9.1273819 $\times 10^{-3}$ | 8.3571042 $\times 10^0$ | -1.7221788 $\times 10^2$ | -3.6579871 $\times 10^2$ | 4.8294821 $\times 10^3$  |
| 0.0345  | -9.5657506 $\times 10^{-3}$ | 8.6083924 $\times 10^0$ | -1.7159915 $\times 10^2$ | -3.6543501 $\times 10^2$ | 4.9320575 $\times 10^3$  |
| 0.0350  | -1.1015059 $\times 10^{-2}$ | 9.0096826 $\times 10^0$ | -1.7825786 $\times 10^2$ | -1.8416297 $\times 10^2$ | 3.5624987 $\times 10^3$  |
| 0.0355  | -1.1959132 $\times 10^{-2}$ | 9.3389942 $\times 10^0$ | -1.8042763 $\times 10^2$ | -8.7846858 $\times 10^1$ | 2.9059444 $\times 10^3$  |
| 0.0360  | -1.3886189 $\times 10^{-2}$ | 9.8044979 $\times 10^0$ | -1.8864278 $\times 10^2$ | 1.5419294 $\times 10^2$  | 1.1351017 $\times 10^3$  |
| 0.0365  | -1.5565519 $\times 10^{-2}$ | 1.0229200 $\times 10^1$ | -1.9410328 $\times 10^2$ | 3.5588009 $\times 10^2$  | -3.1705787 $\times 10^2$ |
| 0.0370  | -1.7400006 $\times 10^{-2}$ | 1.0686035 $\times 10^1$ | -2.0004923 $\times 10^2$ | 5.7942490 $\times 10^2$  | -1.8692257 $\times 10^3$ |
| 0.0375  | -2.0124586 $\times 10^{-2}$ | 1.1241795 $\times 10^1$ | -2.0932852 $\times 10^2$ | 8.7722455 $\times 10^2$  | -3.8552011 $\times 10^3$ |

TABLE III. COEFFICIENTS  $A_i$  FOR ISOCHORES IN EQUATION (2)-CONTINUED

| DENSITY | A1                          | A2                      | A3                       | A4                       | A5                       |
|---------|-----------------------------|-------------------------|--------------------------|--------------------------|--------------------------|
| 0.0380  | $-2.2408441 \times 10^{-2}$ | $1.1740489 \times 10^1$ | $-2.1504047 \times 10^2$ | $1.1212214 \times 10^3$  | $-5.4197643 \times 10^3$ |
| 0.0385  | $-2.3066439 \times 10^{-2}$ | $1.2016333 \times 10^1$ | $-2.0928329 \times 10^2$ | $1.1541824 \times 10^3$  | $-5.4462613 \times 10^3$ |
| 0.0390  | $-2.3612257 \times 10^{-2}$ | $1.2275667 \times 10^1$ | $-2.0118944 \times 10^2$ | $1.1518611 \times 10^3$  | $-5.1573924 \times 10^3$ |
| 0.0395  | $-2.1131850 \times 10^{-2}$ | $1.2205924 \times 10^1$ | $-1.7942589 \times 10^2$ | $9.4203092 \times 10^2$  | $-3.6215951 \times 10^3$ |
| 0.0400  | $-1.5787078 \times 10^{-2}$ | $1.1833711 \times 10^1$ | $-1.4498536 \times 10^2$ | $5.4030442 \times 10^2$  | $-9.1656659 \times 10^2$ |
| 0.0405  | $-7.2297747 \times 10^{-3}$ | $1.1143704 \times 10^1$ | $-9.8067031 \times 10^1$ | $-3.5545003 \times 10^1$ | $2.7670921 \times 10^3$  |
| 0.0410  | $-1.1157932 \times 10^{-2}$ | $1.1728386 \times 10^1$ | $-9.7440413 \times 10^1$ | $1.5041468 \times 10^2$  | $2.0174573 \times 10^3$  |
| 0.0415  | $2.0572108 \times 10^{-4}$  | $1.0774412 \times 10^1$ | $-3.8944428 \times 10^1$ | $-5.6987252 \times 10^2$ | $6.5948069 \times 10^3$  |
| 0.0420  | $9.1201507 \times 10^{-3}$  | $1.0186019 \times 10^1$ | $2.2018214 \times 10^0$  | $-8.9772310 \times 10^2$ | $8.2338889 \times 10^3$  |
| 0.0425  | $-3.6886842 \times 10^{-2}$ | $1.4999411 \times 10^1$ | $-1.5324378 \times 10^2$ | $1.9715175 \times 10^3$  | $-9.3307466 \times 10^3$ |
| 0.0430  | $-2.5967306 \times 10^{-1}$ | $3.7406308 \times 10^1$ | $-9.6215597 \times 10^2$ | $1.5643871 \times 10^4$  | $-9.3572403 \times 10^4$ |
| 0.0435  | $2.0399673 \times 10^{-2}$  | $1.0508182 \times 10^1$ | $3.6778774 \times 10^1$  |                          |                          |
| 0.0440  | $4.1266163 \times 10^{-2}$  | $9.6191112 \times 10^0$ | $7.2762252 \times 10^1$  |                          |                          |
| 0.0445  | $6.8570651 \times 10^{-2}$  | $8.3929369 \times 10^0$ | $1.1458652 \times 10^2$  |                          |                          |
| 0.0450  | $1.4766631 \times 10^{-1}$  | $4.3831287 \times 10^0$ | $1.9525322 \times 10^2$  |                          |                          |

TABLE IV. REPRESENTATIVE DEVIATIONS FOR SELECTED ISDCHOSES

| DENSITY = 0.0050 |                     |      |    | DENSITY = 0.0100 |                     |      |    | DENSITY = 0.0150 |                     |      |    | DENSITY = 0.0200 |                     |      |    |
|------------------|---------------------|------|----|------------------|---------------------|------|----|------------------|---------------------|------|----|------------------|---------------------|------|----|
| T                | DELTA               | P    | ** | T                | DELTA               | P    | ** | T                | DELTA               | P    | ** | T                | DELTA               | P    | ** |
| DEG-K            | ATMX10 <sup>3</sup> | PCT  |    | DEG-K            | ATMX10 <sup>3</sup> | PCT  |    | DEG-K            | ATMX10 <sup>3</sup> | PCT  |    | DEG-K            | ATMX10 <sup>3</sup> | PCT  |    |
| * 29.626         | -1                  | 0.01 |    | * 32.430         | -12                 | 0.10 |    | * 32.975         | 3                   | 0.02 |    | * 32.707         | 33                  | 0.27 |    |
| 30.              | -1                  | 0.01 |    | 33.              | -1                  | 0.01 |    | 33.              | 0                   | 0.00 |    | 33.              | 31                  | 0.24 |    |
| 31.              | -1                  | 0.01 |    | 34.              | 6                   | 0.05 |    | 34.              | -1                  | 0.01 |    | 34.              | -29                 | 0.18 |    |
| 32.              | 1                   | 0.01 |    | 35.              | 8                   | 0.05 |    | 35.              | -3                  | 0.02 |    | 35.              | -35                 | 0.19 |    |
| 33.              | 1                   | 0.01 |    | 36.              | 6                   | 0.04 |    | 36.              | -2                  | 0.01 |    | 36.              | -29                 | 0.14 |    |
| 34.              | 1                   | 0.01 |    | 37.              | 4                   | 0.02 |    | 37.              | -2                  | 0.01 |    | 37.              | -17                 | 0.07 |    |
| 35.              | 1                   | 0.01 |    | 38.              | 2                   | 0.01 |    | 38.              | 0                   | 0.00 |    | 38.              | -6                  | 0.02 |    |
| 36.              | 0                   | 0.00 |    | 39.              | 0                   | 0.00 |    | 39.              | 0                   | 0.00 |    | 39.              | 3                   | 0.01 |    |
| 37.              | 0                   | 0.00 |    | 40.              | -1                  | 0.01 |    | 40.              | 2                   | 0.01 |    | 40.              | 6                   | 0.02 |    |
| 38.              | 0                   | 0.00 |    | 42.              | -7                  | 0.03 |    | 42.              | 6                   | 0.02 |    | 42.              | 20                  | 0.05 |    |
| 39.              | -1                  | 0.00 |    | 44.              | -6                  | 0.02 |    | 44.              | 3                   | 0.01 |    | 44.              | 26                  | 0.06 |    |
| 40.              | 0                   | 0.00 |    | 46.              | -5                  | 0.02 |    | 46.              | -4                  | 0.01 |    | 46.              | 16                  | 0.03 |    |
| 42.              | 0                   | 0.00 |    | 48.              | -5                  | 0.02 |    | 48.              | -2                  | 0.00 |    | 48.              | 12                  | 0.02 |    |
| 44.              | -2                  | 0.01 |    | 50.              | -1                  | 0.00 |    | 50.              | -2                  | 0.00 |    | 50.              | 5                   | 0.01 |    |
| 46.              | -1                  | 0.01 |    | 55.              | 4                   | 0.01 |    | 55.              | 0                   | 0.00 |    | 55.              | -10                 | 0.01 |    |
| 48.              | -1                  | 0.01 |    | 60.              | 4                   | 0.01 |    | 60.              | -4                  | 0.01 |    | 60.              | -27                 | 0.03 |    |
| 50.              | -1                  | 0.00 |    | 65.              | 9                   | 0.02 |    | 65.              | 3                   | 0.00 |    | 65.              | -11                 | 0.01 |    |
| 55.              | 1                   | 0.01 |    | 70.              | 7                   | 0.01 |    | 70.              | 8                   | 0.01 |    | 70.              | 1                   | 0.00 |    |
| 60.              | 0                   | 0.00 |    | 75.              | -8                  | 0.01 |    | 75.              | 0                   | 0.00 |    | 75.              | 0                   | 0.00 |    |
| 65.              | 3                   | 0.01 |    | 80.              | -10                 | 0.02 |    | 80.              | -4                  | 0.00 |    | 80.              | -9                  | 0.01 |    |
| 70.              | 2                   | 0.01 |    | 85.              | -4                  | 0.01 |    | 85.              | -6                  | 0.01 |    | 85.              | 4                   | 0.00 |    |
| 75.              | -2                  | 0.01 |    | 90.              | 7                   | 0.01 |    | 90.              | -1                  | 0.00 |    | 90.              | 33                  | 0.02 |    |
| 80.              | -2                  | 0.01 |    | 95.              | 2                   | 0.00 |    | 95.              | 10                  | 0.01 |    | 95.              | 4                   | 0.00 |    |
| 85.              | -4                  | 0.01 |    | 100.             | -1                  | 0.00 |    | 100.             | -4                  | 0.00 |    | 100.             | -20                 | 0.01 |    |
| 90.              | 1                   | 0.00 |    |                  |                     |      |    |                  |                     |      |    |                  |                     |      |    |
| 95.              | 3                   | 0.01 |    |                  |                     |      |    |                  |                     |      |    |                  |                     |      |    |
| 100.             | -1                  | 0.00 |    |                  |                     |      |    |                  |                     |      |    |                  |                     |      |    |

| DENSITY = 0.0250 |                     |      |    | DENSITY = 0.0300 |                     |      |    | DENSITY = 0.0350 |                     |      |    | DENSITY = 0.0400 |                     |      |    |
|------------------|---------------------|------|----|------------------|---------------------|------|----|------------------|---------------------|------|----|------------------|---------------------|------|----|
| T                | DELTA               | P    | ** | T                | DELTA               | P    | ** | T                | DELTA               | P    | ** | T                | DELTA               | P    | ** |
| DEG-K            | ATMX10 <sup>3</sup> | PCT  |    | DEG-K            | ATMX10 <sup>3</sup> | PCT  |    | DEG-K            | ATMX10 <sup>3</sup> | PCT  |    | DEG-K            | ATMX10 <sup>3</sup> | PCT  |    |
| * 31.050         | 30                  | 0.31 |    | * 27.270         | -31                 | 0.60 |    | * 20.469         | 10                  | 0.91 |    | * 16.013         | 14                  | 0.02 |    |
| 32.              | -2                  | 0.02 |    | 28.              | 7                   | 0.08 |    | 21.              | -17                 | 0.32 |    | 17.              | 4                   | 0.00 |    |
| 33.              | -25                 | 0.14 |    | 29.              | 24                  | 0.15 |    | 22.              | 2                   | 0.01 |    | 18.              | -58                 | 0.06 |    |
| 34.              | -17                 | 0.08 |    | 30.              | 7                   | 0.03 |    | 23.              | -14                 | 0.06 |    | 19.              | 13                  | 0.01 |    |
| 35.              | -10                 | 0.04 |    | 31.              | 9                   | 0.03 |    | 24.              | 5                   | 0.02 |    | 20.              | 33                  | 0.03 |    |
| 36.              | -5                  | 0.02 |    | 32.              | 7                   | 0.02 |    | 25.              | 21                  | 0.05 |    | 21.              | 1                   | 0.00 |    |
| 37.              | 0                   | 0.00 |    | 33.              | 4                   | 0.01 |    | 26.              | 20                  | 0.04 |    | 22.              | 16                  | 0.01 |    |
| 38.              | 5                   | 0.01 |    | 34.              | -8                  | 0.02 |    | 27.              | 7                   | 0.01 |    | 23.              | -14                 | 0.01 |    |
| 39.              | 8                   | 0.02 |    | 35.              | -9                  | 0.02 |    | 28.              | 11                  | 0.02 |    | 24.              | -9                  | 0.01 |    |
| 40.              | 13                  | 0.03 |    | 36.              | -5                  | 0.01 |    | 29.              | -4                  | 0.01 |    | 25.              | -7                  | 0.00 |    |
| 42.              | 13                  | 0.02 |    | 37.              | -2                  | 0.00 |    | 30.              | -10                 | 0.01 |    | 26.              | -2                  | 0.00 |    |
| 44.              | 5                   | 0.01 |    | 38.              | 0                   | 0.00 |    | 31.              | -22                 | 0.03 |    | 27.              | 17                  | 0.01 |    |
| 46.              | 3                   | 0.00 |    | 39.              | -2                  | 0.00 |    | 32.              | -28                 | 0.03 |    | 28.              | 11                  | 0.01 |    |
| 48.              | -2                  | 0.00 |    | 40.              | -6                  | 0.01 |    | 33.              | -6                  | 0.01 |    | 29.              | 11                  | 0.01 |    |
| 50.              | -7                  | 0.01 |    | 42.              | -8                  | 0.01 |    | 34.              | -22                 | 0.02 |    | 30.              | 21                  | 0.01 |    |
| 55.              | -2                  | 0.00 |    | 44.              | 0                   | 0.00 |    | 35.              | -9                  | 0.01 |    | 31.              | -29                 | 0.01 |    |
| 60.              | -10                 | 0.01 |    | 46.              | -8                  | 0.01 |    | 36.              | 3                   | 0.00 |    | 32.              | -49                 | 0.02 |    |
| 65.              | 3                   | 0.00 |    | 48.              | 5                   | 0.00 |    | 37.              | 3                   | 0.00 |    | 33.              | -24                 | 0.01 |    |
| 70.              | 16                  | 0.01 |    | 50.              | 5                   | 0.00 |    | 38.              | 17                  | 0.01 |    | 34.              | 9                   | 0.00 |    |
| 75.              | -18                 | 0.01 |    | 55.              | 5                   | 0.00 |    | 39.              | 17                  | 0.01 |    | 35.              | 25                  | 0.01 |    |
| 80.              | -19                 | 0.01 |    | 60.              | -4                  | 0.00 |    | 40.              | 32                  | 0.02 |    | 36.              | 13                  | 0.00 |    |
| 85.              | -1                  | 0.00 |    | 65.              | 31                  | 0.01 |    | 42.              | 23                  | 0.01 |    | 37.              | 13                  | 0.00 |    |
| 90.              | 28                  | 0.01 |    | 70.              | 15                  | 0.01 |    | 44.              | -4                  | 0.00 |    | 38.              | -12                 | 0.00 |    |
| 95.              | 20                  | 0.01 |    | 75.              | -13                 | 0.00 |    | 46.              | -1                  | 0.00 |    | 39.              | -3                  | 0.00 |    |
| 100.             | -24                 | 0.01 |    | 80.              | -68                 | 0.02 |    | 48.              | -25                 | 0.01 |    | 40.              | 31                  | 0.01 |    |
|                  |                     |      |    | 85.              | 46                  | 0.01 |    | 50.              | -10                 | 0.00 |    | 42.              | -24                 | 0.01 |    |
|                  |                     |      |    |                  |                     |      |    | 55.              | -8                  | 0.00 |    |                  |                     |      |    |
|                  |                     |      |    |                  |                     |      |    | 60.              | 11                  | 0.00 |    |                  |                     |      |    |

\* SATURATION TEMPERATURE  
 \*\* ABSOLUTE VALUE

TABLE IX. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, SATURATED LIQUID AND SATURATED VAPOR \*

| TEMPERATURE<br>DEG. KELVIN | PRESSURE<br>ATM    | VOLUME<br>CM <sup>3</sup> /GMOL F | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_p$<br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|-----------------------------------|------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 13.803                     | 0.069 <sub>5</sub> | 26.17                             | 23328.                                                                             | 9.403                                                          | -622.9                        | -622.7              | 10.00                | 9.50                                  | 13.13                                 | 1273                              |
| 13.803                     | 0.069 <sub>5</sub> | 16056.81                          | 1098.                                                                              | 0.005                                                          | 169.8                         | 282.8               | 75.63                | 12.52                                 | 21.20                                 | 305                               |
| 14.                        | 0.077 <sub>8</sub> | 26.23                             | 22864.                                                                             | 9.370                                                          | -620.3                        | -620.1              | 10.19                | 9.56                                  | 13.31                                 | 1264                              |
| 14.                        | 0.077 <sub>8</sub> | 14519.41                          | 1110.                                                                              | 0.006                                                          | 172.0                         | 286.5               | 74.96                | 12.52                                 | 21.24                                 | 307                               |
| 15.                        | 0.133              | 26.53                             | 21360.                                                                             | 9.132                                                          | -606.5                        | -606.2              | 11.14                | 9.90                                  | 14.08                                 | 1235                              |
| 15.                        | 0.133              | 9049.48                           | 1170.                                                                              | 0.009                                                          | 182.9                         | 304.6               | 71.86                | 12.58                                 | 21.51                                 | 317                               |
| 16.                        | 0.213              | 26.84                             | 19950.                                                                             | 8.919                                                          | -592.0                        | -591.4              | 12.08                | 10.26                                 | 14.92                                 | 1207                              |
| 16.                        | 0.213              | 5955.49                           | 1223.                                                                              | 0.014                                                          | 193.2                         | 321.7               | 69.15                | 12.65                                 | 21.87                                 | 325                               |
| 17.                        | 0.325              | 27.18                             | 18327.                                                                             | 8.746                                                          | -576.6                        | -575.7              | 13.01                | 10.61                                 | 15.92                                 | 1175                              |
| 17.                        | 0.325              | 4096.06                           | 1267.                                                                              | 0.020                                                          | 202.9                         | 337.8               | 66.75                | 12.74                                 | 22.31                                 | 333                               |
| 18.                        | 0.476              | 27.54                             | 16910.                                                                             | 8.589                                                          | -560.2                        | -558.9              | 13.95                | 10.94                                 | 16.98                                 | 1148                              |
| 18.                        | 0.476              | 2920.83                           | 1302.                                                                              | 0.029                                                          | 211.9                         | 352.7               | 64.60                | 12.84                                 | 22.86                                 | 341                               |
| 19.                        | 0.673              | 27.93                             | 15663.                                                                             | 8.423                                                          | -542.9                        | -541.0              | 14.88                | 11.24                                 | 18.05                                 | 1124                              |
| 19.                        | 0.673              | 2145.87                           | 1326.                                                                              | 0.040                                                          | 220.0                         | 366.2               | 62.64                | 12.96                                 | 23.51                                 | 347                               |
| 20.                        | 0.923              | 28.36                             | 14525.                                                                             | 8.252                                                          | -524.6                        | -521.9              | 15.83                | 11.51                                 | 19.15                                 | 1102                              |
| 20.                        | 0.923              | 1616.07                           | 1340.                                                                              | 0.053                                                          | 227.2                         | 378.3               | 60.85                | 13.08                                 | 24.28                                 | 353                               |
| 20.268                     | 1.000              | 28.48                             | 14091.                                                                             | 8.204                                                          | -519.5                        | -516.6              | 16.08                | 11.57                                 | 19.53                                 | 1093                              |
| 20.268                     | 1.000              | 1506.86                           | 1343.                                                                              | 0.057                                                          | 229.0                         | 381.7               | 60.41                | 13.11                                 | 24.50                                 | 355                               |
| 21.                        | 1.233              | 28.82                             | 13123.                                                                             | 8.057                                                          | -505.1                        | -501.5              | 16.78                | 11.74                                 | 20.49                                 | 1072                              |
| 21.                        | 1.233              | 1245.28                           | 1344.                                                                              | 0.070                                                          | 233.5                         | 389.1               | 59.21                | 13.20                                 | 25.18                                 | 358                               |
| 22.                        | 1.613              | 29.34                             | 11914.                                                                             | 7.842                                                          | -484.5                        | -479.7              | 17.74                | 11.94                                 | 21.84                                 | 1046                              |
| 22.                        | 1.613              | 973.39                            | 1333.                                                                              | 0.090                                                          | 238.5                         | 397.6               | 57.64                | 13.33                                 | 26.27                                 | 363                               |
| 23.                        | 2.069              | 29.90                             | 10507.                                                                             | 7.583                                                          | -462.6                        | -456.3              | 18.72                | 12.11                                 | 23.51                                 | 1012                              |
| 23.                        | 2.069              | 771.82                            | 1310.                                                                              | 0.115                                                          | 242.3                         | 404.2               | 56.15                | 13.46                                 | 27.59                                 | 367                               |
| 24.                        | 2.611              | 30.54                             | 9273.                                                                              | 7.291                                                          | -439.3                        | -431.2              | 19.72                | 12.25                                 | 25.25                                 | 980                               |
| 24.                        | 2.611              | 619.37                            | 1272.                                                                              | 0.146                                                          | 244.7                         | 408.5               | 54.73                | 13.59                                 | 29.22                                 | 370                               |
| 25.                        | 3.245              | 31.26                             | 8021.                                                                              | 6.965                                                          | -414.5                        | -404.2              | 20.74                | 12.37                                 | 27.35                                 | 943                               |
| 25.                        | 3.245              | 501.85                            | 1219.                                                                              | 0.183                                                          | 245.4                         | 410.4               | 53.34                | 13.74                                 | 31.28                                 | 373                               |
| 26.                        | 3.982              | 32.08                             | 6810.                                                                              | 6.591                                                          | -387.9                        | -374.9              | 21.79                | 12.49                                 | 29.79                                 | 903                               |
| 26.                        | 3.982              | 409.62                            | 1149.                                                                              | 0.228                                                          | 244.1                         | 409.4               | 51.98                | 13.90                                 | 33.98                                 | 375                               |
| 27.                        | 4.829              | 33.04                             | 5613.                                                                              | 6.182                                                          | -359.3                        | -343.1              | 22.89                | 12.61                                 | 32.94                                 | 858                               |
| 27.                        | 4.829              | 336.00                            | 1061.                                                                              | 0.284                                                          | 240.5                         | 404.9               | 50.61                | 14.09                                 | 37.62                                 | 377                               |
| 28.                        | 5.794              | 34.19                             | 4425.                                                                              | 5.736                                                          | -328.3                        | -308.2              | 24.04                | 12.74                                 | 37.39                                 | 807                               |
| 28.                        | 5.794              | 276.24                            | 954.                                                                               | 0.354                                                          | 234.0                         | 396.1               | 49.21                | 14.34                                 | 42.82                                 | 378                               |
| 29.                        | 6.887              | 35.59                             | 3339.                                                                              | 5.253                                                          | -294.2                        | -269.3              | 25.27                | 12.89                                 | 43.64                                 | 753                               |
| 29.                        | 6.887              | 226.85                            | 823.                                                                               | 0.443                                                          | 223.7                         | 382.0               | 47.74                | 14.67                                 | 50.79                                 | 378                               |
| 30.                        | 8.118              | 37.38                             | 2300.                                                                              | 4.720                                                          | -255.9                        | -225.1              | 26.61                | 13.07                                 | 54.20                                 | 692                               |
| 30.                        | 8.118              | 185.17                            | 665.                                                                               | 0.561                                                          | 208.1                         | 360.4               | 46.14                | 15.12                                 | 64.50                                 | 377                               |
| 31.                        | 9.501              | 39.85                             | 1376.                                                                              | 4.118                                                          | -211.3                        | -172.9              | 28.15                | 13.33                                 | 74.81                                 | 623                               |
| 31.                        | 9.501              | 148.88                            | 471.                                                                               | 0.727                                                          | 184.4                         | 327.7               | 44.30                | 15.77                                 | 93.87                                 | 375                               |
| 32.                        | 11.051             | 43.83                             | 593.                                                                               | 3.393                                                          | -154.4                        | -105.3              | 30.08                | 13.79                                 | 134.66                                | 539                               |
| 32.                        | 11.051             | 115.21                            | 256.                                                                               | 0.977                                                          | 145.3                         | 274.3               | 41.95                | 16.47                                 | 176.84                                | 371                               |
| 32.976                     | 12.759             | 64.14                             |                                                                                    | 1.874                                                          | -5.3                          | 77.6                | 35.42                | 19.88                                 |                                       | 349                               |
| 32.976                     | 12.759             | 64.14                             |                                                                                    | 1.874                                                          | -6.2                          | 76.7                | 35.40                | 19.66                                 |                                       | 351                               |

\* THE FIRST ENTRY FOR EACH TEMPERATURE PERTAINS TO THE SATURATED LIQUID

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBAR

0.07 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATH/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>v</sub> HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|----------------------------------------------|----------------------------------------------|-----------------------------------|
| * 13.816                   | 26.18                            | 23125.                                                                                              | 9.400                                                                       | -622.7                        | -622.6              | 10.01                | 9.50                                         | 13.17                                        | 1269                              |
| * 13.816                   | 15949.                           | 1098.                                                                                               | 0.005                                                                       | 170.0                         | 283.1               | 75.58                | 12.52                                        | 21.20                                        | 306                               |
| 14                         | 16167.                           | 1114.                                                                                               | 0.005                                                                       | 172.3                         | 287.0               | 75.86                | 12.51                                        | 21.19                                        | 308                               |
| 15                         | 17362.                           | 1200.                                                                                               | 0.005                                                                       | 185.0                         | 308.1               | 77.32                | 12.50                                        | 21.11                                        | 319                               |
| 16                         | 18554.                           | 1285.                                                                                               | 0.004                                                                       | 197.6                         | 329.2               | 78.68                | 12.50                                        | 21.06                                        | 330                               |
| 17                         | 19743.                           | 1369.                                                                                               | 0.004                                                                       | 210.2                         | 350.3               | 79.96                | 12.49                                        | 21.03                                        | 340                               |
| 18                         | 20930.                           | 1454.                                                                                               | 0.004                                                                       | 222.8                         | 371.3               | 81.16                | 12.49                                        | 21.00                                        | 350                               |
| 19                         | 22114.                           | 1537.                                                                                               | 0.004                                                                       | 235.4                         | 392.3               | 82.29                | 12.49                                        | 20.97                                        | 360                               |
| 20                         | 23298.                           | 1621.                                                                                               | 0.004                                                                       | 248.0                         | 413.2               | 83.37                | 12.49                                        | 20.95                                        | 370                               |
| 21                         | 24480.                           | 1704.                                                                                               | 0.003                                                                       | 260.5                         | 434.2               | 84.39                | 12.49                                        | 20.93                                        | 379                               |
| 22                         | 25661.                           | 1787.                                                                                               | 0.003                                                                       | 273.1                         | 455.1               | 85.36                | 12.49                                        | 20.92                                        | 388                               |
| 23                         | 26842.                           | 1870.                                                                                               | 0.003                                                                       | 285.6                         | 476.0               | 86.29                | 12.48                                        | 20.91                                        | 397                               |
| 24                         | 28021.                           | 1954.                                                                                               | 0.003                                                                       | 298.2                         | 496.9               | 87.18                | 12.48                                        | 20.90                                        | 405                               |
| 25                         | 29200.                           | 2037.                                                                                               | 0.003                                                                       | 310.7                         | 517.8               | 88.04                | 12.48                                        | 20.89                                        | 414                               |
| 26                         | 30379.                           | 2119.                                                                                               | 0.003                                                                       | 323.2                         | 538.7               | 88.86                | 12.48                                        | 20.88                                        | 422                               |
| 27                         | 31557.                           | 2202.                                                                                               | 0.003                                                                       | 335.7                         | 559.6               | 89.64                | 12.48                                        | 20.87                                        | 430                               |
| 28                         | 32734.                           | 2285.                                                                                               | 0.003                                                                       | 348.3                         | 580.4               | 90.40                | 12.48                                        | 20.86                                        | 438                               |
| 29                         | 33911.                           | 2368.                                                                                               | 0.002                                                                       | 360.8                         | 601.3               | 91.13                | 12.48                                        | 20.86                                        | 446                               |
| 30                         | 35088.                           | 2450.                                                                                               | 0.002                                                                       | 373.3                         | 622.1               | 91.84                | 12.48                                        | 20.85                                        | 454                               |
| 31                         | 36264.                           | 2533.                                                                                               | 0.002                                                                       | 385.8                         | 643.0               | 92.53                | 12.48                                        | 20.85                                        | 461                               |
| 32                         | 37440.                           | 2616.                                                                                               | 0.002                                                                       | 398.3                         | 663.8               | 93.19                | 12.48                                        | 20.85                                        | 469                               |
| 33                         | 38616.                           | 2699.                                                                                               | 0.002                                                                       | 410.8                         | 684.7               | 93.83                | 12.48                                        | 20.84                                        | 476                               |
| 34                         | 39791.                           | 2781.                                                                                               | 0.002                                                                       | 423.3                         | 705.5               | 94.45                | 12.48                                        | 20.84                                        | 483                               |
| 35                         | 40967.                           | 2863.                                                                                               | 0.002                                                                       | 435.8                         | 726.4               | 95.06                | 12.48                                        | 20.84                                        | 490                               |
| 36                         | 42142.                           | 2946.                                                                                               | 0.002                                                                       | 448.3                         | 747.2               | 95.64                | 12.48                                        | 20.84                                        | 497                               |
| 37                         | 43317.                           | 3028.                                                                                               | 0.002                                                                       | 460.8                         | 768.1               | 96.21                | 12.49                                        | 20.84                                        | 504                               |
| 38                         | 44492.                           | 3111.                                                                                               | 0.002                                                                       | 473.3                         | 788.9               | 96.77                | 12.49                                        | 20.84                                        | 511                               |
| 39                         | 45666.                           | 3193.                                                                                               | 0.002                                                                       | 485.8                         | 809.7               | 97.31                | 12.49                                        | 20.84                                        | 517                               |
| 40                         | 46841.                           | 3275.                                                                                               | 0.002                                                                       | 498.3                         | 830.6               | 97.84                | 12.50                                        | 20.84                                        | 524                               |
| 41                         | 48015.                           | 3358.                                                                                               | 0.002                                                                       | 510.9                         | 851.4               | 98.35                | 12.50                                        | 20.84                                        | 530                               |
| 42                         | 49190.                           | 3440.                                                                                               | 0.002                                                                       | 523.4                         | 872.3               | 98.85                | 12.51                                        | 20.85                                        | 537                               |
| 43                         | 50364.                           | 3522.                                                                                               | 0.002                                                                       | 535.9                         | 893.1               | 99.35                | 12.52                                        | 20.86                                        | 543                               |
| 44                         | 51538.                           | 3605.                                                                                               | 0.002                                                                       | 548.4                         | 914.0               | 99.83                | 12.53                                        | 20.87                                        | 549                               |
| 45                         | 52712.                           | 3687.                                                                                               | 0.002                                                                       | 561.0                         | 934.8               | 100.29               | 12.54                                        | 20.88                                        | 555                               |
| 46                         | 53886.                           | 3769.                                                                                               | 0.002                                                                       | 573.5                         | 955.7               | 100.75               | 12.55                                        | 20.89                                        | 561                               |
| 47                         | 55060.                           | 3852.                                                                                               | 0.001                                                                       | 586.1                         | 976.6               | 101.20               | 12.57                                        | 20.91                                        | 567                               |
| 48                         | 56233.                           | 3934.                                                                                               | 0.001                                                                       | 598.7                         | 997.5               | 101.64               | 12.59                                        | 20.92                                        | 573                               |
| 49                         | 57407.                           | 4016.                                                                                               | 0.001                                                                       | 611.3                         | 1018.5              | 102.07               | 12.61                                        | 20.94                                        | 579                               |
| 50                         | 58581.                           | 4098.                                                                                               | 0.001                                                                       | 623.9                         | 1039.4              | 102.50               | 12.64                                        | 20.97                                        | 585                               |
| 51                         | 59754.                           | 4181.                                                                                               | 0.001                                                                       | 636.6                         | 1060.4              | 102.91               | 12.66                                        | 21.00                                        | 590                               |
| 52                         | 60928.                           | 4263.                                                                                               | 0.001                                                                       | 649.3                         | 1081.4              | 103.32               | 12.70                                        | 21.03                                        | 596                               |
| 53                         | 62101.                           | 4345.                                                                                               | 0.001                                                                       | 662.0                         | 1102.5              | 103.72               | 12.73                                        | 21.06                                        | 601                               |
| 54                         | 63275.                           | 4427.                                                                                               | 0.001                                                                       | 674.8                         | 1123.6              | 104.12               | 12.77                                        | 21.10                                        | 606                               |
| 55                         | 64448.                           | 4509.                                                                                               | 0.001                                                                       | 687.6                         | 1144.7              | 104.50               | 12.81                                        | 21.14                                        | 612                               |
| 56                         | 65621.                           | 4592.                                                                                               | 0.001                                                                       | 700.4                         | 1165.8              | 104.89               | 12.86                                        | 21.19                                        | 617                               |
| 57                         | 66795.                           | 4674.                                                                                               | 0.001                                                                       | 713.3                         | 1187.1              | 105.26               | 12.91                                        | 21.24                                        | 622                               |
| 58                         | 67968.                           | 4756.                                                                                               | 0.001                                                                       | 726.2                         | 1208.3              | 105.63               | 12.96                                        | 21.29                                        | 627                               |
| 59                         | 69141.                           | 4838.                                                                                               | 0.001                                                                       | 739.2                         | 1229.6              | 105.99               | 13.02                                        | 21.35                                        | 631                               |
| 60                         | 70314.                           | 4920.                                                                                               | 0.001                                                                       | 752.3                         | 1251.0              | 106.35               | 13.09                                        | 21.41                                        | 636                               |
| 61                         | 71487.                           | 5003.                                                                                               | 0.001                                                                       | 765.4                         | 1272.5              | 106.71               | 13.15                                        | 21.48                                        | 641                               |
| 62                         | 72661.                           | 5085.                                                                                               | 0.001                                                                       | 778.6                         | 1294.0              | 107.06               | 13.23                                        | 21.55                                        | 645                               |
| 63                         | 73834.                           | 5167.                                                                                               | 0.001                                                                       | 791.9                         | 1315.6              | 107.40               | 13.30                                        | 21.63                                        | 650                               |
| 64                         | 75007.                           | 5249.                                                                                               | 0.001                                                                       | 805.2                         | 1337.2              | 107.75               | 13.39                                        | 21.71                                        | 654                               |
| 65                         | 76180.                           | 5331.                                                                                               | 0.001                                                                       | 818.7                         | 1359.0              | 108.08               | 13.47                                        | 21.80                                        | 658                               |
| 66                         | 77353.                           | 5413.                                                                                               | 0.001                                                                       | 832.2                         | 1380.9              | 108.42               | 13.57                                        | 21.89                                        | 663                               |
| 67                         | 78526.                           | 5496.                                                                                               | 0.001                                                                       | 845.8                         | 1402.8              | 108.75               | 13.66                                        | 21.99                                        | 667                               |
| 68                         | 79699.                           | 5578.                                                                                               | 0.001                                                                       | 859.5                         | 1424.8              | 109.07               | 13.76                                        | 22.09                                        | 671                               |
| 69                         | 80872.                           | 5660.                                                                                               | 0.001                                                                       | 873.4                         | 1447.0              | 109.40               | 13.87                                        | 22.19                                        | 675                               |
| 70                         | 82044.                           | 5742.                                                                                               | 0.001                                                                       | 887.3                         | 1469.2              | 109.72               | 13.98                                        | 22.30                                        | 679                               |
| 71                         | 83217.                           | 5824.                                                                                               | 0.001                                                                       | 901.3                         | 1491.6              | 110.03               | 14.09                                        | 22.42                                        | 682                               |
| 72                         | 84390.                           | 5906.                                                                                               | 0.001                                                                       | 915.5                         | 1514.1              | 110.35               | 14.21                                        | 22.54                                        | 686                               |
| 73                         | 85563.                           | 5988.                                                                                               | 0.001                                                                       | 929.8                         | 1536.7              | 110.66               | 14.34                                        | 22.66                                        | 690                               |
| 74                         | 86736.                           | 6071.                                                                                               | 0.001                                                                       | 944.2                         | 1559.4              | 110.97               | 14.46                                        | 22.79                                        | 693                               |
| 75                         | 87909.                           | 6153.                                                                                               | 0.001                                                                       | 958.7                         | 1582.2              | 111.28               | 14.60                                        | 22.92                                        | 697                               |
| 76                         | 89082.                           | 6235.                                                                                               | 0.001                                                                       | 973.4                         | 1605.2              | 111.58               | 14.73                                        | 23.05                                        | 700                               |
| 77                         | 90254.                           | 6317.                                                                                               | 0.001                                                                       | 988.2                         | 1628.3              | 111.88               | 14.87                                        | 23.19                                        | 704                               |
| 78                         | 91427.                           | 6399.                                                                                               | 0.001                                                                       | 1003.1                        | 1651.6              | 112.18               | 15.01                                        | 23.33                                        | 707                               |
| 79                         | 92600.                           | 6481.                                                                                               | 0.001                                                                       | 1018.2                        | 1675.0              | 112.48               | 15.16                                        | 23.48                                        | 710                               |
| 80                         | 93773.                           | 6563.                                                                                               | 0.001                                                                       | 1033.5                        | 1698.6              | 112.78               | 15.31                                        | 23.63                                        | 714                               |
| 81                         | 94945.                           | 6646.                                                                                               | 0.001                                                                       | 1048.9                        | 1722.3              | 113.07               | 15.46                                        | 23.78                                        | 717                               |
| 82                         | 96118.                           | 6728.                                                                                               | 0.001                                                                       | 1064.4                        | 1746.1              | 113.36               | 15.62                                        | 23.94                                        | 720                               |
| 83                         | 97291.                           | 6810.                                                                                               | 0.001                                                                       | 1080.1                        | 1770.2              | 113.65               | 15.78                                        | 24.10                                        | 723                               |
| 84                         | 98464.                           | 6892.                                                                                               | 0.001                                                                       | 1096.0                        | 1794.3              | 113.94               | 15.94                                        | 24.26                                        | 726                               |
| 85                         | 99636.                           | 6974.                                                                                               | 0.001                                                                       | 1112.0                        | 1818.7              | 114.23               | 16.10                                        | 24.42                                        | 729                               |
| 86                         | 100809.                          | 7056.                                                                                               | 0.001                                                                       | 1128.2                        | 1843.2              | 114.52               | 16.27                                        | 24.59                                        | 732                               |
| 87                         | 101982.                          | 7138.                                                                                               | 0.001                                                                       | 1144.5                        | 1867.8              | 114.80               | 16.43                                        | 24.75                                        | 735                               |
| 88                         | 103154.                          | 7220.                                                                                               | 0.001                                                                       | 1161.0                        | 1892.7              | 115.09               | 16.60                                        | 24.92                                        | 738                               |
| 89                         | 104327.                          | 7302.                                                                                               | 0.001                                                                       | 1177.7                        | 1917.7              | 115.37               | 16.77                                        | 25.09                                        | 741                               |
| 90                         | 105500.                          | 7384.                                                                                               | 0.001                                                                       | 1194.6                        | 1942.9              | 115.65               | 16.94                                        | 25.26                                        | 744                               |
| 91                         | 106672.                          | 7467.                                                                                               | 0.001                                                                       | 1211.6                        | 1968.2              | 115.93               | 17.12                                        | 25.44                                        | 747                               |
| 92                         | 107845.                          | 7549.                                                                                               | 0.001                                                                       | 1228.8                        | 1993.7              | 116.21               | 17.29                                        | 25.61                                        | 750                               |
| 93                         | 109017.                          | 7631.                                                                                               | 0.001                                                                       | 1246.2                        | 2019.4              | 116.49               | 17.47                                        | 25.78                                        | 752                               |
| 94                         | 110190.                          | 7713.                                                                                               | 0.001                                                                       | 1263.8                        | 2045.3              | 116.77               | 17.64                                        | 25.96                                        | 755                               |
| 95                         | 111363.                          | 7795.                                                                                               | 0.001                                                                       | 1281.5                        | 2071.4              | 117.04               | 17.82                                        | 26.13                                        | 758                               |
| 96                         | 112535.                          | 7877.                                                                                               | 0.001                                                                       | 1299.4                        | 2097.6              | 117.32               | 17.99                                        | 26.31                                        | 761                               |
| 97                         | 113708.                          | 7959.                                                                                               | 0.001                                                                       | 1317.5                        | 2124.0              | 117.59               | 18.17                                        | 26.49                                        | 764                               |
| 98                         | 114880.                          | 8041.                                                                                               | 0.001                                                                       | 1335.7                        | 2150.6              | 117.86               | 18.34                                        | 26.66                                        | 766                               |
| 99                         | 116053.                          | 8124.                                                                                               | 0.001                                                                       | 1354.2                        | 2177.3              | 118.13               | 18.52                                        | 26.84                                        | 769                               |
| 100                        | 117226.                          | 8206.                                                                                               | 0.001                                                                       | 1372.8                        | 2204.2              | 118.40               | 18.69                                        | 27.01                                        | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

0.08 ATMOSPHERE ISO8AR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 14                         | 26.23                            | 2284 <sup>a</sup> .                                                                                | 9.369                                                                       | -620.2                        | -620.0              | 10.19                | 9.56                                           | 13.31                                          | 1264                              |
| 14.049                     | 26.24                            | 2283 <sup>a</sup> .                                                                                | 9.362                                                                       | -619.6                        | -619.4              | 10.24                | 9.58                                           | 13.34                                          | 1264                              |
| 14.049                     | 14166.                           | 111 <sup>a</sup> .                                                                                 | 0.006                                                                       | 172.6                         | 287.4               | 74.80                | 12.53                                          | 21.25                                          | 308                               |
| 15                         | 15163.                           | 119 <sup>a</sup> .                                                                                 | 0.005                                                                       | 184.7                         | 307.6               | 76.19                | 12.51                                          | 21.17                                          | 319                               |
| 16                         | 16209.                           | 128 <sup>a</sup> .                                                                                 | 0.005                                                                       | 197.3                         | 328.7               | 77.55                | 12.50                                          | 21.11                                          | 330                               |
| 17                         | 17251.                           | 136 <sup>a</sup> .                                                                                 | 0.005                                                                       | 210.0                         | 349.8               | 78.83                | 12.50                                          | 21.06                                          | 340                               |
| 18                         | 18292.                           | 145 <sup>a</sup> .                                                                                 | 0.005                                                                       | 222.6                         | 370.8               | 80.04                | 12.49                                          | 21.03                                          | 350                               |
| 19                         | 19330.                           | 153 <sup>a</sup> .                                                                                 | 0.004                                                                       | 235.2                         | 391.9               | 81.17                | 12.49                                          | 21.00                                          | 360                               |
| 20                         | 20367.                           | 161 <sup>a</sup> .                                                                                 | 0.004                                                                       | 247.8                         | 412.9               | 82.25                | 12.49                                          | 20.98                                          | 370                               |
| 21                         | 21403.                           | 1701.                                                                                              | 0.004                                                                       | 260.3                         | 433.8               | 83.27                | 12.49                                          | 20.96                                          | 379                               |
| 22                         | 22438.                           | 1785.                                                                                              | 0.004                                                                       | 272.9                         | 454.8               | 84.25                | 12.49                                          | 20.94                                          | 388                               |
| 23                         | 23471.                           | 1868.                                                                                              | 0.004                                                                       | 285.4                         | 475.7               | 85.18                | 12.49                                          | 20.93                                          | 397                               |
| 24                         | 24505.                           | 1951.                                                                                              | 0.003                                                                       | 298.0                         | 496.6               | 86.07                | 12.49                                          | 20.91                                          | 405                               |
| 25                         | 25537.                           | 2034.                                                                                              | 0.003                                                                       | 310.5                         | 517.5               | 86.92                | 12.48                                          | 20.90                                          | 414                               |
| 26                         | 26569.                           | 2117.                                                                                              | 0.003                                                                       | 323.1                         | 538.4               | 87.74                | 12.48                                          | 20.89                                          | 422                               |
| 27                         | 27600.                           | 2200.                                                                                              | 0.003                                                                       | 335.6                         | 559.3               | 88.53                | 12.48                                          | 20.88                                          | 430                               |
| 28                         | 28631.                           | 2283.                                                                                              | 0.003                                                                       | 348.1                         | 580.2               | 89.29                | 12.48                                          | 20.88                                          | 438                               |
| 29                         | 29661.                           | 2366.                                                                                              | 0.003                                                                       | 360.6                         | 601.1               | 90.02                | 12.48                                          | 20.87                                          | 446                               |
| 30                         | 30692.                           | 2449.                                                                                              | 0.003                                                                       | 373.2                         | 621.9               | 90.73                | 12.48                                          | 20.86                                          | 454                               |
| 31                         | 31721.                           | 2532.                                                                                              | 0.003                                                                       | 385.7                         | 642.8               | 91.41                | 12.48                                          | 20.86                                          | 461                               |
| 32                         | 32751.                           | 2614.                                                                                              | 0.003                                                                       | 398.2                         | 663.7               | 92.07                | 12.48                                          | 20.85                                          | 469                               |
| 33                         | 33780.                           | 2697.                                                                                              | 0.002                                                                       | 410.7                         | 684.5               | 92.72                | 12.48                                          | 20.85                                          | 476                               |
| 34                         | 34809.                           | 2779.                                                                                              | 0.002                                                                       | 423.2                         | 705.4               | 93.34                | 12.48                                          | 20.85                                          | 483                               |
| 35                         | 35838.                           | 2862.                                                                                              | 0.002                                                                       | 435.7                         | 726.2               | 93.94                | 12.48                                          | 20.84                                          | 490                               |
| 36                         | 36867.                           | 2945.                                                                                              | 0.002                                                                       | 448.2                         | 747.1               | 94.53                | 12.48                                          | 20.84                                          | 497                               |
| 37                         | 37895.                           | 3027.                                                                                              | 0.002                                                                       | 460.7                         | 767.9               | 95.10                | 12.49                                          | 20.84                                          | 504                               |
| 38                         | 38923.                           | 3109.                                                                                              | 0.002                                                                       | 473.2                         | 788.7               | 95.66                | 12.49                                          | 20.84                                          | 511                               |
| 39                         | 39951.                           | 3192.                                                                                              | 0.002                                                                       | 485.7                         | 809.6               | 96.20                | 12.49                                          | 20.84                                          | 517                               |
| 40                         | 40979.                           | 3274.                                                                                              | 0.002                                                                       | 498.2                         | 830.4               | 96.73                | 12.50                                          | 20.85                                          | 524                               |
| 41                         | 42007.                           | 3357.                                                                                              | 0.002                                                                       | 510.8                         | 851.3               | 97.24                | 12.50                                          | 20.85                                          | 530                               |
| 42                         | 43035.                           | 3439.                                                                                              | 0.002                                                                       | 523.3                         | 872.1               | 97.74                | 12.51                                          | 20.85                                          | 537                               |
| 43                         | 44063.                           | 3521.                                                                                              | 0.002                                                                       | 535.8                         | 893.0               | 98.23                | 12.52                                          | 20.86                                          | 543                               |
| 44                         | 45090.                           | 3604.                                                                                              | 0.002                                                                       | 548.4                         | 913.9               | 98.71                | 12.53                                          | 20.87                                          | 549                               |
| 45                         | 46118.                           | 3686.                                                                                              | 0.002                                                                       | 560.9                         | 934.7               | 99.18                | 12.54                                          | 20.88                                          | 555                               |
| 46                         | 47145.                           | 3768.                                                                                              | 0.002                                                                       | 573.5                         | 955.6               | 99.64                | 12.55                                          | 20.89                                          | 561                               |
| 47                         | 48172.                           | 3851.                                                                                              | 0.002                                                                       | 586.0                         | 976.5               | 100.09               | 12.57                                          | 20.91                                          | 567                               |
| 48                         | 49200.                           | 3933.                                                                                              | 0.002                                                                       | 598.6                         | 997.4               | 100.53               | 12.59                                          | 20.93                                          | 573                               |
| 49                         | 50227.                           | 4015.                                                                                              | 0.002                                                                       | 611.2                         | 1018.4              | 100.96               | 12.61                                          | 20.95                                          | 579                               |
| 50                         | 51254.                           | 4098.                                                                                              | 0.002                                                                       | 623.9                         | 1039.3              | 101.39               | 12.64                                          | 20.97                                          | 585                               |
| 51                         | 52281.                           | 4180.                                                                                              | 0.002                                                                       | 636.5                         | 1060.3              | 101.80               | 12.66                                          | 21.00                                          | 590                               |
| 52                         | 53308.                           | 4262.                                                                                              | 0.002                                                                       | 649.2                         | 1081.3              | 102.21               | 12.70                                          | 21.03                                          | 596                               |
| 53                         | 54335.                           | 4344.                                                                                              | 0.002                                                                       | 662.0                         | 1102.4              | 102.61               | 12.73                                          | 21.06                                          | 601                               |
| 54                         | 55362.                           | 4427.                                                                                              | 0.001                                                                       | 674.7                         | 1123.5              | 103.00               | 12.77                                          | 21.10                                          | 606                               |
| 55                         | 56389.                           | 4509.                                                                                              | 0.001                                                                       | 687.5                         | 1144.6              | 103.39               | 12.81                                          | 21.14                                          | 612                               |
| 56                         | 57415.                           | 4591.                                                                                              | 0.001                                                                       | 700.4                         | 1165.8              | 103.77               | 12.86                                          | 21.19                                          | 617                               |
| 57                         | 58442.                           | 4673.                                                                                              | 0.001                                                                       | 713.2                         | 1187.0              | 104.15               | 12.91                                          | 21.24                                          | 622                               |
| 58                         | 59469.                           | 4756.                                                                                              | 0.001                                                                       | 726.2                         | 1208.2              | 104.52               | 12.96                                          | 21.29                                          | 627                               |
| 59                         | 60495.                           | 4838.                                                                                              | 0.001                                                                       | 739.2                         | 1229.6              | 104.88               | 13.02                                          | 21.35                                          | 631                               |
| 60                         | 61522.                           | 4920.                                                                                              | 0.001                                                                       | 752.2                         | 1250.9              | 105.24               | 13.09                                          | 21.41                                          | 636                               |
| 61                         | 62549.                           | 5002.                                                                                              | 0.001                                                                       | 765.4                         | 1272.4              | 105.60               | 13.15                                          | 21.48                                          | 641                               |
| 62                         | 63575.                           | 5084.                                                                                              | 0.001                                                                       | 778.6                         | 1293.9              | 105.95               | 13.23                                          | 21.55                                          | 645                               |
| 63                         | 64602.                           | 5167.                                                                                              | 0.001                                                                       | 791.8                         | 1315.5              | 106.29               | 13.30                                          | 21.63                                          | 650                               |
| 64                         | 65628.                           | 5249.                                                                                              | 0.001                                                                       | 805.2                         | 1337.2              | 106.63               | 13.39                                          | 21.71                                          | 654                               |
| 65                         | 66655.                           | 5331.                                                                                              | 0.001                                                                       | 818.6                         | 1358.9              | 106.97               | 13.47                                          | 21.80                                          | 658                               |
| 66                         | 67681.                           | 5413.                                                                                              | 0.001                                                                       | 832.2                         | 1380.8              | 107.31               | 13.57                                          | 21.89                                          | 663                               |
| 67                         | 68708.                           | 5495.                                                                                              | 0.001                                                                       | 845.8                         | 1402.7              | 107.64               | 13.66                                          | 21.99                                          | 667                               |
| 68                         | 69734.                           | 5577.                                                                                              | 0.001                                                                       | 859.5                         | 1424.8              | 107.96               | 13.76                                          | 22.09                                          | 671                               |
| 69                         | 70761.                           | 5660.                                                                                              | 0.001                                                                       | 873.3                         | 1446.9              | 108.28               | 13.87                                          | 22.19                                          | 675                               |
| 70                         | 71787.                           | 5747.                                                                                              | 0.001                                                                       | 887.3                         | 1469.2              | 108.61               | 13.98                                          | 22.30                                          | 679                               |
| 71                         | 72813.                           | 5824.                                                                                              | 0.001                                                                       | 901.3                         | 1491.5              | 108.92               | 14.09                                          | 22.42                                          | 682                               |
| 72                         | 73840.                           | 5906.                                                                                              | 0.001                                                                       | 915.0                         | 1514.0              | 109.24               | 14.21                                          | 22.54                                          | 686                               |
| 73                         | 74866.                           | 5989.                                                                                              | 0.001                                                                       | 929.7                         | 1536.6              | 109.55               | 14.34                                          | 22.66                                          | 690                               |
| 74                         | 75892.                           | 6070.                                                                                              | 0.001                                                                       | 944.1                         | 1559.3              | 109.86               | 14.46                                          | 22.79                                          | 693                               |
| 75                         | 76919.                           | 6153.                                                                                              | 0.001                                                                       | 958.7                         | 1582.2              | 110.16               | 14.60                                          | 22.92                                          | 697                               |
| 76                         | 77945.                           | 6235.                                                                                              | 0.001                                                                       | 973.3                         | 1605.2              | 110.47               | 14.73                                          | 23.05                                          | 700                               |
| 77                         | 78971.                           | 6317.                                                                                              | 0.001                                                                       | 988.1                         | 1628.3              | 110.77               | 14.87                                          | 23.19                                          | 704                               |
| 78                         | 79997.                           | 6399.                                                                                              | 0.001                                                                       | 1003.1                        | 1651.6              | 111.07               | 15.01                                          | 23.34                                          | 707                               |
| 79                         | 81024.                           | 6481.                                                                                              | 0.001                                                                       | 1018.2                        | 1675.0              | 111.37               | 15.16                                          | 23.48                                          | 710                               |
| 80                         | 82050.                           | 6563.                                                                                              | 0.001                                                                       | 1033.4                        | 1698.5              | 111.67               | 15.31                                          | 23.63                                          | 714                               |
| 81                         | 83076.                           | 6645.                                                                                              | 0.001                                                                       | 1048.8                        | 1722.2              | 111.96               | 15.46                                          | 23.78                                          | 717                               |
| 82                         | 84102.                           | 6727.                                                                                              | 0.001                                                                       | 1064.4                        | 1746.1              | 112.25               | 15.62                                          | 23.94                                          | 720                               |
| 83                         | 85128.                           | 6810.                                                                                              | 0.001                                                                       | 1080.1                        | 1770.1              | 112.54               | 15.78                                          | 24.10                                          | 723                               |
| 84                         | 86155.                           | 6892.                                                                                              | 0.001                                                                       | 1095.9                        | 1794.3              | 112.83               | 15.94                                          | 24.26                                          | 726                               |
| 85                         | 87181.                           | 6974.                                                                                              | 0.001                                                                       | 1111.9                        | 1818.6              | 113.12               | 16.10                                          | 24.42                                          | 729                               |
| 86                         | 88207.                           | 7056.                                                                                              | 0.001                                                                       | 1128.1                        | 1843.1              | 113.41               | 16.27                                          | 24.59                                          | 732                               |
| 87                         | 89233.                           | 7138.                                                                                              | 0.001                                                                       | 1144.5                        | 1867.8              | 113.69               | 16.43                                          | 24.75                                          | 735                               |
| 88                         | 90259.                           | 7220.                                                                                              | 0.001                                                                       | 1161.0                        | 1892.6              | 113.98               | 16.60                                          | 24.92                                          | 738                               |
| 89                         | 91285.                           | 7302.                                                                                              | 0.001                                                                       | 1177.7                        | 1917.7              | 114.26               | 16.77                                          | 25.09                                          | 741                               |
| 90                         | 92311.                           | 7384.                                                                                              | 0.001                                                                       | 1194.6                        | 1942.8              | 114.54               | 16.94                                          | 25.26                                          | 744                               |
| 91                         | 93338.                           | 7467.                                                                                              | 0.001                                                                       | 1211.6                        | 1968.2              | 114.82               | 17.12                                          | 25.44                                          | 747                               |
| 92                         | 94364.                           | 7549.                                                                                              | 0.001                                                                       | 1228.8                        | 1993.7              | 115.10               | 17.29                                          | 25.61                                          | 750                               |
| 93                         | 95390.                           | 7631.                                                                                              | 0.001                                                                       | 1246.2                        | 2019.4              | 115.38               | 17.47                                          | 25.79                                          | 752                               |
| 94                         | 96416.                           | 7713.                                                                                              | 0.001                                                                       | 1263.7                        | 2045.3              | 115.66               | 17.64                                          | 25.96                                          | 755                               |
| 95                         | 97442.                           | 7795.                                                                                              | 0.001                                                                       | 1281.5                        | 2071.3              | 115.93               | 17.82                                          | 26.14                                          | 758                               |
| 96                         | 98468.                           | 7877.                                                                                              | 0.001                                                                       | 1299.4                        | 2097.6              | 116.21               | 17.99                                          | 26.31                                          | 761                               |
| 97                         | 99494.                           | 7959.                                                                                              | 0.001                                                                       | 1317.5                        | 2124.0              | 116.48               | 18.17                                          | 26.49                                          | 764                               |
| 98                         | 100520.                          | 8041.                                                                                              | 0.001                                                                       | 1335.7                        | 2150.5              | 116.75               | 18.34                                          | 26.66                                          | 766                               |
| 99                         | 101546.                          | 8123.                                                                                              | 0.001                                                                       | 1354.1                        | 2177.3              | 117.02               | 18.52                                          | 26.84                                          | 769                               |
| 100                        | 102572.                          | 8206.                                                                                              | 0.001                                                                       | 1372.8                        | 2204.2              | 117.29               | 18.69                                          | 27.01                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

0.10 ATMOSPHERE ISOBAR

| TEMPERATURE<br>OEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial p$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>p</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 13.804                     | 26.18                            | 23311.                                                                                           | 9.402                                                                       | -622.9                        | -622.6              | 10.00                | 9.50                                           | 13.13                                          | 1273                              |
| 14                         | 26.23                            | 22846.                                                                                           | 9.369                                                                       | -620.2                        | -620.0              | 10.19                | 9.56                                           | 13.31                                          | 1264                              |
| 14.454                     | 26.36                            | 22191.                                                                                           | 9.275                                                                       | -614.1                        | -613.9              | 10.62                | 9.71                                           | 13.66                                          | 1252                              |
| 14.454                     | 11627.                           | 1138.                                                                                            | 0.007                                                                       | 177.0                         | 294.8               | 73.50                | 12.55                                          | 21.36                                          | 312                               |
| 15                         | 12085.                           | 1186.                                                                                            | 0.007                                                                       | 184.0                         | 306.5               | 74.29                | 12.53                                          | 21.29                                          | 318                               |
| 16                         | 12925.                           | 1272.                                                                                            | 0.006                                                                       | 196.7                         | 327.7               | 75.66                | 12.52                                          | 21.21                                          | 329                               |
| 17                         | 13763.                           | 1358.                                                                                            | 0.006                                                                       | 209.4                         | 348.9               | 76.95                | 12.51                                          | 21.14                                          | 340                               |
| 18                         | 14598.                           | 1443.                                                                                            | 0.006                                                                       | 222.1                         | 370.0               | 78.15                | 12.50                                          | 21.09                                          | 350                               |
| 19                         | 15432.                           | 1527.                                                                                            | 0.005                                                                       | 234.7                         | 391.1               | 79.29                | 12.50                                          | 21.06                                          | 360                               |
| 20                         | 16264.                           | 1612.                                                                                            | 0.005                                                                       | 247.3                         | 412.1               | 80.37                | 12.50                                          | 21.03                                          | 369                               |
| 21                         | 17095.                           | 1696.                                                                                            | 0.005                                                                       | 259.9                         | 433.1               | 81.40                | 12.49                                          | 21.00                                          | 378                               |
| 22                         | 17924.                           | 1780.                                                                                            | 0.005                                                                       | 272.5                         | 454.1               | 82.37                | 12.49                                          | 20.98                                          | 388                               |
| 23                         | 18753.                           | 1863.                                                                                            | 0.004                                                                       | 285.1                         | 475.1               | 83.31                | 12.49                                          | 20.96                                          | 396                               |
| 24                         | 19581.                           | 1947.                                                                                            | 0.004                                                                       | 297.6                         | 496.1               | 84.20                | 12.49                                          | 20.95                                          | 405                               |
| 25                         | 20408.                           | 2030.                                                                                            | 0.004                                                                       | 310.2                         | 517.0               | 85.05                | 12.49                                          | 20.93                                          | 414                               |
| 26                         | 21235.                           | 2113.                                                                                            | 0.004                                                                       | 322.8                         | 537.9               | 85.87                | 12.49                                          | 20.92                                          | 422                               |
| 27                         | 22061.                           | 2197.                                                                                            | 0.004                                                                       | 335.3                         | 558.8               | 86.66                | 12.49                                          | 20.91                                          | 430                               |
| 28                         | 22887.                           | 2280.                                                                                            | 0.004                                                                       | 347.8                         | 579.7               | 87.42                | 12.48                                          | 20.90                                          | 438                               |
| 29                         | 23712.                           | 2363.                                                                                            | 0.003                                                                       | 360.4                         | 600.6               | 88.16                | 12.48                                          | 20.89                                          | 446                               |
| 30                         | 24537.                           | 2446.                                                                                            | 0.003                                                                       | 372.9                         | 621.5               | 88.86                | 12.48                                          | 20.88                                          | 453                               |
| 31                         | 25362.                           | 2528.                                                                                            | 0.003                                                                       | 385.4                         | 642.4               | 89.55                | 12.48                                          | 20.88                                          | 461                               |
| 32                         | 26186.                           | 2611.                                                                                            | 0.003                                                                       | 397.9                         | 663.3               | 90.21                | 12.48                                          | 20.87                                          | 468                               |
| 33                         | 27010.                           | 2694.                                                                                            | 0.003                                                                       | 410.5                         | 684.1               | 90.85                | 12.48                                          | 20.87                                          | 476                               |
| 34                         | 27834.                           | 2777.                                                                                            | 0.003                                                                       | 423.0                         | 705.0               | 91.48                | 12.48                                          | 20.86                                          | 483                               |
| 35                         | 28658.                           | 2859.                                                                                            | 0.003                                                                       | 435.5                         | 725.9               | 92.08                | 12.48                                          | 20.86                                          | 490                               |
| 36                         | 29481.                           | 2942.                                                                                            | 0.003                                                                       | 448.0                         | 746.7               | 92.67                | 12.49                                          | 20.86                                          | 497                               |
| 37                         | 30304.                           | 3025.                                                                                            | 0.003                                                                       | 460.5                         | 767.6               | 93.24                | 12.49                                          | 20.85                                          | 504                               |
| 38                         | 31128.                           | 3107.                                                                                            | 0.003                                                                       | 473.0                         | 788.4               | 93.80                | 12.49                                          | 20.85                                          | 511                               |
| 39                         | 31951.                           | 3190.                                                                                            | 0.003                                                                       | 485.6                         | 809.3               | 94.34                | 12.49                                          | 20.85                                          | 517                               |
| 40                         | 32773.                           | 3272.                                                                                            | 0.003                                                                       | 498.1                         | 830.1               | 94.87                | 12.50                                          | 20.86                                          | 524                               |
| 41                         | 33596.                           | 3355.                                                                                            | 0.002                                                                       | 510.6                         | 851.0               | 95.38                | 12.50                                          | 20.86                                          | 530                               |
| 42                         | 34419.                           | 3437.                                                                                            | 0.002                                                                       | 523.1                         | 871.9               | 95.88                | 12.51                                          | 20.86                                          | 537                               |
| 43                         | 35241.                           | 3520.                                                                                            | 0.002                                                                       | 535.7                         | 892.7               | 96.37                | 12.52                                          | 20.87                                          | 543                               |
| 44                         | 36064.                           | 3602.                                                                                            | 0.002                                                                       | 548.2                         | 913.6               | 96.85                | 12.53                                          | 20.88                                          | 549                               |
| 45                         | 36886.                           | 3685.                                                                                            | 0.002                                                                       | 560.7                         | 934.5               | 97.32                | 12.54                                          | 20.89                                          | 555                               |
| 46                         | 37708.                           | 3767.                                                                                            | 0.002                                                                       | 573.3                         | 955.4               | 97.78                | 12.55                                          | 20.90                                          | 561                               |
| 47                         | 38530.                           | 3849.                                                                                            | 0.002                                                                       | 585.9                         | 976.3               | 98.23                | 12.57                                          | 20.92                                          | 567                               |
| 48                         | 39352.                           | 3932.                                                                                            | 0.002                                                                       | 598.5                         | 997.2               | 98.67                | 12.59                                          | 20.93                                          | 573                               |
| 49                         | 40174.                           | 4014.                                                                                            | 0.002                                                                       | 611.1                         | 1018.2              | 99.10                | 12.61                                          | 20.95                                          | 579                               |
| 50                         | 40996.                           | 4096.                                                                                            | 0.002                                                                       | 623.7                         | 1039.1              | 99.53                | 12.64                                          | 20.98                                          | 585                               |
| 51                         | 41818.                           | 4179.                                                                                            | 0.002                                                                       | 636.4                         | 1060.1              | 99.94                | 12.66                                          | 21.00                                          | 590                               |
| 52                         | 42640.                           | 4261.                                                                                            | 0.002                                                                       | 649.1                         | 1081.2              | 100.35               | 12.70                                          | 21.03                                          | 596                               |
| 53                         | 43462.                           | 4343.                                                                                            | 0.002                                                                       | 661.8                         | 1102.2              | 100.75               | 12.73                                          | 21.07                                          | 601                               |
| 54                         | 44284.                           | 4426.                                                                                            | 0.002                                                                       | 674.6                         | 1123.3              | 101.15               | 12.77                                          | 21.11                                          | 606                               |
| 55                         | 45105.                           | 4508.                                                                                            | 0.002                                                                       | 687.4                         | 1144.4              | 101.54               | 12.81                                          | 21.15                                          | 612                               |
| 56                         | 45927.                           | 4590.                                                                                            | 0.002                                                                       | 700.2                         | 1165.6              | 101.92               | 12.86                                          | 21.19                                          | 617                               |
| 57                         | 46749.                           | 4677.                                                                                            | 0.002                                                                       | 713.1                         | 1186.8              | 102.29               | 12.91                                          | 21.24                                          | 622                               |
| 58                         | 47570.                           | 4755.                                                                                            | 0.002                                                                       | 726.1                         | 1208.1              | 102.66               | 12.96                                          | 21.30                                          | 627                               |
| 59                         | 48392.                           | 4837.                                                                                            | 0.002                                                                       | 739.1                         | 1229.4              | 103.03               | 13.02                                          | 21.36                                          | 631                               |
| 60                         | 49213.                           | 4919.                                                                                            | 0.002                                                                       | 752.1                         | 1250.8              | 103.39               | 13.09                                          | 21.42                                          | 636                               |
| 61                         | 50035.                           | 5001.                                                                                            | 0.002                                                                       | 765.3                         | 1272.2              | 103.74               | 13.15                                          | 21.49                                          | 641                               |
| 62                         | 50856.                           | 5084.                                                                                            | 0.002                                                                       | 778.5                         | 1293.8              | 104.09               | 13.23                                          | 21.56                                          | 645                               |
| 63                         | 51677.                           | 5166.                                                                                            | 0.002                                                                       | 791.7                         | 1315.4              | 104.44               | 13.31                                          | 21.64                                          | 650                               |
| 64                         | 52499.                           | 5248.                                                                                            | 0.002                                                                       | 805.1                         | 1337.0              | 104.78               | 13.39                                          | 21.72                                          | 654                               |
| 65                         | 53320.                           | 5330.                                                                                            | 0.002                                                                       | 818.5                         | 1358.8              | 105.11               | 13.47                                          | 21.80                                          | 658                               |
| 66                         | 54142.                           | 5412.                                                                                            | 0.002                                                                       | 832.1                         | 1380.7              | 105.45               | 13.57                                          | 21.89                                          | 663                               |
| 67                         | 54963.                           | 5495.                                                                                            | 0.001                                                                       | 845.7                         | 1402.6              | 105.78               | 13.66                                          | 21.99                                          | 667                               |
| 68                         | 55784.                           | 5577.                                                                                            | 0.001                                                                       | 859.4                         | 1424.6              | 106.10               | 13.76                                          | 22.09                                          | 671                               |
| 69                         | 56605.                           | 5659.                                                                                            | 0.001                                                                       | 873.2                         | 1446.8              | 106.43               | 13.87                                          | 22.20                                          | 675                               |
| 70                         | 57427.                           | 5741.                                                                                            | 0.001                                                                       | 887.2                         | 1469.0              | 106.75               | 13.98                                          | 22.31                                          | 679                               |
| 71                         | 58248.                           | 5823.                                                                                            | 0.001                                                                       | 901.2                         | 1491.4              | 107.07               | 14.09                                          | 22.42                                          | 682                               |
| 72                         | 59069.                           | 5905.                                                                                            | 0.001                                                                       | 915.4                         | 1513.9              | 107.38               | 14.21                                          | 22.54                                          | 686                               |
| 73                         | 59890.                           | 5988.                                                                                            | 0.001                                                                       | 929.6                         | 1536.5              | 107.69               | 14.34                                          | 22.66                                          | 690                               |
| 74                         | 60711.                           | 6070.                                                                                            | 0.001                                                                       | 944.1                         | 1559.2              | 108.00               | 14.46                                          | 22.79                                          | 693                               |
| 75                         | 61532.                           | 6152.                                                                                            | 0.001                                                                       | 958.6                         | 1582.1              | 108.31               | 14.60                                          | 22.92                                          | 697                               |
| 76                         | 62354.                           | 6234.                                                                                            | 0.001                                                                       | 973.3                         | 1605.1              | 108.61               | 14.73                                          | 23.06                                          | 700                               |
| 77                         | 63175.                           | 6316.                                                                                            | 0.001                                                                       | 988.1                         | 1628.2              | 108.91               | 14.87                                          | 23.20                                          | 704                               |
| 78                         | 63996.                           | 6399.                                                                                            | 0.001                                                                       | 1003.0                        | 1651.5              | 109.21               | 15.01                                          | 23.34                                          | 707                               |
| 79                         | 64817.                           | 6481.                                                                                            | 0.001                                                                       | 1018.1                        | 1674.9              | 109.51               | 15.16                                          | 23.48                                          | 710                               |
| 80                         | 65638.                           | 6563.                                                                                            | 0.001                                                                       | 1033.4                        | 1698.4              | 109.81               | 15.31                                          | 23.63                                          | 714                               |
| 81                         | 66459.                           | 6645.                                                                                            | 0.001                                                                       | 1048.7                        | 1722.1              | 110.10               | 15.46                                          | 23.79                                          | 717                               |
| 82                         | 67280.                           | 6727.                                                                                            | 0.001                                                                       | 1064.3                        | 1746.0              | 110.40               | 15.62                                          | 23.94                                          | 720                               |
| 83                         | 68101.                           | 6809.                                                                                            | 0.001                                                                       | 1080.0                        | 1770.0              | 110.69               | 15.78                                          | 24.10                                          | 723                               |
| 84                         | 68922.                           | 6891.                                                                                            | 0.001                                                                       | 1095.9                        | 1794.2              | 110.98               | 15.94                                          | 24.26                                          | 726                               |
| 85                         | 69743.                           | 6974.                                                                                            | 0.001                                                                       | 1111.9                        | 1818.5              | 111.27               | 16.10                                          | 24.42                                          | 729                               |
| 86                         | 70564.                           | 7056.                                                                                            | 0.001                                                                       | 1128.1                        | 1843.1              | 111.55               | 16.27                                          | 24.59                                          | 732                               |
| 87                         | 71385.                           | 7138.                                                                                            | 0.001                                                                       | 1144.4                        | 1867.7              | 111.84               | 16.43                                          | 24.76                                          | 735                               |
| 88                         | 72206.                           | 7220.                                                                                            | 0.001                                                                       | 1160.9                        | 1892.6              | 112.12               | 16.60                                          | 24.92                                          | 738                               |
| 89                         | 73027.                           | 7307.                                                                                            | 0.001                                                                       | 1177.6                        | 1917.6              | 112.40               | 16.77                                          | 25.09                                          | 741                               |
| 90                         | 73848.                           | 7384.                                                                                            | 0.001                                                                       | 1194.5                        | 1942.8              | 112.69               | 16.94                                          | 25.27                                          | 744                               |
| 91                         | 74669.                           | 7466.                                                                                            | 0.001                                                                       | 1211.5                        | 1968.1              | 112.97               | 17.12                                          | 25.44                                          | 747                               |
| 92                         | 75490.                           | 7549.                                                                                            | 0.001                                                                       | 1228.7                        | 1993.6              | 113.24               | 17.29                                          | 25.61                                          | 750                               |
| 93                         | 76311.                           | 7631.                                                                                            | 0.001                                                                       | 1246.1                        | 2019.3              | 113.52               | 17.47                                          | 25.79                                          | 752                               |
| 94                         | 77132.                           | 7713.                                                                                            | 0.001                                                                       | 1263.7                        | 2045.2              | 113.80               | 17.64                                          | 25.96                                          | 755                               |
| 95                         | 77953.                           | 7795.                                                                                            | 0.001                                                                       | 1281.4                        | 2071.3              | 114.07               | 17.82                                          | 26.14                                          | 758                               |
| 96                         | 78774.                           | 7877.                                                                                            | 0.001                                                                       | 1299.3                        | 2097.5              | 114.35               | 17.99                                          | 26.31                                          | 761                               |
| 97                         | 79595.                           | 7959.                                                                                            | 0.001                                                                       | 1317.4                        | 2123.9              | 114.62               | 18.17                                          | 26.49                                          | 764                               |
| 98                         | 80415.                           | 8041.                                                                                            | 0.001                                                                       | 1335.7                        | 2150.5              | 114.90               | 18.34                                          | 26.66                                          | 766                               |
| 99                         | 81236.                           | 8123.                                                                                            | 0.001                                                                       | 1354.1                        | 2177.2              | 115.17               | 18.52                                          | 26.84                                          | 769                               |
| 100                        | 82057.                           | 8205.                                                                                            | 0.001                                                                       | 1372.7                        | 2204.1              | 115.44               | 18.69                                          | 27.01                                          | 772                               |

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

0.15 ATMOSPHERE ISOBAR

| TEMPERATURE<br>OEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>2</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 13.806                     | 26.18                            | 23316.                                                                                              | 9.402                                                                       | -622.9                        | -622.5              | 10.00                | 9.50                                           | 13.13                                          | 1273                              |
| 14                         | 26.23                            | 22855.                                                                                              | 9.370                                                                       | -620.3                        | -619.9              | 10.19                | 9.56                                           | 13.31                                          | 1265                              |
| 15                         | 26.52                            | 21381.                                                                                              | 9.135                                                                       | -606.6                        | -606.2              | 11.14                | 9.90                                           | 14.08                                          | 1236                              |
| 15.248                     | 26.60                            | 21020.                                                                                              | 9.077                                                                       | -603.0                        | -602.6              | 11.37                | 9.99                                           | 14.28                                          | 1229                              |
| 15.248                     | 8119.9                           | 1184.                                                                                               | 0.010                                                                       | 185.5                         | 308.9               | 71.16                | 12.59                                          | 21.59                                          | 319                               |
| 16                         | 8546.3                           | 1251.                                                                                               | 0.010                                                                       | 195.2                         | 325.1               | 72.19                | 12.56                                          | 21.47                                          | 328                               |
| 17                         | 9111.3                           | 1338.                                                                                               | 0.009                                                                       | 208.1                         | 346.5               | 73.49                | 12.54                                          | 21.36                                          | 338                               |
| 18                         | 9673.6                           | 1425.                                                                                               | 0.009                                                                       | 220.8                         | 367.9               | 74.71                | 12.53                                          | 21.27                                          | 349                               |
| 19                         | 10234.                           | 1511.                                                                                               | 0.008                                                                       | 233.6                         | 389.1               | 75.86                | 12.52                                          | 21.21                                          | 359                               |
| 20                         | 10792.                           | 1597.                                                                                               | 0.008                                                                       | 246.2                         | 410.3               | 76.95                | 12.51                                          | 21.16                                          | 368                               |
| 21                         | 11350.                           | 1682.                                                                                               | 0.007                                                                       | 258.9                         | 431.4               | 77.98                | 12.51                                          | 21.12                                          | 378                               |
| 22                         | 11906.                           | 1766.                                                                                               | 0.007                                                                       | 271.6                         | 452.5               | 78.96                | 12.50                                          | 21.08                                          | 387                               |
| 23                         | 12461.                           | 1851.                                                                                               | 0.007                                                                       | 284.2                         | 473.6               | 79.89                | 12.50                                          | 21.05                                          | 396                               |
| 24                         | 13016.                           | 1935.                                                                                               | 0.006                                                                       | 296.8                         | 494.6               | 80.79                | 12.50                                          | 21.03                                          | 405                               |
| 25                         | 13570.                           | 2019.                                                                                               | 0.006                                                                       | 309.4                         | 515.6               | 81.65                | 12.50                                          | 21.01                                          | 413                               |
| 26                         | 14123.                           | 2103.                                                                                               | 0.006                                                                       | 322.0                         | 536.6               | 82.47                | 12.49                                          | 20.99                                          | 421                               |
| 27                         | 14675.                           | 2187.                                                                                               | 0.006                                                                       | 334.6                         | 557.6               | 83.26                | 12.49                                          | 20.97                                          | 430                               |
| 28                         | 15228.                           | 2271.                                                                                               | 0.005                                                                       | 347.1                         | 578.6               | 84.03                | 12.49                                          | 20.96                                          | 438                               |
| 29                         | 15780.                           | 2354.                                                                                               | 0.005                                                                       | 359.7                         | 599.5               | 84.76                | 12.49                                          | 20.94                                          | 445                               |
| 30                         | 16331.                           | 2438.                                                                                               | 0.005                                                                       | 372.3                         | 620.5               | 85.47                | 12.49                                          | 20.93                                          | 453                               |
| 31                         | 16882.                           | 2521.                                                                                               | 0.005                                                                       | 384.8                         | 641.4               | 86.16                | 12.49                                          | 20.92                                          | 461                               |
| 32                         | 17433.                           | 2604.                                                                                               | 0.005                                                                       | 397.4                         | 662.3               | 86.82                | 12.49                                          | 20.91                                          | 468                               |
| 33                         | 17984.                           | 2687.                                                                                               | 0.005                                                                       | 409.9                         | 683.2               | 87.46                | 12.49                                          | 20.90                                          | 475                               |
| 34                         | 18534.                           | 2770.                                                                                               | 0.004                                                                       | 422.4                         | 704.1               | 88.09                | 12.49                                          | 20.90                                          | 483                               |
| 35                         | 19084.                           | 2853.                                                                                               | 0.004                                                                       | 435.0                         | 725.0               | 88.69                | 12.49                                          | 20.89                                          | 490                               |
| 36                         | 19634.                           | 2936.                                                                                               | 0.004                                                                       | 447.5                         | 745.9               | 89.28                | 12.49                                          | 20.89                                          | 497                               |
| 37                         | 20184.                           | 3019.                                                                                               | 0.004                                                                       | 460.0                         | 766.8               | 89.86                | 12.49                                          | 20.88                                          | 504                               |
| 38                         | 20733.                           | 3102.                                                                                               | 0.004                                                                       | 472.6                         | 787.7               | 90.41                | 12.49                                          | 20.88                                          | 510                               |
| 39                         | 21283.                           | 3185.                                                                                               | 0.004                                                                       | 485.1                         | 808.6               | 90.95                | 12.50                                          | 20.88                                          | 517                               |
| 40                         | 21832.                           | 3267.                                                                                               | 0.004                                                                       | 497.6                         | 829.4               | 91.48                | 12.50                                          | 20.88                                          | 524                               |
| 41                         | 22381.                           | 3350.                                                                                               | 0.004                                                                       | 510.2                         | 850.3               | 92.00                | 12.51                                          | 20.88                                          | 530                               |
| 42                         | 22930.                           | 3433.                                                                                               | 0.004                                                                       | 522.7                         | 871.2               | 92.50                | 12.51                                          | 20.89                                          | 537                               |
| 43                         | 23479.                           | 3515.                                                                                               | 0.004                                                                       | 535.2                         | 892.1               | 92.99                | 12.52                                          | 20.89                                          | 543                               |
| 44                         | 24028.                           | 3598.                                                                                               | 0.003                                                                       | 547.8                         | 913.0               | 93.47                | 12.53                                          | 20.90                                          | 549                               |
| 45                         | 24577.                           | 3680.                                                                                               | 0.003                                                                       | 560.4                         | 933.9               | 93.94                | 12.54                                          | 20.91                                          | 555                               |
| 46                         | 25126.                           | 3763.                                                                                               | 0.003                                                                       | 572.9                         | 954.8               | 94.40                | 12.56                                          | 20.92                                          | 561                               |
| 47                         | 25674.                           | 3846.                                                                                               | 0.003                                                                       | 585.5                         | 975.7               | 94.85                | 12.57                                          | 20.93                                          | 567                               |
| 48                         | 26223.                           | 3928.                                                                                               | 0.003                                                                       | 598.1                         | 996.7               | 95.29                | 12.59                                          | 20.95                                          | 573                               |
| 49                         | 26771.                           | 4010.                                                                                               | 0.003                                                                       | 610.8                         | 1017.7              | 95.73                | 12.61                                          | 20.97                                          | 579                               |
| 50                         | 27320.                           | 4093.                                                                                               | 0.003                                                                       | 623.4                         | 1038.6              | 96.15                | 12.64                                          | 20.99                                          | 585                               |
| 51                         | 27868.                           | 4175.                                                                                               | 0.003                                                                       | 636.1                         | 1059.6              | 96.57                | 12.67                                          | 21.02                                          | 590                               |
| 52                         | 28416.                           | 4258.                                                                                               | 0.003                                                                       | 648.8                         | 1080.7              | 96.97                | 12.70                                          | 21.05                                          | 596                               |
| 53                         | 28965.                           | 4340.                                                                                               | 0.003                                                                       | 661.5                         | 1101.7              | 97.38                | 12.73                                          | 21.08                                          | 601                               |
| 54                         | 29513.                           | 4423.                                                                                               | 0.003                                                                       | 674.3                         | 1122.8              | 97.77                | 12.77                                          | 21.12                                          | 606                               |
| 55                         | 30061.                           | 4505.                                                                                               | 0.003                                                                       | 687.1                         | 1144.0              | 98.16                | 12.81                                          | 21.16                                          | 611                               |
| 56                         | 30609.                           | 4587.                                                                                               | 0.003                                                                       | 699.9                         | 1165.2              | 98.54                | 12.86                                          | 21.20                                          | 617                               |
| 57                         | 31157.                           | 4670.                                                                                               | 0.003                                                                       | 712.8                         | 1186.4              | 98.92                | 12.91                                          | 21.25                                          | 622                               |
| 58                         | 31705.                           | 4752.                                                                                               | 0.003                                                                       | 725.8                         | 1207.7              | 99.29                | 12.96                                          | 21.31                                          | 627                               |
| 59                         | 32253.                           | 4834.                                                                                               | 0.003                                                                       | 738.8                         | 1229.0              | 99.65                | 13.02                                          | 21.37                                          | 631                               |
| 60                         | 32801.                           | 4917.                                                                                               | 0.003                                                                       | 751.9                         | 1250.4              | 100.01               | 13.09                                          | 21.43                                          | 636                               |
| 61                         | 33349.                           | 4999.                                                                                               | 0.002                                                                       | 765.0                         | 1271.9              | 100.37               | 13.16                                          | 21.50                                          | 641                               |
| 62                         | 33897.                           | 5081.                                                                                               | 0.002                                                                       | 778.2                         | 1293.4              | 100.72               | 13.23                                          | 21.57                                          | 645                               |
| 63                         | 34445.                           | 5164.                                                                                               | 0.002                                                                       | 791.5                         | 1315.0              | 101.06               | 13.31                                          | 21.64                                          | 650                               |
| 64                         | 34993.                           | 5246.                                                                                               | 0.002                                                                       | 804.9                         | 1336.7              | 101.40               | 13.39                                          | 21.73                                          | 654                               |
| 65                         | 35541.                           | 5328.                                                                                               | 0.002                                                                       | 818.3                         | 1358.5              | 101.74               | 13.48                                          | 21.81                                          | 658                               |
| 66                         | 36088.                           | 5411.                                                                                               | 0.002                                                                       | 831.8                         | 1380.3              | 102.07               | 13.57                                          | 21.90                                          | 663                               |
| 67                         | 36636.                           | 5493.                                                                                               | 0.002                                                                       | 845.5                         | 1402.3              | 102.40               | 13.66                                          | 22.00                                          | 667                               |
| 68                         | 37184.                           | 5575.                                                                                               | 0.002                                                                       | 859.2                         | 1424.3              | 102.73               | 13.76                                          | 22.10                                          | 671                               |
| 69                         | 37732.                           | 5657.                                                                                               | 0.002                                                                       | 873.0                         | 1446.5              | 103.05               | 13.87                                          | 22.20                                          | 675                               |
| 70                         | 38279.                           | 5740.                                                                                               | 0.002                                                                       | 886.9                         | 1468.7              | 103.37               | 13.98                                          | 22.31                                          | 679                               |
| 71                         | 38827.                           | 5822.                                                                                               | 0.002                                                                       | 901.0                         | 1491.1              | 103.69               | 14.10                                          | 22.43                                          | 682                               |
| 72                         | 39375.                           | 5904.                                                                                               | 0.002                                                                       | 915.2                         | 1513.6              | 104.01               | 14.21                                          | 22.55                                          | 686                               |
| 73                         | 39922.                           | 5986.                                                                                               | 0.002                                                                       | 929.4                         | 1536.2              | 104.32               | 14.34                                          | 22.67                                          | 690                               |
| 74                         | 40470.                           | 6069.                                                                                               | 0.002                                                                       | 943.8                         | 1558.9              | 104.63               | 14.47                                          | 22.80                                          | 693                               |
| 75                         | 41018.                           | 6151.                                                                                               | 0.002                                                                       | 958.4                         | 1581.8              | 104.93               | 14.60                                          | 22.93                                          | 697                               |
| 76                         | 41565.                           | 6233.                                                                                               | 0.002                                                                       | 973.1                         | 1604.8              | 105.24               | 14.73                                          | 23.06                                          | 700                               |
| 77                         | 42113.                           | 6315.                                                                                               | 0.002                                                                       | 987.9                         | 1627.9              | 105.54               | 14.87                                          | 23.20                                          | 704                               |
| 78                         | 42660.                           | 6397.                                                                                               | 0.002                                                                       | 1002.8                        | 1651.2              | 105.84               | 15.01                                          | 23.34                                          | 707                               |
| 79                         | 43208.                           | 6480.                                                                                               | 0.002                                                                       | 1017.9                        | 1674.6              | 106.14               | 15.16                                          | 23.49                                          | 710                               |
| 80                         | 43755.                           | 6562.                                                                                               | 0.002                                                                       | 1033.2                        | 1698.2              | 106.44               | 15.31                                          | 23.64                                          | 714                               |
| 81                         | 44303.                           | 6644.                                                                                               | 0.002                                                                       | 1048.6                        | 1721.9              | 106.73               | 15.46                                          | 23.79                                          | 717                               |
| 82                         | 44850.                           | 6726.                                                                                               | 0.002                                                                       | 1064.1                        | 1745.8              | 107.02               | 15.62                                          | 23.95                                          | 720                               |
| 83                         | 45398.                           | 6808.                                                                                               | 0.002                                                                       | 1079.8                        | 1769.8              | 107.31               | 15.78                                          | 24.10                                          | 723                               |
| 84                         | 45945.                           | 6891.                                                                                               | 0.002                                                                       | 1095.7                        | 1794.0              | 107.60               | 15.94                                          | 24.26                                          | 726                               |
| 85                         | 46493.                           | 6973.                                                                                               | 0.002                                                                       | 1111.7                        | 1818.3              | 107.89               | 16.10                                          | 24.43                                          | 729                               |
| 86                         | 47040.                           | 7055.                                                                                               | 0.002                                                                       | 1127.9                        | 1842.8              | 108.18               | 16.27                                          | 24.59                                          | 732                               |
| 87                         | 47588.                           | 7137.                                                                                               | 0.002                                                                       | 1144.2                        | 1867.5              | 108.46               | 16.43                                          | 24.76                                          | 735                               |
| 88                         | 48135.                           | 7219.                                                                                               | 0.002                                                                       | 1160.8                        | 1892.4              | 108.75               | 16.60                                          | 24.93                                          | 738                               |
| 89                         | 48683.                           | 7301.                                                                                               | 0.002                                                                       | 1177.5                        | 1917.4              | 109.03               | 16.77                                          | 25.10                                          | 741                               |
| 90                         | 49230.                           | 7384.                                                                                               | 0.002                                                                       | 1194.3                        | 1942.6              | 109.31               | 16.94                                          | 25.27                                          | 744                               |
| 91                         | 49778.                           | 7466.                                                                                               | 0.002                                                                       | 1211.4                        | 1967.9              | 109.59               | 17.12                                          | 25.44                                          | 747                               |
| 92                         | 50325.                           | 7548.                                                                                               | 0.002                                                                       | 1228.6                        | 1993.4              | 109.87               | 17.29                                          | 25.62                                          | 750                               |
| 93                         | 50872.                           | 7630.                                                                                               | 0.002                                                                       | 1246.0                        | 2019.2              | 110.15               | 17.47                                          | 25.79                                          | 753                               |
| 94                         | 51420.                           | 7712.                                                                                               | 0.002                                                                       | 1263.5                        | 2045.0              | 110.43               | 17.64                                          | 25.97                                          | 755                               |
| 95                         | 51967.                           | 7794.                                                                                               | 0.002                                                                       | 1281.3                        | 2071.1              | 110.70               | 17.82                                          | 26.14                                          | 758                               |
| 96                         | 52515.                           | 7877.                                                                                               | 0.002                                                                       | 1299.2                        | 2097.3              | 110.98               | 17.99                                          | 26.32                                          | 761                               |
| 97                         | 53062.                           | 7959.                                                                                               | 0.002                                                                       | 1317.2                        | 2123.7              | 111.25               | 18.17                                          | 26.49                                          | 764                               |
| 98                         | 53609.                           | 8041.                                                                                               | 0.002                                                                       | 1335.5                        | 2150.3              | 111.52               | 18.34                                          | 26.67                                          | 766                               |
| 99                         | 54157.                           | 8123.                                                                                               | 0.002                                                                       | 1353.9                        | 2177.1              | 111.79               | 18.52                                          | 26.84                                          | 769                               |
| 100                        | 54704.                           | 8205.                                                                                               | 0.002                                                                       | 1372.6                        | 2204.0              | 112.07               | 18.69                                          | 27.01                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

0.20 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 13.808                     | 26.17                            | 23322.                                                                                             | 9.402                                                                      | -622.9                        | -622.3              | 10.00                | 9.50                                           | 13.13                                          | 1273                              |
| 14                         | 26.23                            | 22864.                                                                                             | 9.370                                                                      | -620.3                        | -619.8              | 10.19                | 9.56                                           | 13.31                                          | 1265                              |
| 15                         | 26.52                            | 21390.                                                                                             | 9.136                                                                      | -606.6                        | -606.1              | 11.13                | 9.90                                           | 14.07                                          | 1236                              |
| 15.861                     | 26.80                            | 20155.                                                                                             | 8.946                                                                      | -594.1                        | -593.5              | 11.95                | 10.21                                          | 14.79                                          | 1211                              |
| 15.861                     | 6294.2                           | 1216.                                                                                              | 0.013                                                                      | 191.8                         | 319.4               | 69.51                | 12.64                                          | 21.81                                          | 325                               |
| 16                         | 6355.4                           | 1228.                                                                                              | 0.013                                                                      | 193.7                         | 322.5               | 69.70                | 12.63                                          | 21.78                                          | 326                               |
| 17                         | 6784.4                           | 1318.                                                                                              | 0.012                                                                      | 206.7                         | 344.1               | 71.02                | 12.58                                          | 21.59                                          | 337                               |
| 18                         | 7210.4                           | 1407.                                                                                              | 0.011                                                                      | 219.5                         | 365.7               | 72.25                | 12.56                                          | 21.46                                          | 348                               |
| 19                         | 7634.3                           | 1494.                                                                                              | 0.011                                                                      | 232.4                         | 387.1               | 73.40                | 12.54                                          | 21.37                                          | 358                               |
| 20                         | 8056.4                           | 1581.                                                                                              | 0.010                                                                      | 245.1                         | 408.4               | 74.50                | 12.53                                          | 21.29                                          | 368                               |
| 21                         | 8477.1                           | 1668.                                                                                              | 0.010                                                                      | 257.9                         | 429.7               | 75.54                | 12.52                                          | 21.23                                          | 377                               |
| 22                         | 8896.7                           | 1753.                                                                                              | 0.009                                                                      | 270.6                         | 450.9               | 76.52                | 12.51                                          | 21.19                                          | 386                               |
| 23                         | 9315.3                           | 1839.                                                                                              | 0.009                                                                      | 283.3                         | 472.1               | 77.46                | 12.51                                          | 21.15                                          | 395                               |
| 24                         | 9733.1                           | 1924.                                                                                              | 0.008                                                                      | 295.9                         | 493.2               | 78.36                | 12.51                                          | 21.11                                          | 404                               |
| 25                         | 10150.                           | 2009.                                                                                              | 0.008                                                                      | 308.6                         | 514.3               | 79.22                | 12.50                                          | 21.08                                          | 413                               |
| 26                         | 10567.                           | 2093.                                                                                              | 0.008                                                                      | 321.2                         | 535.3               | 80.05                | 12.50                                          | 21.06                                          | 421                               |
| 27                         | 10983.                           | 2177.                                                                                              | 0.008                                                                      | 333.8                         | 556.4               | 80.84                | 12.50                                          | 21.03                                          | 429                               |
| 28                         | 11398.                           | 2262.                                                                                              | 0.007                                                                      | 346.4                         | 577.4               | 81.61                | 12.50                                          | 21.01                                          | 437                               |
| 29                         | 11813.                           | 2346.                                                                                              | 0.007                                                                      | 359.0                         | 598.4               | 82.35                | 12.50                                          | 21.00                                          | 445                               |
| 30                         | 12228.                           | 2429.                                                                                              | 0.007                                                                      | 371.6                         | 619.4               | 83.06                | 12.49                                          | 20.98                                          | 453                               |
| 31                         | 12642.                           | 2513.                                                                                              | 0.007                                                                      | 384.2                         | 640.4               | 83.75                | 12.49                                          | 20.97                                          | 460                               |
| 32                         | 13056.                           | 2597.                                                                                              | 0.006                                                                      | 396.8                         | 661.4               | 84.41                | 12.49                                          | 20.96                                          | 468                               |
| 33                         | 13470.                           | 2680.                                                                                              | 0.006                                                                      | 409.3                         | 682.3               | 85.06                | 12.49                                          | 20.94                                          | 475                               |
| 34                         | 13884.                           | 2764.                                                                                              | 0.006                                                                      | 421.9                         | 703.2               | 85.68                | 12.49                                          | 20.93                                          | 482                               |
| 35                         | 14297.                           | 2847.                                                                                              | 0.006                                                                      | 434.4                         | 724.2               | 86.29                | 12.49                                          | 20.93                                          | 490                               |
| 36                         | 14710.                           | 2930.                                                                                              | 0.006                                                                      | 447.0                         | 745.1               | 86.88                | 12.49                                          | 20.92                                          | 497                               |
| 37                         | 15123.                           | 3013.                                                                                              | 0.005                                                                      | 459.5                         | 766.0               | 87.45                | 12.49                                          | 20.91                                          | 503                               |
| 38                         | 15536.                           | 3096.                                                                                              | 0.005                                                                      | 472.1                         | 786.9               | 88.01                | 12.50                                          | 20.91                                          | 510                               |
| 39                         | 15949.                           | 3179.                                                                                              | 0.005                                                                      | 484.6                         | 807.8               | 88.55                | 12.50                                          | 20.91                                          | 517                               |
| 40                         | 16361.                           | 3262.                                                                                              | 0.005                                                                      | 497.2                         | 828.7               | 89.08                | 12.50                                          | 20.91                                          | 524                               |
| 41                         | 16774.                           | 3345.                                                                                              | 0.005                                                                      | 509.7                         | 849.7               | 89.60                | 12.51                                          | 20.91                                          | 530                               |
| 42                         | 17186.                           | 3428.                                                                                              | 0.005                                                                      | 522.3                         | 870.6               | 90.10                | 12.51                                          | 20.91                                          | 537                               |
| 43                         | 17598.                           | 3511.                                                                                              | 0.005                                                                      | 534.8                         | 891.5               | 90.59                | 12.52                                          | 20.91                                          | 543                               |
| 44                         | 18011.                           | 3594.                                                                                              | 0.005                                                                      | 547.4                         | 912.4               | 91.07                | 12.53                                          | 20.92                                          | 549                               |
| 45                         | 18423.                           | 3676.                                                                                              | 0.004                                                                      | 560.0                         | 933.3               | 91.54                | 12.54                                          | 20.93                                          | 555                               |
| 46                         | 18834.                           | 3759.                                                                                              | 0.004                                                                      | 572.6                         | 954.2               | 92.00                | 12.56                                          | 20.94                                          | 561                               |
| 47                         | 19246.                           | 3842.                                                                                              | 0.004                                                                      | 585.2                         | 975.2               | 92.45                | 12.57                                          | 20.95                                          | 567                               |
| 48                         | 19658.                           | 3924.                                                                                              | 0.004                                                                      | 597.8                         | 996.2               | 92.90                | 12.59                                          | 20.97                                          | 573                               |
| 49                         | 20070.                           | 4007.                                                                                              | 0.004                                                                      | 610.4                         | 1017.1              | 93.33                | 12.62                                          | 20.99                                          | 579                               |
| 50                         | 20481.                           | 4090.                                                                                              | 0.004                                                                      | 623.1                         | 1038.1              | 93.75                | 12.64                                          | 21.01                                          | 584                               |
| 51                         | 20893.                           | 4172.                                                                                              | 0.004                                                                      | 635.8                         | 1059.1              | 94.17                | 12.67                                          | 21.03                                          | 590                               |
| 52                         | 21305.                           | 4255.                                                                                              | 0.004                                                                      | 648.5                         | 1080.2              | 94.58                | 12.70                                          | 21.06                                          | 596                               |
| 53                         | 21716.                           | 4337.                                                                                              | 0.004                                                                      | 661.2                         | 1101.3              | 94.98                | 12.73                                          | 21.09                                          | 601                               |
| 54                         | 22128.                           | 4420.                                                                                              | 0.004                                                                      | 674.0                         | 1122.4              | 95.37                | 12.77                                          | 21.13                                          | 606                               |
| 55                         | 22539.                           | 4502.                                                                                              | 0.004                                                                      | 686.8                         | 1143.5              | 95.76                | 12.81                                          | 21.17                                          | 611                               |
| 56                         | 22950.                           | 4585.                                                                                              | 0.004                                                                      | 699.7                         | 1164.7              | 96.14                | 12.86                                          | 21.22                                          | 617                               |
| 57                         | 23362.                           | 4667.                                                                                              | 0.004                                                                      | 712.6                         | 1186.0              | 96.52                | 12.91                                          | 21.26                                          | 622                               |
| 58                         | 23773.                           | 4750.                                                                                              | 0.003                                                                      | 725.5                         | 1207.3              | 96.89                | 12.97                                          | 21.32                                          | 627                               |
| 59                         | 24184.                           | 4832.                                                                                              | 0.003                                                                      | 738.5                         | 1228.6              | 97.25                | 13.02                                          | 21.38                                          | 631                               |
| 60                         | 24595.                           | 4915.                                                                                              | 0.003                                                                      | 751.6                         | 1250.0              | 97.61                | 13.09                                          | 21.44                                          | 636                               |
| 61                         | 25006.                           | 4997.                                                                                              | 0.003                                                                      | 764.7                         | 1271.5              | 97.97                | 13.16                                          | 21.50                                          | 641                               |
| 62                         | 25418.                           | 5079.                                                                                              | 0.003                                                                      | 778.0                         | 1293.0              | 98.32                | 13.23                                          | 21.58                                          | 645                               |
| 63                         | 25829.                           | 5162.                                                                                              | 0.003                                                                      | 791.2                         | 1314.7              | 98.66                | 13.31                                          | 21.65                                          | 650                               |
| 64                         | 26240.                           | 5244.                                                                                              | 0.003                                                                      | 804.6                         | 1336.4              | 99.01                | 13.39                                          | 21.73                                          | 654                               |
| 65                         | 26651.                           | 5326.                                                                                              | 0.003                                                                      | 818.1                         | 1358.1              | 99.34                | 13.48                                          | 21.82                                          | 658                               |
| 66                         | 27062.                           | 5409.                                                                                              | 0.003                                                                      | 831.6                         | 1380.0              | 99.68                | 13.57                                          | 21.91                                          | 663                               |
| 67                         | 27473.                           | 5491.                                                                                              | 0.003                                                                      | 845.2                         | 1402.0              | 100.01               | 13.66                                          | 22.01                                          | 667                               |
| 68                         | 27884.                           | 5573.                                                                                              | 0.003                                                                      | 858.9                         | 1424.0              | 100.34               | 13.77                                          | 22.11                                          | 671                               |
| 69                         | 28295.                           | 5656.                                                                                              | 0.003                                                                      | 872.8                         | 1446.2              | 100.66               | 13.87                                          | 22.21                                          | 675                               |
| 70                         | 28706.                           | 5738.                                                                                              | 0.003                                                                      | 886.7                         | 1468.4              | 100.98               | 13.98                                          | 22.32                                          | 679                               |
| 71                         | 29117.                           | 5820.                                                                                              | 0.003                                                                      | 900.8                         | 1490.8              | 101.30               | 14.10                                          | 22.43                                          | 682                               |
| 72                         | 29527.                           | 5903.                                                                                              | 0.003                                                                      | 914.9                         | 1513.3              | 101.61               | 14.21                                          | 22.55                                          | 686                               |
| 73                         | 29938.                           | 5985.                                                                                              | 0.003                                                                      | 929.2                         | 1535.9              | 101.92               | 14.34                                          | 22.68                                          | 690                               |
| 74                         | 30349.                           | 6067.                                                                                              | 0.003                                                                      | 943.6                         | 1558.7              | 102.23               | 14.47                                          | 22.80                                          | 693                               |
| 75                         | 30760.                           | 6150.                                                                                              | 0.003                                                                      | 958.2                         | 1581.5              | 102.54               | 14.60                                          | 22.93                                          | 697                               |
| 76                         | 31171.                           | 6232.                                                                                              | 0.003                                                                      | 972.9                         | 1604.5              | 102.84               | 14.73                                          | 23.07                                          | 700                               |
| 77                         | 31582.                           | 6314.                                                                                              | 0.003                                                                      | 987.7                         | 1627.7              | 103.15               | 14.87                                          | 23.21                                          | 704                               |
| 78                         | 31993.                           | 6396.                                                                                              | 0.003                                                                      | 1002.6                        | 1651.0              | 103.45               | 15.02                                          | 23.35                                          | 707                               |
| 79                         | 32403.                           | 6479.                                                                                              | 0.003                                                                      | 1017.7                        | 1674.4              | 103.75               | 15.16                                          | 23.49                                          | 710                               |
| 80                         | 32814.                           | 6561.                                                                                              | 0.003                                                                      | 1033.0                        | 1697.9              | 104.04               | 15.31                                          | 23.64                                          | 714                               |
| 81                         | 33225.                           | 6643.                                                                                              | 0.002                                                                      | 1048.4                        | 1721.7              | 104.34               | 15.46                                          | 23.80                                          | 717                               |
| 82                         | 33636.                           | 6725.                                                                                              | 0.002                                                                      | 1063.9                        | 1745.5              | 104.63               | 15.62                                          | 23.95                                          | 720                               |
| 83                         | 34046.                           | 6808.                                                                                              | 0.002                                                                      | 1079.6                        | 1769.6              | 104.92               | 15.78                                          | 24.11                                          | 723                               |
| 84                         | 34457.                           | 6890.                                                                                              | 0.002                                                                      | 1095.5                        | 1793.8              | 105.21               | 15.94                                          | 24.27                                          | 726                               |
| 85                         | 34868.                           | 6972.                                                                                              | 0.002                                                                      | 1111.5                        | 1818.1              | 105.50               | 16.10                                          | 24.43                                          | 729                               |
| 86                         | 35278.                           | 7054.                                                                                              | 0.002                                                                      | 1127.7                        | 1842.6              | 105.79               | 16.27                                          | 24.60                                          | 732                               |
| 87                         | 35689.                           | 7136.                                                                                              | 0.002                                                                      | 1144.1                        | 1867.3              | 106.07               | 16.43                                          | 24.76                                          | 735                               |
| 88                         | 36100.                           | 7219.                                                                                              | 0.002                                                                      | 1160.6                        | 1892.2              | 106.35               | 16.60                                          | 24.93                                          | 738                               |
| 89                         | 36510.                           | 7301.                                                                                              | 0.002                                                                      | 1177.3                        | 1917.2              | 106.64               | 16.77                                          | 25.10                                          | 741                               |
| 90                         | 36921.                           | 7383.                                                                                              | 0.002                                                                      | 1194.2                        | 1942.4              | 106.92               | 16.95                                          | 25.27                                          | 744                               |
| 91                         | 37332.                           | 7465.                                                                                              | 0.002                                                                      | 1211.2                        | 1967.7              | 107.20               | 17.12                                          | 25.45                                          | 747                               |
| 92                         | 37742.                           | 7547.                                                                                              | 0.002                                                                      | 1228.4                        | 1993.3              | 107.48               | 17.29                                          | 25.62                                          | 750                               |
| 93                         | 38153.                           | 7630.                                                                                              | 0.002                                                                      | 1245.8                        | 2019.0              | 107.76               | 17.47                                          | 25.79                                          | 753                               |
| 94                         | 38564.                           | 7712.                                                                                              | 0.002                                                                      | 1263.4                        | 2044.9              | 108.03               | 17.64                                          | 25.97                                          | 755                               |
| 95                         | 38974.                           | 7794.                                                                                              | 0.002                                                                      | 1281.1                        | 2070.9              | 108.31               | 17.82                                          | 26.14                                          | 758                               |
| 96                         | 39385.                           | 7876.                                                                                              | 0.002                                                                      | 1299.0                        | 2097.1              | 108.58               | 17.99                                          | 26.32                                          | 761                               |
| 97                         | 39796.                           | 7958.                                                                                              | 0.002                                                                      | 1317.1                        | 2123.6              | 108.86               | 18.17                                          | 26.49                                          | 764                               |
| 98                         | 40206.                           | 8041.                                                                                              | 0.002                                                                      | 1335.4                        | 2150.1              | 109.13               | 18.34                                          | 26.67                                          | 767                               |
| 99                         | 40617.                           | 8123.                                                                                              | 0.002                                                                      | 1353.8                        | 2176.9              | 109.40               | 18.52                                          | 26.84                                          | 769                               |
| 100                        | 41027.                           | 8205.                                                                                              | 0.002                                                                      | 1372.4                        | 2203.8              | 109.67               | 18.69                                          | 27.02                                          | 772                               |

• TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, 150BAR5-CONTINUED

0.30 ATMOSPHERE 150BAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>P</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>V</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.811                   | 26.17                            | 23332.                                                                                              | 9.402                                                                       | -622.9                        | -622.1              | 10.00                | 9.50                                           | 13.13                                          | 1273                              |
| 14                         | 26.23                            | 22882.                                                                                              | 9.371                                                                       | -620.3                        | -619.5              | 10.19                | 9.56                                           | 13.31                                          | 1265                              |
| 15                         | 26.52                            | 21409.                                                                                              | 9.138                                                                       | -606.6                        | -605.8              | 11.13                | 9.90                                           | 14.07                                          | 1237                              |
| 16                         | 26.84                            | 19979.                                                                                              | 8.923                                                                       | -592.1                        | -591.2              | 12.07                | 10.26                                          | 14.91                                          | 1208                              |
| * 16.802                   | 27.11                            | 18605.                                                                                              | 8.778                                                                       | -579.7                        | -578.9              | 12.83                | 10.54                                          | 15.73                                          | 1181                              |
| * 16.802                   | 4397.5                           | 1259.                                                                                               | 0.019                                                                       | 201.1                         | 334.7               | 67.20                | 12.72                                          | 22.22                                          | 332                               |
| 17                         | 4455.4                           | 1277.                                                                                               | 0.019                                                                       | 203.7                         | 339.1               | 67.46                | 12.70                                          | 22.15                                          | 335                               |
| 18                         | 4745.9                           | 1377.                                                                                               | 0.018                                                                       | 216.9                         | 361.1               | 68.72                | 12.64                                          | 21.90                                          | 345                               |
| 19                         | 5033.7                           | 1461.                                                                                               | 0.017                                                                       | 229.9                         | 383.0               | 69.90                | 12.60                                          | 21.72                                          | 356                               |
| 20                         | 5319.5                           | 1557.                                                                                               | 0.016                                                                       | 242.9                         | 404.6               | 71.01                | 12.57                                          | 21.59                                          | 366                               |
| 21                         | 5603.8                           | 1637.                                                                                               | 0.015                                                                       | 255.8                         | 426.1               | 72.06                | 12.55                                          | 21.49                                          | 376                               |
| 22                         | 5886.9                           | 1727.                                                                                               | 0.014                                                                       | 268.6                         | 447.6               | 73.06                | 12.54                                          | 21.41                                          | 385                               |
| 23                         | 6168.9                           | 1814.                                                                                               | 0.013                                                                       | 281.4                         | 469.0               | 74.01                | 12.53                                          | 21.34                                          | 394                               |
| 24                         | 6450.1                           | 1901.                                                                                               | 0.013                                                                       | 294.2                         | 490.3               | 74.92                | 12.53                                          | 21.29                                          | 403                               |
| 25                         | 6730.5                           | 1987.                                                                                               | 0.012                                                                       | 306.9                         | 511.5               | 75.79                | 12.52                                          | 21.24                                          | 412                               |
| 26                         | 7010.3                           | 2073.                                                                                               | 0.012                                                                       | 319.7                         | 532.8               | 76.62                | 12.52                                          | 21.20                                          | 420                               |
| 27                         | 7289.6                           | 2158.                                                                                               | 0.011                                                                       | 332.4                         | 553.9               | 77.42                | 12.51                                          | 21.16                                          | 428                               |
| 28                         | 7568.4                           | 2243.                                                                                               | 0.011                                                                       | 345.0                         | 575.1               | 78.19                | 12.51                                          | 21.13                                          | 436                               |
| 29                         | 7846.7                           | 2328.                                                                                               | 0.011                                                                       | 357.7                         | 596.2               | 78.93                | 12.51                                          | 21.11                                          | 444                               |
| 30                         | 8124.7                           | 2413.                                                                                               | 0.010                                                                       | 370.3                         | 617.3               | 79.64                | 12.51                                          | 21.08                                          | 452                               |
| 31                         | 8402.4                           | 2498.                                                                                               | 0.010                                                                       | 383.0                         | 638.4               | 80.33                | 12.50                                          | 21.06                                          | 460                               |
| 32                         | 8679.7                           | 2582.                                                                                               | 0.010                                                                       | 395.6                         | 659.4               | 81.00                | 12.50                                          | 21.04                                          | 467                               |
| 33                         | 8956.8                           | 2666.                                                                                               | 0.009                                                                       | 408.2                         | 680.5               | 81.65                | 12.50                                          | 21.02                                          | 475                               |
| 34                         | 9233.6                           | 2750.                                                                                               | 0.009                                                                       | 420.8                         | 701.5               | 82.28                | 12.50                                          | 21.01                                          | 482                               |
| 35                         | 9510.3                           | 2834.                                                                                               | 0.009                                                                       | 433.4                         | 722.5               | 82.89                | 12.50                                          | 21.00                                          | 489                               |
| 36                         | 9786.7                           | 2918.                                                                                               | 0.008                                                                       | 446.0                         | 743.5               | 83.48                | 12.50                                          | 20.98                                          | 496                               |
| 37                         | 10063.                           | 3002.                                                                                               | 0.008                                                                       | 458.6                         | 764.4               | 84.05                | 12.50                                          | 20.98                                          | 503                               |
| 38                         | 10339.                           | 3085.                                                                                               | 0.008                                                                       | 471.1                         | 785.4               | 84.61                | 12.50                                          | 20.97                                          | 510                               |
| 39                         | 10615.                           | 3169.                                                                                               | 0.008                                                                       | 483.7                         | 806.4               | 85.16                | 12.51                                          | 20.96                                          | 517                               |
| 40                         | 10891.                           | 3252.                                                                                               | 0.008                                                                       | 496.3                         | 827.3               | 85.69                | 12.51                                          | 20.96                                          | 523                               |
| 41                         | 11166.                           | 3335.                                                                                               | 0.007                                                                       | 508.9                         | 848.3               | 86.20                | 12.51                                          | 20.95                                          | 530                               |
| 42                         | 11442.                           | 3419.                                                                                               | 0.007                                                                       | 521.4                         | 869.3               | 86.71                | 12.52                                          | 20.95                                          | 536                               |
| 43                         | 11717.                           | 3502.                                                                                               | 0.007                                                                       | 534.0                         | 890.2               | 87.20                | 12.53                                          | 20.96                                          | 543                               |
| 44                         | 11993.                           | 3585.                                                                                               | 0.007                                                                       | 546.6                         | 911.2               | 87.68                | 12.54                                          | 20.96                                          | 549                               |
| 45                         | 12268.                           | 3668.                                                                                               | 0.007                                                                       | 559.2                         | 932.1               | 88.15                | 12.55                                          | 20.97                                          | 555                               |
| 46                         | 12543.                           | 3751.                                                                                               | 0.007                                                                       | 571.8                         | 953.1               | 88.62                | 12.56                                          | 20.97                                          | 561                               |
| 47                         | 12818.                           | 3834.                                                                                               | 0.006                                                                       | 584.4                         | 974.1               | 89.07                | 12.58                                          | 20.99                                          | 567                               |
| 48                         | 13093.                           | 3917.                                                                                               | 0.006                                                                       | 597.1                         | 995.1               | 89.51                | 12.60                                          | 21.00                                          | 573                               |
| 49                         | 13368.                           | 4000.                                                                                               | 0.006                                                                       | 609.7                         | 1016.1              | 89.94                | 12.62                                          | 21.02                                          | 579                               |
| 50                         | 13643.                           | 4083.                                                                                               | 0.006                                                                       | 622.4                         | 1037.1              | 90.37                | 12.64                                          | 21.04                                          | 584                               |
| 51                         | 13918.                           | 4166.                                                                                               | 0.006                                                                       | 635.1                         | 1058.2              | 90.78                | 12.67                                          | 21.06                                          | 590                               |
| 52                         | 14193.                           | 4249.                                                                                               | 0.006                                                                       | 647.8                         | 1079.2              | 91.19                | 12.70                                          | 21.09                                          | 595                               |
| 53                         | 14468.                           | 4331.                                                                                               | 0.006                                                                       | 660.6                         | 1100.4              | 91.60                | 12.74                                          | 21.12                                          | 601                               |
| 54                         | 14742.                           | 4414.                                                                                               | 0.006                                                                       | 673.4                         | 1121.5              | 91.99                | 12.77                                          | 21.16                                          | 606                               |
| 55                         | 15017.                           | 4497.                                                                                               | 0.005                                                                       | 686.2                         | 1142.7              | 92.38                | 12.82                                          | 21.20                                          | 611                               |
| 56                         | 15291.                           | 4580.                                                                                               | 0.005                                                                       | 699.1                         | 1163.9              | 92.76                | 12.86                                          | 21.24                                          | 616                               |
| 57                         | 15566.                           | 4662.                                                                                               | 0.005                                                                       | 712.0                         | 1185.2              | 93.14                | 12.91                                          | 21.29                                          | 622                               |
| 58                         | 15840.                           | 4745.                                                                                               | 0.005                                                                       | 725.0                         | 1206.5              | 93.51                | 12.97                                          | 21.34                                          | 626                               |
| 59                         | 16115.                           | 4827.                                                                                               | 0.005                                                                       | 738.0                         | 1227.8              | 93.87                | 13.03                                          | 21.40                                          | 631                               |
| 60                         | 16389.                           | 4910.                                                                                               | 0.005                                                                       | 751.1                         | 1249.3              | 94.23                | 13.09                                          | 21.46                                          | 636                               |
| 61                         | 16664.                           | 4993.                                                                                               | 0.005                                                                       | 764.2                         | 1270.8              | 94.59                | 13.16                                          | 21.52                                          | 641                               |
| 62                         | 16938.                           | 5075.                                                                                               | 0.005                                                                       | 777.4                         | 1292.3              | 94.94                | 13.23                                          | 21.60                                          | 645                               |
| 63                         | 17212.                           | 5158.                                                                                               | 0.005                                                                       | 790.7                         | 1313.9              | 95.29                | 13.31                                          | 21.67                                          | 650                               |
| 64                         | 17487.                           | 5240.                                                                                               | 0.005                                                                       | 804.1                         | 1335.7              | 95.63                | 13.39                                          | 21.75                                          | 654                               |
| 65                         | 17761.                           | 5323.                                                                                               | 0.005                                                                       | 817.6                         | 1357.5              | 95.97                | 13.48                                          | 21.84                                          | 658                               |
| 66                         | 18035.                           | 5405.                                                                                               | 0.005                                                                       | 831.1                         | 1379.3              | 96.30                | 13.57                                          | 21.93                                          | 663                               |
| 67                         | 18309.                           | 5488.                                                                                               | 0.004                                                                       | 844.8                         | 1401.3              | 96.63                | 13.67                                          | 22.02                                          | 667                               |
| 68                         | 18584.                           | 5571.                                                                                               | 0.004                                                                       | 858.5                         | 1423.4              | 96.96                | 13.77                                          | 22.12                                          | 671                               |
| 69                         | 18858.                           | 5653.                                                                                               | 0.004                                                                       | 872.3                         | 1445.6              | 97.28                | 13.87                                          | 22.23                                          | 675                               |
| 70                         | 19132.                           | 5735.                                                                                               | 0.004                                                                       | 886.3                         | 1467.8              | 97.60                | 13.98                                          | 22.33                                          | 679                               |
| 71                         | 19406.                           | 5818.                                                                                               | 0.004                                                                       | 900.3                         | 1490.2              | 97.92                | 14.10                                          | 22.45                                          | 682                               |
| 72                         | 19680.                           | 5900.                                                                                               | 0.004                                                                       | 914.5                         | 1512.7              | 98.23                | 14.22                                          | 22.57                                          | 686                               |
| 73                         | 19954.                           | 5982.                                                                                               | 0.004                                                                       | 928.8                         | 1535.4              | 98.55                | 14.34                                          | 22.69                                          | 690                               |
| 74                         | 20229.                           | 6065.                                                                                               | 0.004                                                                       | 943.2                         | 1558.1              | 98.86                | 14.47                                          | 22.81                                          | 693                               |
| 75                         | 20503.                           | 6147.                                                                                               | 0.004                                                                       | 957.8                         | 1581.0              | 99.16                | 14.60                                          | 22.95                                          | 697                               |
| 76                         | 20777.                           | 6229.                                                                                               | 0.004                                                                       | 972.5                         | 1604.0              | 99.47                | 14.73                                          | 23.08                                          | 700                               |
| 77                         | 21051.                           | 6312.                                                                                               | 0.004                                                                       | 987.3                         | 1627.2              | 99.77                | 14.87                                          | 23.22                                          | 704                               |
| 78                         | 21325.                           | 6394.                                                                                               | 0.004                                                                       | 1002.2                        | 1650.5              | 100.07               | 15.02                                          | 23.36                                          | 707                               |
| 79                         | 21599.                           | 6477.                                                                                               | 0.004                                                                       | 1017.3                        | 1673.9              | 100.37               | 15.16                                          | 23.51                                          | 710                               |
| 80                         | 21873.                           | 6559.                                                                                               | 0.004                                                                       | 1032.6                        | 1697.5              | 100.67               | 15.31                                          | 23.65                                          | 714                               |
| 81                         | 22147.                           | 6641.                                                                                               | 0.004                                                                       | 1048.0                        | 1721.2              | 100.96               | 15.46                                          | 23.81                                          | 717                               |
| 82                         | 22421.                           | 6724.                                                                                               | 0.004                                                                       | 1063.6                        | 1745.1              | 101.25               | 15.62                                          | 23.96                                          | 720                               |
| 83                         | 22695.                           | 6806.                                                                                               | 0.004                                                                       | 1079.3                        | 1769.1              | 101.54               | 15.78                                          | 24.12                                          | 723                               |
| 84                         | 22969.                           | 6888.                                                                                               | 0.004                                                                       | 1095.1                        | 1793.3              | 101.83               | 15.94                                          | 24.28                                          | 726                               |
| 85                         | 23243.                           | 6971.                                                                                               | 0.004                                                                       | 1111.2                        | 1817.7              | 102.12               | 16.10                                          | 24.44                                          | 729                               |
| 86                         | 23517.                           | 7053.                                                                                               | 0.003                                                                       | 1127.4                        | 1842.2              | 102.41               | 16.27                                          | 24.61                                          | 732                               |
| 87                         | 23790.                           | 7135.                                                                                               | 0.003                                                                       | 1143.7                        | 1866.9              | 102.70               | 16.43                                          | 24.77                                          | 735                               |
| 88                         | 24064.                           | 7217.                                                                                               | 0.003                                                                       | 1160.3                        | 1891.8              | 102.98               | 16.60                                          | 24.94                                          | 738                               |
| 89                         | 24338.                           | 7300.                                                                                               | 0.003                                                                       | 1177.0                        | 1916.8              | 103.26               | 16.77                                          | 25.11                                          | 741                               |
| 90                         | 24612.                           | 7382.                                                                                               | 0.003                                                                       | 1193.8                        | 1942.0              | 103.54               | 16.95                                          | 25.28                                          | 744                               |
| 91                         | 24886.                           | 7464.                                                                                               | 0.003                                                                       | 1210.9                        | 1967.4              | 103.82               | 17.12                                          | 25.45                                          | 747                               |
| 92                         | 25160.                           | 7547.                                                                                               | 0.003                                                                       | 1228.1                        | 1992.9              | 104.10               | 17.29                                          | 25.63                                          | 750                               |
| 93                         | 25434.                           | 7629.                                                                                               | 0.003                                                                       | 1245.5                        | 2018.6              | 104.38               | 17.47                                          | 25.80                                          | 753                               |
| 94                         | 25708.                           | 7711.                                                                                               | 0.003                                                                       | 1263.0                        | 2044.5              | 104.66               | 17.64                                          | 25.98                                          | 755                               |
| 95                         | 25982.                           | 7793.                                                                                               | 0.003                                                                       | 1280.8                        | 2070.6              | 104.93               | 17.82                                          | 26.15                                          | 758                               |
| 96                         | 26255.                           | 7874.                                                                                               | 0.003                                                                       | 1298.7                        | 2096.8              | 105.21               | 17.99                                          | 26.33                                          | 761                               |
| 97                         | 26529.                           | 7956.                                                                                               | 0.003                                                                       | 1316.8                        | 2123.2              | 105.48               | 18.17                                          | 26.50                                          | 764                               |
| 98                         | 26803.                           | 8038.                                                                                               | 0.003                                                                       | 1335.1                        | 2149.8              | 105.76               | 18.34                                          | 26.68                                          | 767                               |
| 99                         | 27077.                           | 8120.                                                                                               | 0.003                                                                       | 1353.5                        | 2176.6              | 106.03               | 18.52                                          | 26.85                                          | 769                               |
| 100                        | 27351.                           | 8204.                                                                                               | 0.003                                                                       | 1372.1                        | 2203.5              | 106.30               | 18.69                                          | 27.02                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 0.40 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial p$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>p</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.814                   | 26.17                            | 23343.                                                                                           | 9.403                                                                       | -622.8                        | -621.8              | 10.01                | 9.50                                           | 13.13                                          | 1273                              |
| 14                         | 26.22                            | 22907.                                                                                           | 9.372                                                                       | -620.4                        | -619.3              | 10.18                | 9.56                                           | 13.31                                          | 1265                              |
| 15                         | 26.51                            | 21428.                                                                                           | 9.141                                                                       | -606.7                        | -605.6              | 11.13                | 9.90                                           | 14.07                                          | 1237                              |
| 16                         | 26.83                            | 19998.                                                                                           | 8.926                                                                       | -592.1                        | -591.0              | 12.07                | 10.26                                          | 14.91                                          | 1209                              |
| 17                         | 27.18                            | 18347.                                                                                           | 8.749                                                                       | -576.6                        | -575.5              | 13.01                | 10.61                                          | 15.92                                          | 1176                              |
| * 17.532                   | 27.37                            | 17563.                                                                                           | 8.663                                                                       | -568.0                        | -566.9              | 13.51                | 10.79                                          | 16.48                                          | 1161                              |
| * 17.532                   | 3407.8                           | 1287.                                                                                            | 0.025                                                                       | 207.8                         | 345.9               | 65.58                | 12.79                                          | 22.59                                          | 338                               |
| 18                         | 3512.0                           | 1332.                                                                                            | 0.024                                                                       | 214.1                         | 356.4               | 66.17                | 12.74                                          | 22.41                                          | 343                               |
| 19                         | 3732.3                           | 1426.                                                                                            | 0.022                                                                       | 227.4                         | 378.7               | 67.37                | 12.67                                          | 22.12                                          | 354                               |
| 20                         | 3950.2                           | 1519.                                                                                            | 0.021                                                                       | 240.6                         | 400.7               | 68.50                | 12.62                                          | 21.91                                          | 364                               |
| 21                         | 4166.5                           | 1610.                                                                                            | 0.020                                                                       | 253.7                         | 422.5               | 69.57                | 12.59                                          | 21.76                                          | 374                               |
| 22                         | 4381.5                           | 1700.                                                                                            | 0.019                                                                       | 266.6                         | 444.2               | 70.58                | 12.57                                          | 21.64                                          | 383                               |
| 23                         | 4595.3                           | 1789.                                                                                            | 0.018                                                                       | 279.6                         | 465.8               | 71.54                | 12.56                                          | 21.55                                          | 393                               |
| 24                         | 4808.3                           | 1877.                                                                                            | 0.017                                                                       | 292.4                         | 487.3               | 72.45                | 12.55                                          | 21.47                                          | 402                               |
| 25                         | 5020.4                           | 1965.                                                                                            | 0.017                                                                       | 305.3                         | 508.8               | 73.33                | 12.54                                          | 21.40                                          | 411                               |
| 26                         | 5231.9                           | 2057.                                                                                            | 0.016                                                                       | 318.1                         | 530.1               | 74.17                | 12.53                                          | 21.34                                          | 419                               |
| 27                         | 5442.9                           | 2139.                                                                                            | 0.015                                                                       | 330.9                         | 551.5               | 74.97                | 12.53                                          | 21.30                                          | 427                               |
| 28                         | 5653.3                           | 2225.                                                                                            | 0.015                                                                       | 343.6                         | 572.7               | 75.74                | 12.52                                          | 21.25                                          | 436                               |
| 29                         | 5863.4                           | 2311.                                                                                            | 0.014                                                                       | 356.3                         | 594.0               | 76.49                | 12.52                                          | 21.22                                          | 444                               |
| 30                         | 6073.0                           | 2397.                                                                                            | 0.014                                                                       | 369.0                         | 615.2               | 77.21                | 12.52                                          | 21.18                                          | 452                               |
| 31                         | 6282.3                           | 2487.                                                                                            | 0.013                                                                       | 381.7                         | 636.3               | 77.90                | 12.51                                          | 21.15                                          | 459                               |
| 32                         | 6491.3                           | 2567.                                                                                            | 0.013                                                                       | 394.4                         | 657.5               | 78.57                | 12.51                                          | 21.13                                          | 467                               |
| 33                         | 6700.0                           | 2657.                                                                                            | 0.012                                                                       | 407.0                         | 678.6               | 79.22                | 12.51                                          | 21.11                                          | 474                               |
| 34                         | 6908.5                           | 2737.                                                                                            | 0.012                                                                       | 419.7                         | 699.7               | 79.85                | 12.51                                          | 21.08                                          | 482                               |
| 35                         | 7116.8                           | 2821.                                                                                            | 0.012                                                                       | 432.3                         | 720.8               | 80.46                | 12.51                                          | 21.07                                          | 489                               |
| 36                         | 7324.8                           | 2906.                                                                                            | 0.011                                                                       | 445.0                         | 741.8               | 81.06                | 12.51                                          | 21.05                                          | 496                               |
| 37                         | 7532.7                           | 2990.                                                                                            | 0.011                                                                       | 457.6                         | 762.9               | 81.63                | 12.51                                          | 21.04                                          | 503                               |
| 38                         | 7740.4                           | 3074.                                                                                            | 0.011                                                                       | 470.2                         | 783.9               | 82.19                | 12.51                                          | 21.03                                          | 510                               |
| 39                         | 7948.0                           | 3158.                                                                                            | 0.010                                                                       | 482.8                         | 804.9               | 82.74                | 12.51                                          | 21.02                                          | 516                               |
| 40                         | 8155.4                           | 3247.                                                                                            | 0.010                                                                       | 495.4                         | 825.9               | 83.27                | 12.51                                          | 21.01                                          | 523                               |
| 41                         | 8362.7                           | 3326.                                                                                            | 0.010                                                                       | 508.0                         | 846.9               | 83.79                | 12.52                                          | 21.00                                          | 530                               |
| 42                         | 8569.9                           | 3409.                                                                                            | 0.010                                                                       | 520.6                         | 867.9               | 84.30                | 12.52                                          | 21.00                                          | 536                               |
| 43                         | 8776.9                           | 3493.                                                                                            | 0.009                                                                       | 533.2                         | 888.9               | 84.79                | 12.53                                          | 21.00                                          | 542                               |
| 44                         | 8983.9                           | 3577.                                                                                            | 0.009                                                                       | 545.8                         | 909.9               | 85.27                | 12.54                                          | 21.00                                          | 549                               |
| 45                         | 9190.8                           | 3660.                                                                                            | 0.009                                                                       | 558.4                         | 931.0               | 85.75                | 12.55                                          | 21.00                                          | 555                               |
| 46                         | 9397.6                           | 3743.                                                                                            | 0.009                                                                       | 571.1                         | 952.0               | 86.21                | 12.57                                          | 21.01                                          | 561                               |
| 47                         | 9604.3                           | 3827.                                                                                            | 0.009                                                                       | 583.7                         | 973.0               | 86.66                | 12.58                                          | 21.02                                          | 567                               |
| 48                         | 9810.9                           | 3910.                                                                                            | 0.008                                                                       | 596.4                         | 994.0               | 87.10                | 12.60                                          | 21.03                                          | 573                               |
| 49                         | 10018.                           | 3993.                                                                                            | 0.008                                                                       | 609.0                         | 1015.0              | 87.54                | 12.62                                          | 21.05                                          | 579                               |
| 50                         | 10224.                           | 4076.                                                                                            | 0.008                                                                       | 621.7                         | 1036.1              | 87.96                | 12.65                                          | 21.07                                          | 584                               |
| 51                         | 10430.                           | 4159.                                                                                            | 0.008                                                                       | 634.4                         | 1057.2              | 88.38                | 12.67                                          | 21.09                                          | 590                               |
| 52                         | 10637.                           | 4247.                                                                                            | 0.008                                                                       | 647.2                         | 1078.3              | 88.79                | 12.70                                          | 21.12                                          | 595                               |
| 53                         | 10843.                           | 4328.                                                                                            | 0.008                                                                       | 660.0                         | 1099.4              | 89.19                | 12.74                                          | 21.15                                          | 601                               |
| 54                         | 11049.                           | 4408.                                                                                            | 0.007                                                                       | 672.8                         | 1120.6              | 89.59                | 12.78                                          | 21.18                                          | 606                               |
| 55                         | 11256.                           | 4491.                                                                                            | 0.007                                                                       | 685.6                         | 1141.8              | 89.98                | 12.82                                          | 21.22                                          | 611                               |
| 56                         | 11462.                           | 4574.                                                                                            | 0.007                                                                       | 698.5                         | 1163.0              | 90.36                | 12.87                                          | 21.26                                          | 616                               |
| 57                         | 11668.                           | 4657.                                                                                            | 0.007                                                                       | 711.4                         | 1184.3              | 90.74                | 12.92                                          | 21.31                                          | 621                               |
| 58                         | 11874.                           | 4740.                                                                                            | 0.007                                                                       | 724.4                         | 1205.7              | 91.11                | 12.97                                          | 21.36                                          | 626                               |
| 59                         | 12080.                           | 4823.                                                                                            | 0.007                                                                       | 737.4                         | 1227.0              | 91.47                | 13.03                                          | 21.42                                          | 631                               |
| 60                         | 12286.                           | 4906.                                                                                            | 0.007                                                                       | 750.5                         | 1248.5              | 91.83                | 13.09                                          | 21.48                                          | 636                               |
| 61                         | 12492.                           | 4988.                                                                                            | 0.007                                                                       | 763.7                         | 1270.0              | 92.19                | 13.16                                          | 21.54                                          | 641                               |
| 62                         | 12698.                           | 5071.                                                                                            | 0.006                                                                       | 776.9                         | 1291.6              | 92.54                | 13.23                                          | 21.61                                          | 645                               |
| 63                         | 12904.                           | 5154.                                                                                            | 0.006                                                                       | 790.2                         | 1313.2              | 92.89                | 13.31                                          | 21.69                                          | 650                               |
| 64                         | 13110.                           | 5236.                                                                                            | 0.006                                                                       | 803.6                         | 1335.0              | 93.23                | 13.39                                          | 21.77                                          | 654                               |
| 65                         | 13316.                           | 5319.                                                                                            | 0.006                                                                       | 817.1                         | 1356.8              | 93.57                | 13.48                                          | 21.85                                          | 658                               |
| 66                         | 13522.                           | 5402.                                                                                            | 0.006                                                                       | 830.6                         | 1378.7              | 93.90                | 13.57                                          | 21.94                                          | 663                               |
| 67                         | 13728.                           | 5484.                                                                                            | 0.006                                                                       | 844.3                         | 1400.7              | 94.23                | 13.67                                          | 22.04                                          | 667                               |
| 68                         | 13934.                           | 5567.                                                                                            | 0.006                                                                       | 858.0                         | 1422.8              | 94.56                | 13.77                                          | 22.14                                          | 671                               |
| 69                         | 14139.                           | 5649.                                                                                            | 0.006                                                                       | 871.9                         | 1444.9              | 94.88                | 13.87                                          | 22.24                                          | 675                               |
| 70                         | 14345.                           | 5732.                                                                                            | 0.006                                                                       | 885.8                         | 1467.2              | 95.20                | 13.98                                          | 22.35                                          | 679                               |
| 71                         | 14551.                           | 5815.                                                                                            | 0.006                                                                       | 899.9                         | 1489.7              | 95.52                | 14.10                                          | 22.46                                          | 682                               |
| 72                         | 14757.                           | 5897.                                                                                            | 0.006                                                                       | 914.1                         | 1512.2              | 95.84                | 14.22                                          | 22.58                                          | 686                               |
| 73                         | 14962.                           | 5980.                                                                                            | 0.005                                                                       | 928.4                         | 1534.8              | 96.15                | 14.34                                          | 22.70                                          | 690                               |
| 74                         | 15168.                           | 6062.                                                                                            | 0.005                                                                       | 942.8                         | 1557.6              | 96.46                | 14.47                                          | 22.83                                          | 693                               |
| 75                         | 15374.                           | 6145.                                                                                            | 0.005                                                                       | 957.4                         | 1580.5              | 96.77                | 14.60                                          | 22.96                                          | 697                               |
| 76                         | 15580.                           | 6227.                                                                                            | 0.005                                                                       | 972.1                         | 1603.5              | 97.07                | 14.74                                          | 23.09                                          | 700                               |
| 77                         | 15785.                           | 6310.                                                                                            | 0.005                                                                       | 986.9                         | 1626.7              | 97.37                | 14.87                                          | 23.23                                          | 704                               |
| 78                         | 15991.                           | 6397.                                                                                            | 0.005                                                                       | 1001.8                        | 1650.0              | 97.67                | 15.02                                          | 23.37                                          | 707                               |
| 79                         | 16197.                           | 6475.                                                                                            | 0.005                                                                       | 1017.0                        | 1673.4              | 97.97                | 15.16                                          | 23.52                                          | 713                               |
| 80                         | 16402.                           | 6557.                                                                                            | 0.005                                                                       | 1032.2                        | 1697.0              | 98.27                | 15.31                                          | 23.66                                          | 714                               |
| 81                         | 16608.                           | 6639.                                                                                            | 0.005                                                                       | 1047.6                        | 1720.7              | 98.56                | 15.47                                          | 23.82                                          | 717                               |
| 82                         | 16813.                           | 6722.                                                                                            | 0.005                                                                       | 1063.2                        | 1744.6              | 98.86                | 15.62                                          | 23.97                                          | 720                               |
| 83                         | 17019.                           | 6804.                                                                                            | 0.005                                                                       | 1078.9                        | 1768.7              | 99.15                | 15.78                                          | 24.13                                          | 723                               |
| 84                         | 17225.                           | 6887.                                                                                            | 0.005                                                                       | 1094.8                        | 1792.9              | 99.44                | 15.94                                          | 24.29                                          | 726                               |
| 85                         | 17430.                           | 6969.                                                                                            | 0.005                                                                       | 1110.8                        | 1817.3              | 99.73                | 16.10                                          | 24.45                                          | 729                               |
| 86                         | 17636.                           | 7051.                                                                                            | 0.005                                                                       | 1127.0                        | 1841.8              | 100.01               | 16.27                                          | 24.61                                          | 732                               |
| 87                         | 17841.                           | 7134.                                                                                            | 0.005                                                                       | 1143.4                        | 1866.5              | 100.30               | 16.44                                          | 24.78                                          | 735                               |
| 88                         | 18047.                           | 7216.                                                                                            | 0.005                                                                       | 1159.9                        | 1891.4              | 100.58               | 16.60                                          | 24.95                                          | 738                               |
| 89                         | 18252.                           | 7298.                                                                                            | 0.005                                                                       | 1176.6                        | 1916.4              | 100.87               | 16.77                                          | 25.12                                          | 741                               |
| 90                         | 18458.                           | 7381.                                                                                            | 0.004                                                                       | 1193.5                        | 1941.6              | 101.15               | 16.95                                          | 25.29                                          | 744                               |
| 91                         | 18663.                           | 7463.                                                                                            | 0.004                                                                       | 1210.6                        | 1967.0              | 101.43               | 17.12                                          | 25.46                                          | 747                               |
| 92                         | 18869.                           | 7546.                                                                                            | 0.004                                                                       | 1227.8                        | 1992.5              | 101.71               | 17.29                                          | 25.63                                          | 750                               |
| 93                         | 19074.                           | 7628.                                                                                            | 0.004                                                                       | 1245.2                        | 2018.2              | 101.99               | 17.47                                          | 25.81                                          | 753                               |
| 94                         | 19280.                           | 7710.                                                                                            | 0.004                                                                       | 1262.7                        | 2044.1              | 102.26               | 17.64                                          | 25.98                                          | 755                               |
| 95                         | 19485.                           | 7797.                                                                                            | 0.004                                                                       | 1280.5                        | 2070.2              | 102.54               | 17.82                                          | 26.16                                          | 758                               |
| 96                         | 19691.                           | 7878.                                                                                            | 0.004                                                                       | 1298.4                        | 2096.5              | 102.81               | 17.99                                          | 26.33                                          | 761                               |
| 97                         | 19896.                           | 7957.                                                                                            | 0.004                                                                       | 1316.5                        | 2122.9              | 103.09               | 18.17                                          | 26.51                                          | 764                               |
| 98                         | 20102.                           | 8039.                                                                                            | 0.004                                                                       | 1334.8                        | 2149.5              | 103.36               | 18.34                                          | 26.68                                          | 767                               |
| 99                         | 20307.                           | 8122.                                                                                            | 0.004                                                                       | 1353.2                        | 2176.2              | 103.63               | 18.52                                          | 26.86                                          | 769                               |
| 100                        | 20512.                           | 8204.                                                                                            | 0.004                                                                       | 1371.8                        | 2203.2              | 103.90               | 18.69                                          | 27.03                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

0.50 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /MOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOBORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|---------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| • 13.818                   | 26.17                           | 23353.                                                                                             | 9.403                                                                      | -622.8                        | -621.5              | 10.01                | 9.50                                           | 13.13                                          | 1274                              |
| 14                         | 26.22                           | 22918.                                                                                             | 9.373                                                                      | -620.4                        | -619.1              | 10.18                | 9.56                                           | 13.30                                          | 1266                              |
| 15                         | 26.51                           | 21447.                                                                                             | 9.143                                                                      | -606.7                        | -605.4              | 11.12                | 9.90                                           | 14.07                                          | 1237                              |
| 16                         | 26.83                           | 20017.                                                                                             | 8.928                                                                      | -592.2                        | -590.8              | 12.07                | 10.26                                          | 14.91                                          | 1209                              |
| 17                         | 27.17                           | 18368.                                                                                             | 8.751                                                                      | -576.7                        | -575.3              | 13.01                | 10.61                                          | 15.92                                          | 1177                              |
| 18                         | 27.54                           | 16914.                                                                                             | 8.589                                                                      | -560.3                        | -558.9              | 13.95                | 10.94                                          | 16.98                                          | 1148                              |
| • 18.137                   | 27.59                           | 16845.                                                                                             | 8.567                                                                      | -557.9                        | -556.5              | 14.07                | 10.99                                          | 17.08                                          | 1147                              |
| • 18.137                   | 2795.4                          | 1306.                                                                                              | 0.030                                                                      | 213.0                         | 354.6               | 64.32                | 12.86                                          | 22.94                                          | 342                               |
| 19                         | 2950.4                          | 1391.                                                                                              | 0.029                                                                      | 224.8                         | 374.3               | 65.37                | 12.76                                          | 22.58                                          | 352                               |
| 20                         | 3128.0                          | 1487.                                                                                              | 0.027                                                                      | 238.2                         | 396.7               | 66.52                | 12.68                                          | 22.28                                          | 362                               |
| 21                         | 3303.6                          | 1580.                                                                                              | 0.025                                                                      | 251.5                         | 418.8               | 67.61                | 12.64                                          | 22.06                                          | 372                               |
| 22                         | 3477.8                          | 1673.                                                                                              | 0.024                                                                      | 264.6                         | 440.8               | 68.63                | 12.61                                          | 21.89                                          | 382                               |
| 23                         | 3650.8                          | 1764.                                                                                              | 0.023                                                                      | 277.7                         | 462.6               | 69.60                | 12.59                                          | 21.76                                          | 391                               |
| 24                         | 3822.9                          | 1854.                                                                                              | 0.022                                                                      | 290.7                         | 484.3               | 70.52                | 12.57                                          | 21.66                                          | 401                               |
| 25                         | 3994.2                          | 1943.                                                                                              | 0.021                                                                      | 303.6                         | 506.0               | 71.40                | 12.56                                          | 21.57                                          | 410                               |
| 26                         | 4164.7                          | 2031.                                                                                              | 0.020                                                                      | 316.5                         | 527.5               | 72.25                | 12.55                                          | 21.50                                          | 418                               |
| 27                         | 4334.7                          | 2119.                                                                                              | 0.019                                                                      | 329.3                         | 549.0               | 73.06                | 12.54                                          | 21.43                                          | 427                               |
| 28                         | 4504.2                          | 2207.                                                                                              | 0.018                                                                      | 342.2                         | 570.4               | 73.84                | 12.54                                          | 21.38                                          | 435                               |
| 29                         | 4673.2                          | 2294.                                                                                              | 0.018                                                                      | 355.0                         | 591.7               | 74.59                | 12.53                                          | 21.33                                          | 443                               |
| 30                         | 4841.9                          | 2380.                                                                                              | 0.017                                                                      | 367.7                         | 613.0               | 75.31                | 12.53                                          | 21.29                                          | 451                               |
| 31                         | 5010.2                          | 2467.                                                                                              | 0.017                                                                      | 380.5                         | 634.3               | 76.01                | 12.53                                          | 21.25                                          | 459                               |
| 32                         | 5178.2                          | 2552.                                                                                              | 0.016                                                                      | 393.2                         | 655.5               | 76.68                | 12.52                                          | 21.22                                          | 466                               |
| 33                         | 5345.9                          | 2638.                                                                                              | 0.015                                                                      | 405.9                         | 676.7               | 77.33                | 12.52                                          | 21.19                                          | 474                               |
| 34                         | 5513.4                          | 2723.                                                                                              | 0.015                                                                      | 418.6                         | 697.9               | 77.96                | 12.52                                          | 21.16                                          | 481                               |
| 35                         | 5680.6                          | 2809.                                                                                              | 0.015                                                                      | 431.3                         | 719.1               | 78.58                | 12.52                                          | 21.14                                          | 488                               |
| 36                         | 5847.7                          | 2894.                                                                                              | 0.014                                                                      | 443.9                         | 740.2               | 79.17                | 12.51                                          | 21.12                                          | 495                               |
| 37                         | 6014.5                          | 2978.                                                                                              | 0.014                                                                      | 456.6                         | 761.3               | 79.75                | 12.51                                          | 21.10                                          | 502                               |
| 38                         | 6181.2                          | 3063.                                                                                              | 0.013                                                                      | 469.2                         | 782.4               | 80.31                | 12.52                                          | 21.08                                          | 509                               |
| 39                         | 6347.8                          | 3148.                                                                                              | 0.013                                                                      | 481.9                         | 803.5               | 80.86                | 12.52                                          | 21.07                                          | 516                               |
| 40                         | 6514.2                          | 3232.                                                                                              | 0.013                                                                      | 494.5                         | 824.5               | 81.39                | 12.52                                          | 21.06                                          | 523                               |
| 41                         | 6680.4                          | 3316.                                                                                              | 0.012                                                                      | 507.1                         | 845.6               | 81.91                | 12.52                                          | 21.05                                          | 529                               |
| 42                         | 6846.6                          | 3400.                                                                                              | 0.012                                                                      | 519.8                         | 866.6               | 82.42                | 12.53                                          | 21.05                                          | 536                               |
| 43                         | 7012.6                          | 3484.                                                                                              | 0.012                                                                      | 532.4                         | 887.7               | 82.92                | 12.54                                          | 21.04                                          | 542                               |
| 44                         | 7178.6                          | 3568.                                                                                              | 0.011                                                                      | 545.0                         | 908.7               | 83.40                | 12.55                                          | 21.04                                          | 548                               |
| 45                         | 7344.4                          | 3657.                                                                                              | 0.011                                                                      | 557.7                         | 929.8               | 83.87                | 12.56                                          | 21.04                                          | 555                               |
| 46                         | 7510.2                          | 3736.                                                                                              | 0.011                                                                      | 570.3                         | 950.8               | 84.34                | 12.57                                          | 21.05                                          | 561                               |
| 47                         | 7675.9                          | 3819.                                                                                              | 0.011                                                                      | 583.0                         | 971.9               | 84.79                | 12.59                                          | 21.06                                          | 567                               |
| 48                         | 7841.5                          | 3907.                                                                                              | 0.011                                                                      | 595.7                         | 992.9               | 85.23                | 12.60                                          | 21.07                                          | 573                               |
| 49                         | 8007.0                          | 3986.                                                                                              | 0.010                                                                      | 608.3                         | 1014.0              | 85.67                | 12.63                                          | 21.08                                          | 578                               |
| 50                         | 8172.5                          | 4070.                                                                                              | 0.010                                                                      | 621.1                         | 1035.1              | 86.09                | 12.65                                          | 21.10                                          | 584                               |
| 51                         | 8337.9                          | 4153.                                                                                              | 0.010                                                                      | 633.8                         | 1056.2              | 86.51                | 12.68                                          | 21.12                                          | 590                               |
| 52                         | 8503.3                          | 4236.                                                                                              | 0.010                                                                      | 646.5                         | 1077.3              | 86.92                | 12.71                                          | 21.15                                          | 595                               |
| 53                         | 8668.6                          | 4320.                                                                                              | 0.010                                                                      | 659.3                         | 1098.5              | 87.32                | 12.74                                          | 21.17                                          | 601                               |
| 54                         | 8833.9                          | 4403.                                                                                              | 0.009                                                                      | 672.1                         | 1119.7              | 87.72                | 12.78                                          | 21.21                                          | 606                               |
| 55                         | 8999.1                          | 4486.                                                                                              | 0.009                                                                      | 685.0                         | 1140.9              | 88.11                | 12.82                                          | 21.24                                          | 611                               |
| 56                         | 9164.3                          | 4569.                                                                                              | 0.009                                                                      | 697.9                         | 1162.2              | 88.49                | 12.87                                          | 21.29                                          | 616                               |
| 57                         | 9329.4                          | 4652.                                                                                              | 0.009                                                                      | 710.8                         | 1183.5              | 88.87                | 12.92                                          | 21.33                                          | 621                               |
| 58                         | 9494.5                          | 4735.                                                                                              | 0.009                                                                      | 723.8                         | 1204.9              | 89.24                | 12.97                                          | 21.38                                          | 626                               |
| 59                         | 9659.5                          | 4818.                                                                                              | 0.009                                                                      | 736.9                         | 1226.3              | 89.61                | 13.03                                          | 21.44                                          | 631                               |
| 60                         | 9824.6                          | 4901.                                                                                              | 0.008                                                                      | 750.0                         | 1247.7              | 89.97                | 13.09                                          | 21.50                                          | 636                               |
| 61                         | 9989.5                          | 4984.                                                                                              | 0.008                                                                      | 763.2                         | 1269.3              | 90.32                | 13.16                                          | 21.56                                          | 641                               |
| 62                         | 10154.                          | 5067.                                                                                              | 0.008                                                                      | 776.4                         | 1290.9              | 90.68                | 13.23                                          | 21.63                                          | 645                               |
| 63                         | 10319.                          | 5150.                                                                                              | 0.008                                                                      | 789.7                         | 1312.5              | 91.02                | 13.31                                          | 21.71                                          | 650                               |
| 64                         | 10484.                          | 5233.                                                                                              | 0.008                                                                      | 803.1                         | 1334.3              | 91.36                | 13.39                                          | 21.79                                          | 654                               |
| 65                         | 10649.                          | 5315.                                                                                              | 0.008                                                                      | 816.6                         | 1356.1              | 91.70                | 13.48                                          | 21.87                                          | 658                               |
| 66                         | 10814.                          | 5398.                                                                                              | 0.008                                                                      | 830.2                         | 1378.0              | 92.04                | 13.57                                          | 21.96                                          | 663                               |
| 67                         | 10979.                          | 5481.                                                                                              | 0.007                                                                      | 843.8                         | 1400.0              | 92.37                | 13.67                                          | 22.05                                          | 667                               |
| 68                         | 11144.                          | 5564.                                                                                              | 0.007                                                                      | 857.6                         | 1422.1              | 92.70                | 13.77                                          | 22.15                                          | 671                               |
| 69                         | 11308.                          | 5646.                                                                                              | 0.007                                                                      | 871.4                         | 1444.3              | 93.02                | 13.87                                          | 22.25                                          | 675                               |
| 70                         | 11473.                          | 5729.                                                                                              | 0.007                                                                      | 885.4                         | 1466.6              | 93.34                | 13.99                                          | 22.36                                          | 679                               |
| 71                         | 11638.                          | 5812.                                                                                              | 0.007                                                                      | 899.5                         | 1489.1              | 93.66                | 14.10                                          | 22.48                                          | 682                               |
| 72                         | 11803.                          | 5894.                                                                                              | 0.007                                                                      | 913.7                         | 1511.6              | 93.97                | 14.22                                          | 22.59                                          | 686                               |
| 73                         | 11967.                          | 5977.                                                                                              | 0.007                                                                      | 928.0                         | 1534.3              | 94.29                | 14.34                                          | 22.71                                          | 690                               |
| 74                         | 12132.                          | 6060.                                                                                              | 0.007                                                                      | 942.4                         | 1557.0              | 94.60                | 14.47                                          | 22.84                                          | 693                               |
| 75                         | 12297.                          | 6142.                                                                                              | 0.007                                                                      | 957.0                         | 1579.9              | 94.90                | 14.60                                          | 22.97                                          | 697                               |
| 76                         | 12461.                          | 6225.                                                                                              | 0.007                                                                      | 971.7                         | 1603.0              | 95.21                | 14.74                                          | 23.10                                          | 700                               |
| 77                         | 12626.                          | 6307.                                                                                              | 0.007                                                                      | 986.5                         | 1626.1              | 95.51                | 14.88                                          | 23.24                                          | 704                               |
| 78                         | 12791.                          | 6390.                                                                                              | 0.006                                                                      | 1001.5                        | 1649.5              | 95.81                | 15.02                                          | 23.38                                          | 707                               |
| 79                         | 12955.                          | 6472.                                                                                              | 0.006                                                                      | 1016.6                        | 1672.9              | 96.11                | 15.16                                          | 23.53                                          | 710                               |
| 80                         | 13120.                          | 6555.                                                                                              | 0.006                                                                      | 1031.8                        | 1696.5              | 96.41                | 15.31                                          | 23.67                                          | 714                               |
| 81                         | 13284.                          | 6638.                                                                                              | 0.006                                                                      | 1047.3                        | 1720.3              | 96.70                | 15.47                                          | 23.83                                          | 717                               |
| 82                         | 13449.                          | 6720.                                                                                              | 0.006                                                                      | 1062.8                        | 1744.2              | 97.00                | 15.62                                          | 23.98                                          | 720                               |
| 83                         | 13613.                          | 6803.                                                                                              | 0.006                                                                      | 1078.5                        | 1768.2              | 97.29                | 15.78                                          | 24.14                                          | 723                               |
| 84                         | 13778.                          | 6885.                                                                                              | 0.006                                                                      | 1094.4                        | 1792.5              | 97.58                | 15.94                                          | 24.30                                          | 726                               |
| 85                         | 13943.                          | 6967.                                                                                              | 0.006                                                                      | 1110.5                        | 1816.8              | 97.87                | 16.10                                          | 24.46                                          | 729                               |
| 86                         | 14107.                          | 7050.                                                                                              | 0.006                                                                      | 1126.7                        | 1841.4              | 98.15                | 16.27                                          | 24.62                                          | 732                               |
| 87                         | 14272.                          | 7132.                                                                                              | 0.006                                                                      | 1143.0                        | 1866.1              | 98.44                | 16.44                                          | 24.79                                          | 735                               |
| 88                         | 14436.                          | 7215.                                                                                              | 0.006                                                                      | 1159.6                        | 1891.0              | 98.72                | 16.60                                          | 24.96                                          | 738                               |
| 89                         | 14601.                          | 7297.                                                                                              | 0.006                                                                      | 1176.3                        | 1916.0              | 99.01                | 16.78                                          | 25.13                                          | 741                               |
| 90                         | 14765.                          | 7380.                                                                                              | 0.006                                                                      | 1193.2                        | 1941.2              | 99.29                | 16.95                                          | 25.30                                          | 744                               |
| 91                         | 14930.                          | 7462.                                                                                              | 0.006                                                                      | 1210.2                        | 1966.6              | 99.57                | 17.12                                          | 25.47                                          | 747                               |
| 92                         | 15094.                          | 7545.                                                                                              | 0.005                                                                      | 1227.5                        | 1992.2              | 99.85                | 17.29                                          | 25.64                                          | 750                               |
| 93                         | 15258.                          | 7627.                                                                                              | 0.005                                                                      | 1244.9                        | 2017.9              | 100.13               | 17.47                                          | 25.82                                          | 753                               |
| 94                         | 15423.                          | 7709.                                                                                              | 0.005                                                                      | 1262.4                        | 2043.8              | 100.40               | 17.64                                          | 25.99                                          | 756                               |
| 95                         | 15587.                          | 7797.                                                                                              | 0.005                                                                      | 1280.2                        | 2069.9              | 100.68               | 17.82                                          | 26.17                                          | 758                               |
| 96                         | 15752.                          | 7874.                                                                                              | 0.005                                                                      | 1298.1                        | 2096.1              | 100.96               | 17.99                                          | 26.34                                          | 761                               |
| 97                         | 15916.                          | 7956.                                                                                              | 0.005                                                                      | 1316.2                        | 2122.5              | 101.23               | 18.17                                          | 26.51                                          | 764                               |
| 98                         | 16081.                          | 8039.                                                                                              | 0.005                                                                      | 1334.5                        | 2149.1              | 101.50               | 18.34                                          | 26.69                                          | 767                               |
| 99                         | 16245.                          | 8121.                                                                                              | 0.005                                                                      | 1352.9                        | 2175.9              | 101.77               | 18.52                                          | 26.86                                          | 769                               |
| 100                        | 16409.                          | 8204.                                                                                              | 0.005                                                                      | 1371.5                        | 2202.9              | 102.04               | 18.69                                          | 27.04                                          | 772                               |

• TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

0.60 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.821                   | 26.17                            | 23364.                                                                                             | 9.403                                                                       | -622.8                        | -621.2              | 10.01                | 9.51                                           | 13.14                                          | 1274                              |
| 14                         | 26.22                            | 22935.                                                                                             | 9.374                                                                       | -620.4                        | -618.9              | 10.18                | 9.56                                           | 13.30                                          | 1266                              |
| 15                         | 26.51                            | 21466.                                                                                             | 9.146                                                                       | -606.8                        | -605.2              | 11.12                | 9.90                                           | 14.07                                          | 1238                              |
| 16                         | 26.83                            | 20035.                                                                                             | 8.931                                                                       | -592.2                        | -590.6              | 12.06                | 10.26                                          | 14.90                                          | 1209                              |
| 17                         | 27.17                            | 18389.                                                                                             | 8.754                                                                       | -576.8                        | -575.1              | 13.00                | 10.61                                          | 15.91                                          | 1177                              |
| 18                         | 27.54                            | 16937.                                                                                             | 8.592                                                                       | -560.3                        | -558.7              | 13.94                | 10.94                                          | 16.97                                          | 1149                              |
| * 18.659                   | 27.80                            | 16117.                                                                                             | 8.482                                                                       | -548.9                        | -547.3              | 14.56                | 11.15                                          | 17.67                                          | 1133                              |
| * 18.659                   | 2376.6                           | 1319.                                                                                              | 0.036                                                                       | 217.3                         | 361.8               | 63.29                | 12.92                                          | 23.27                                          | 346                               |
| 19                         | 2428.3                           | 1354.                                                                                              | 0.035                                                                       | 222.0                         | 369.7               | 63.71                | 12.87                                          | 23.09                                          | 349                               |
| 20                         | 2579.2                           | 1453.                                                                                              | 0.033                                                                       | 235.7                         | 392.5               | 64.88                | 12.76                                          | 22.67                                          | 360                               |
| 21                         | 2727.9                           | 1550.                                                                                              | 0.031                                                                       | 249.2                         | 415.1               | 65.98                | 12.69                                          | 22.38                                          | 371                               |
| 22                         | 2875.0                           | 1645.                                                                                              | 0.029                                                                       | 262.5                         | 437.3               | 67.01                | 12.65                                          | 22.16                                          | 381                               |
| 23                         | 3020.9                           | 1738.                                                                                              | 0.028                                                                       | 275.7                         | 459.4               | 68.00                | 12.62                                          | 21.99                                          | 390                               |
| 24                         | 3165.8                           | 1830.                                                                                              | 0.026                                                                       | 288.9                         | 481.3               | 68.93                | 12.60                                          | 21.86                                          | 399                               |
| 25                         | 3309.8                           | 1921.                                                                                              | 0.025                                                                       | 301.9                         | 503.1               | 69.82                | 12.58                                          | 21.74                                          | 408                               |
| 26                         | 3453.1                           | 2010.                                                                                              | 0.024                                                                       | 314.9                         | 524.8               | 70.67                | 12.57                                          | 21.65                                          | 417                               |
| 27                         | 3595.8                           | 2100.                                                                                              | 0.023                                                                       | 327.8                         | 546.4               | 71.49                | 12.56                                          | 21.57                                          | 426                               |
| 28                         | 3738.0                           | 2188.                                                                                              | 0.022                                                                       | 340.7                         | 568.0               | 72.27                | 12.55                                          | 21.51                                          | 434                               |
| 29                         | 3879.8                           | 2276.                                                                                              | 0.021                                                                       | 353.6                         | 589.4               | 73.02                | 12.55                                          | 21.45                                          | 442                               |
| 30                         | 4021.1                           | 2364.                                                                                              | 0.021                                                                       | 366.4                         | 610.9               | 73.75                | 12.54                                          | 21.39                                          | 450                               |
| 31                         | 4162.1                           | 2451.                                                                                              | 0.020                                                                       | 379.2                         | 632.2               | 74.45                | 12.54                                          | 21.35                                          | 458                               |
| 32                         | 4302.7                           | 2538.                                                                                              | 0.019                                                                       | 392.0                         | 653.6               | 75.13                | 12.53                                          | 21.31                                          | 466                               |
| 33                         | 4443.1                           | 2624.                                                                                              | 0.019                                                                       | 404.7                         | 674.9               | 75.78                | 12.53                                          | 21.27                                          | 473                               |
| 34                         | 4583.3                           | 2710.                                                                                              | 0.018                                                                       | 417.5                         | 696.1               | 76.42                | 12.53                                          | 21.24                                          | 481                               |
| 35                         | 4723.2                           | 2796.                                                                                              | 0.018                                                                       | 430.2                         | 717.3               | 77.03                | 12.52                                          | 21.21                                          | 488                               |
| 36                         | 4862.9                           | 2881.                                                                                              | 0.017                                                                       | 442.9                         | 738.5               | 77.63                | 12.52                                          | 21.18                                          | 495                               |
| 37                         | 5002.4                           | 2967.                                                                                              | 0.017                                                                       | 455.6                         | 759.7               | 78.21                | 12.52                                          | 21.16                                          | 502                               |
| 38                         | 5141.7                           | 3052.                                                                                              | 0.016                                                                       | 468.3                         | 780.9               | 78.77                | 12.52                                          | 21.14                                          | 509                               |
| 39                         | 5280.9                           | 3137.                                                                                              | 0.016                                                                       | 480.9                         | 802.0               | 79.32                | 12.52                                          | 21.13                                          | 516                               |
| 40                         | 5420.0                           | 3222.                                                                                              | 0.015                                                                       | 493.6                         | 823.1               | 79.86                | 12.53                                          | 21.11                                          | 522                               |
| 41                         | 5558.9                           | 3306.                                                                                              | 0.015                                                                       | 506.3                         | 844.2               | 80.38                | 12.53                                          | 21.10                                          | 529                               |
| 42                         | 5697.7                           | 3391.                                                                                              | 0.014                                                                       | 518.9                         | 865.3               | 80.89                | 12.53                                          | 21.09                                          | 536                               |
| 43                         | 5836.4                           | 3475.                                                                                              | 0.014                                                                       | 531.6                         | 886.4               | 81.38                | 12.54                                          | 21.09                                          | 542                               |
| 44                         | 5975.0                           | 3559.                                                                                              | 0.014                                                                       | 544.2                         | 907.5               | 81.87                | 12.55                                          | 21.08                                          | 548                               |
| 45                         | 6113.5                           | 3644.                                                                                              | 0.013                                                                       | 556.9                         | 928.6               | 82.34                | 12.56                                          | 21.08                                          | 554                               |
| 46                         | 6251.9                           | 3728.                                                                                              | 0.013                                                                       | 569.6                         | 949.7               | 82.80                | 12.57                                          | 21.09                                          | 561                               |
| 47                         | 6390.3                           | 3812.                                                                                              | 0.013                                                                       | 582.3                         | 970.8               | 83.26                | 12.59                                          | 21.09                                          | 567                               |
| 48                         | 6528.5                           | 3895.                                                                                              | 0.013                                                                       | 594.9                         | 991.9               | 83.70                | 12.61                                          | 21.10                                          | 572                               |
| 49                         | 6666.7                           | 3979.                                                                                              | 0.012                                                                       | 607.7                         | 1013.0              | 84.14                | 12.63                                          | 21.11                                          | 578                               |
| 50                         | 6804.9                           | 4063.                                                                                              | 0.012                                                                       | 620.4                         | 1034.1              | 84.56                | 12.65                                          | 21.13                                          | 584                               |
| 51                         | 6942.9                           | 4147.                                                                                              | 0.012                                                                       | 633.1                         | 1055.2              | 84.98                | 12.68                                          | 21.15                                          | 590                               |
| 52                         | 7080.9                           | 4230.                                                                                              | 0.012                                                                       | 645.9                         | 1076.4              | 85.39                | 12.71                                          | 21.17                                          | 595                               |
| 53                         | 7218.9                           | 4314.                                                                                              | 0.011                                                                       | 658.7                         | 1097.6              | 85.80                | 12.74                                          | 21.20                                          | 601                               |
| 54                         | 7356.8                           | 4397.                                                                                              | 0.011                                                                       | 671.5                         | 1118.8              | 86.19                | 12.78                                          | 21.23                                          | 606                               |
| 55                         | 7494.7                           | 4480.                                                                                              | 0.011                                                                       | 684.4                         | 1140.0              | 86.58                | 12.82                                          | 21.27                                          | 611                               |
| 56                         | 7632.5                           | 4564.                                                                                              | 0.011                                                                       | 697.3                         | 1161.3              | 86.97                | 12.87                                          | 21.31                                          | 616                               |
| 57                         | 7770.3                           | 4647.                                                                                              | 0.011                                                                       | 710.3                         | 1182.7              | 87.34                | 12.92                                          | 21.35                                          | 621                               |
| 58                         | 7908.0                           | 4730.                                                                                              | 0.010                                                                       | 723.3                         | 1204.0              | 87.72                | 12.97                                          | 21.40                                          | 626                               |
| 59                         | 8045.7                           | 4813.                                                                                              | 0.010                                                                       | 736.3                         | 1225.5              | 88.08                | 13.03                                          | 21.46                                          | 631                               |
| 60                         | 8183.4                           | 4897.                                                                                              | 0.010                                                                       | 749.5                         | 1247.0              | 88.44                | 13.10                                          | 21.52                                          | 636                               |
| 61                         | 8321.0                           | 4980.                                                                                              | 0.010                                                                       | 762.6                         | 1268.5              | 88.80                | 13.16                                          | 21.58                                          | 641                               |
| 62                         | 8458.6                           | 5063.                                                                                              | 0.010                                                                       | 775.9                         | 1290.1              | 89.15                | 13.24                                          | 21.65                                          | 645                               |
| 63                         | 8596.2                           | 5146.                                                                                              | 0.010                                                                       | 789.2                         | 1311.8              | 89.50                | 13.31                                          | 21.72                                          | 650                               |
| 64                         | 8733.7                           | 5229.                                                                                              | 0.009                                                                       | 802.6                         | 1333.6              | 89.84                | 13.40                                          | 21.80                                          | 654                               |
| 65                         | 8871.2                           | 5312.                                                                                              | 0.009                                                                       | 816.1                         | 1355.4              | 90.18                | 13.48                                          | 21.89                                          | 658                               |
| 66                         | 9008.7                           | 5395.                                                                                              | 0.009                                                                       | 829.7                         | 1377.4              | 90.51                | 13.57                                          | 21.97                                          | 663                               |
| 67                         | 9146.2                           | 5477.                                                                                              | 0.009                                                                       | 843.3                         | 1399.4              | 90.85                | 13.67                                          | 22.07                                          | 667                               |
| 68                         | 9283.6                           | 5560.                                                                                              | 0.009                                                                       | 857.1                         | 1421.5              | 91.17                | 13.77                                          | 22.17                                          | 671                               |
| 69                         | 9421.1                           | 5643.                                                                                              | 0.009                                                                       | 871.0                         | 1443.7              | 91.50                | 13.88                                          | 22.27                                          | 675                               |
| 70                         | 9558.5                           | 5726.                                                                                              | 0.009                                                                       | 884.9                         | 1466.0              | 91.82                | 13.99                                          | 22.38                                          | 679                               |
| 71                         | 9695.8                           | 5809.                                                                                              | 0.008                                                                       | 899.0                         | 1488.5              | 92.14                | 14.10                                          | 22.49                                          | 682                               |
| 72                         | 9833.2                           | 5892.                                                                                              | 0.008                                                                       | 913.2                         | 1511.0              | 92.45                | 14.22                                          | 22.61                                          | 686                               |
| 73                         | 9970.6                           | 5974.                                                                                              | 0.008                                                                       | 927.5                         | 1533.7              | 92.77                | 14.34                                          | 22.73                                          | 690                               |
| 74                         | 10108.                           | 6057.                                                                                              | 0.008                                                                       | 942.0                         | 1556.5              | 93.08                | 14.47                                          | 22.85                                          | 693                               |
| 75                         | 10245.                           | 6140.                                                                                              | 0.008                                                                       | 956.6                         | 1579.4              | 93.38                | 14.60                                          | 22.98                                          | 697                               |
| 76                         | 10382.                           | 6222.                                                                                              | 0.008                                                                       | 971.3                         | 1602.5              | 93.69                | 14.74                                          | 23.11                                          | 700                               |
| 77                         | 10520.                           | 6305.                                                                                              | 0.008                                                                       | 986.1                         | 1625.6              | 93.99                | 14.88                                          | 23.25                                          | 704                               |
| 78                         | 10657.                           | 6388.                                                                                              | 0.008                                                                       | 1001.1                        | 1649.0              | 94.29                | 15.02                                          | 23.39                                          | 707                               |
| 79                         | 10794.                           | 6470.                                                                                              | 0.008                                                                       | 1016.2                        | 1672.4              | 94.59                | 15.17                                          | 23.54                                          | 710                               |
| 80                         | 10932.                           | 6553.                                                                                              | 0.008                                                                       | 1031.5                        | 1696.0              | 94.89                | 15.31                                          | 23.69                                          | 714                               |
| 81                         | 11069.                           | 6636.                                                                                              | 0.007                                                                       | 1046.9                        | 1719.8              | 95.18                | 15.47                                          | 23.84                                          | 717                               |
| 82                         | 11206.                           | 6718.                                                                                              | 0.007                                                                       | 1062.5                        | 1743.7              | 95.48                | 15.62                                          | 23.99                                          | 720                               |
| 83                         | 11343.                           | 6801.                                                                                              | 0.007                                                                       | 1078.2                        | 1767.8              | 95.77                | 15.78                                          | 24.15                                          | 723                               |
| 84                         | 11480.                           | 6883.                                                                                              | 0.007                                                                       | 1094.1                        | 1792.0              | 96.06                | 15.94                                          | 24.31                                          | 726                               |
| 85                         | 11618.                           | 6966.                                                                                              | 0.007                                                                       | 1110.1                        | 1816.4              | 96.35                | 16.10                                          | 24.47                                          | 729                               |
| 86                         | 11755.                           | 7049.                                                                                              | 0.007                                                                       | 1126.3                        | 1841.0              | 96.63                | 16.27                                          | 24.63                                          | 732                               |
| 87                         | 11892.                           | 7131.                                                                                              | 0.007                                                                       | 1142.7                        | 1865.7              | 96.92                | 16.44                                          | 24.80                                          | 735                               |
| 88                         | 12029.                           | 7214.                                                                                              | 0.007                                                                       | 1159.2                        | 1890.6              | 97.20                | 16.61                                          | 24.97                                          | 738                               |
| 89                         | 12166.                           | 7296.                                                                                              | 0.007                                                                       | 1176.0                        | 1915.6              | 97.49                | 16.78                                          | 25.13                                          | 741                               |
| 90                         | 12303.                           | 7379.                                                                                              | 0.007                                                                       | 1192.8                        | 1940.8              | 97.77                | 16.95                                          | 25.31                                          | 744                               |
| 91                         | 12440.                           | 7461.                                                                                              | 0.007                                                                       | 1209.9                        | 1966.2              | 98.05                | 17.12                                          | 25.48                                          | 747                               |
| 92                         | 12578.                           | 7544.                                                                                              | 0.007                                                                       | 1227.1                        | 1991.8              | 98.33                | 17.29                                          | 25.65                                          | 750                               |
| 93                         | 12715.                           | 7626.                                                                                              | 0.006                                                                       | 1244.5                        | 2017.5              | 98.61                | 17.47                                          | 25.82                                          | 753                               |
| 94                         | 12852.                           | 7708.                                                                                              | 0.006                                                                       | 1262.1                        | 2043.4              | 98.88                | 17.64                                          | 26.00                                          | 756                               |
| 95                         | 12989.                           | 7791.                                                                                              | 0.006                                                                       | 1279.9                        | 2069.5              | 99.16                | 17.82                                          | 26.17                                          | 758                               |
| 96                         | 13126.                           | 7873.                                                                                              | 0.006                                                                       | 1297.8                        | 2095.8              | 99.44                | 17.99                                          | 26.35                                          | 761                               |
| 97                         | 13263.                           | 7956.                                                                                              | 0.006                                                                       | 1315.9                        | 2122.2              | 99.71                | 18.17                                          | 26.52                                          | 764                               |
| 98                         | 13400.                           | 8038.                                                                                              | 0.006                                                                       | 1334.2                        | 2148.8              | 99.98                | 18.35                                          | 26.70                                          | 767                               |
| 99                         | 13537.                           | 8121.                                                                                              | 0.006                                                                       | 1352.6                        | 2175.6              | 100.25               | 18.52                                          | 26.87                                          | 770                               |
| 100                        | 13674.                           | 8203.                                                                                              | 0.006                                                                       | 1371.2                        | 2202.6              | 100.53               | 18.69                                          | 27.04                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

0.70 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.825                   | 26.16                            | 23374.                                                                                             | 9.404                                                                      | -622.8                        | -621.0              | 10.01                | 9.51                                           | 13.14                                          | 1274                              |
| 14                         | 26.22                            | 22953.                                                                                             | 9.375                                                                      | -620.5                        | -618.6              | 10.18                | 9.56                                           | 13.30                                          | 1266                              |
| 15                         | 26.51                            | 21485.                                                                                             | 9.149                                                                      | -606.8                        | -604.9              | 11.12                | 9.90                                           | 14.06                                          | 1238                              |
| 16                         | 26.82                            | 20054.                                                                                             | 8.934                                                                      | -592.3                        | -590.4              | 12.06                | 10.26                                          | 14.90                                          | 1210                              |
| 17                         | 27.16                            | 18410.                                                                                             | 8.757                                                                      | -576.8                        | -574.9              | 13.00                | 10.61                                          | 15.91                                          | 1178                              |
| 18                         | 27.53                            | 16961.                                                                                             | 8.595                                                                      | -560.4                        | -558.4              | 13.94                | 10.94                                          | 16.96                                          | 1150                              |
| 19                         | 27.93                            | 15668.                                                                                             | 8.424                                                                      | -542.9                        | -541.0              | 14.88                | 11.24                                          | 18.05                                          | 1124                              |
| * 19.121                   | 27.98                            | 15564.                                                                                             | 8.402                                                                      | -540.8                        | -538.8              | 15.00                | 11.28                                          | 18.16                                          | 1122                              |
| * 19.121                   | 2071.0                           | 1320.                                                                                              | 0.041                                                                      | 220.9                         | 367.8               | 62.42                | 12.97                                          | 23.60                                          | 348                               |
| 20                         | 2186.6                           | 1410.                                                                                              | 0.039                                                                      | 233.2                         | 388.3               | 63.46                | 12.84                                          | 23.12                                          | 358                               |
| 21                         | 2316.2                           | 1519.                                                                                              | 0.036                                                                      | 246.9                         | 411.2               | 64.58                | 12.75                                          | 22.73                                          | 369                               |
| 22                         | 2444.1                           | 1617.                                                                                              | 0.034                                                                      | 260.4                         | 433.8               | 65.63                | 12.69                                          | 22.45                                          | 379                               |
| 23                         | 2570.7                           | 1717.                                                                                              | 0.033                                                                      | 273.8                         | 456.1               | 66.63                | 12.65                                          | 22.23                                          | 389                               |
| 24                         | 2696.2                           | 1806.                                                                                              | 0.031                                                                      | 287.0                         | 478.3               | 67.57                | 12.62                                          | 22.06                                          | 398                               |
| 25                         | 2820.8                           | 1898.                                                                                              | 0.030                                                                      | 300.2                         | 500.2               | 68.47                | 12.60                                          | 21.93                                          | 407                               |
| 26                         | 2944.7                           | 1989.                                                                                              | 0.028                                                                      | 313.3                         | 522.1               | 69.32                | 12.59                                          | 21.81                                          | 416                               |
| 27                         | 3067.9                           | 2080.                                                                                              | 0.027                                                                      | 326.3                         | 543.9               | 70.15                | 12.58                                          | 21.72                                          | 425                               |
| 28                         | 3190.6                           | 2170.                                                                                              | 0.026                                                                      | 339.3                         | 565.6               | 70.93                | 12.57                                          | 21.64                                          | 433                               |
| 29                         | 3312.9                           | 2259.                                                                                              | 0.025                                                                      | 352.2                         | 587.2               | 71.69                | 12.56                                          | 21.57                                          | 441                               |
| 30                         | 3434.7                           | 2347.                                                                                              | 0.024                                                                      | 365.1                         | 608.7               | 72.42                | 12.55                                          | 21.50                                          | 450                               |
| 31                         | 3556.2                           | 2435.                                                                                              | 0.023                                                                      | 377.9                         | 630.2               | 73.13                | 12.55                                          | 21.45                                          | 457                               |
| 32                         | 3677.4                           | 2523.                                                                                              | 0.023                                                                      | 390.8                         | 651.6               | 73.81                | 12.54                                          | 21.40                                          | 465                               |
| 33                         | 3798.2                           | 2610.                                                                                              | 0.022                                                                      | 403.6                         | 673.0               | 74.46                | 12.54                                          | 21.36                                          | 473                               |
| 34                         | 3918.9                           | 2697.                                                                                              | 0.021                                                                      | 416.4                         | 694.3               | 75.10                | 12.53                                          | 21.32                                          | 480                               |
| 35                         | 4039.2                           | 2783.                                                                                              | 0.021                                                                      | 429.1                         | 715.6               | 75.72                | 12.53                                          | 21.28                                          | 487                               |
| 36                         | 4159.4                           | 2869.                                                                                              | 0.020                                                                      | 441.9                         | 736.9               | 76.32                | 12.53                                          | 21.25                                          | 495                               |
| 37                         | 4279.4                           | 2955.                                                                                              | 0.019                                                                      | 454.6                         | 758.1               | 76.90                | 12.53                                          | 21.23                                          | 502                               |
| 38                         | 4399.2                           | 3041.                                                                                              | 0.019                                                                      | 467.3                         | 779.3               | 77.47                | 12.53                                          | 21.20                                          | 509                               |
| 39                         | 4518.9                           | 3126.                                                                                              | 0.018                                                                      | 480.0                         | 800.5               | 78.02                | 12.53                                          | 21.18                                          | 515                               |
| 40                         | 4638.4                           | 3212.                                                                                              | 0.018                                                                      | 492.7                         | 821.7               | 78.55                | 12.53                                          | 21.16                                          | 522                               |
| 41                         | 4757.8                           | 3297.                                                                                              | 0.017                                                                      | 505.4                         | 842.9               | 79.07                | 12.53                                          | 21.15                                          | 529                               |
| 42                         | 4877.1                           | 3382.                                                                                              | 0.017                                                                      | 518.1                         | 864.0               | 79.58                | 12.54                                          | 21.14                                          | 535                               |
| 43                         | 4996.3                           | 3466.                                                                                              | 0.017                                                                      | 530.8                         | 885.1               | 80.08                | 12.55                                          | 21.13                                          | 542                               |
| 44                         | 5115.3                           | 3551.                                                                                              | 0.016                                                                      | 543.5                         | 906.3               | 80.57                | 12.56                                          | 21.12                                          | 548                               |
| 45                         | 5234.3                           | 3635.                                                                                              | 0.016                                                                      | 556.1                         | 927.4               | 81.04                | 12.57                                          | 21.12                                          | 554                               |
| 46                         | 5353.2                           | 3720.                                                                                              | 0.015                                                                      | 568.8                         | 948.5               | 81.51                | 12.58                                          | 21.12                                          | 560                               |
| 47                         | 5472.0                           | 3804.                                                                                              | 0.015                                                                      | 581.5                         | 969.6               | 81.96                | 12.59                                          | 21.13                                          | 566                               |
| 48                         | 5590.7                           | 3888.                                                                                              | 0.015                                                                      | 594.2                         | 990.8               | 82.41                | 12.61                                          | 21.13                                          | 572                               |
| 49                         | 5709.4                           | 3972.                                                                                              | 0.014                                                                      | 607.0                         | 1011.9              | 82.84                | 12.63                                          | 21.15                                          | 578                               |
| 50                         | 5828.0                           | 4056.                                                                                              | 0.014                                                                      | 619.7                         | 1033.1              | 83.27                | 12.66                                          | 21.16                                          | 584                               |
| 51                         | 5946.5                           | 4140.                                                                                              | 0.014                                                                      | 632.5                         | 1054.2              | 83.69                | 12.68                                          | 21.18                                          | 589                               |
| 52                         | 6065.0                           | 4224.                                                                                              | 0.014                                                                      | 645.3                         | 1075.4              | 84.10                | 12.71                                          | 21.20                                          | 595                               |
| 53                         | 6183.4                           | 4308.                                                                                              | 0.013                                                                      | 658.1                         | 1096.6              | 84.50                | 12.75                                          | 21.23                                          | 600                               |
| 54                         | 6301.8                           | 4391.                                                                                              | 0.013                                                                      | 670.9                         | 1117.9              | 84.90                | 12.78                                          | 21.26                                          | 606                               |
| 55                         | 6420.1                           | 4475.                                                                                              | 0.013                                                                      | 683.8                         | 1139.2              | 85.29                | 12.83                                          | 21.29                                          | 611                               |
| 56                         | 6538.4                           | 4558.                                                                                              | 0.013                                                                      | 696.7                         | 1160.5              | 85.67                | 12.87                                          | 21.33                                          | 616                               |
| 57                         | 6656.6                           | 4642.                                                                                              | 0.012                                                                      | 709.7                         | 1181.8              | 86.05                | 12.92                                          | 21.38                                          | 621                               |
| 58                         | 6774.8                           | 4725.                                                                                              | 0.012                                                                      | 722.7                         | 1203.2              | 86.42                | 12.98                                          | 21.43                                          | 626                               |
| 59                         | 6893.0                           | 4809.                                                                                              | 0.012                                                                      | 735.8                         | 1224.7              | 86.79                | 13.03                                          | 21.48                                          | 631                               |
| 60                         | 7011.1                           | 4892.                                                                                              | 0.012                                                                      | 748.9                         | 1246.2              | 87.15                | 13.10                                          | 21.54                                          | 636                               |
| 61                         | 7129.2                           | 4975.                                                                                              | 0.012                                                                      | 762.1                         | 1267.8              | 87.51                | 13.17                                          | 21.60                                          | 641                               |
| 62                         | 7247.3                           | 5059.                                                                                              | 0.011                                                                      | 775.4                         | 1289.4              | 87.86                | 13.24                                          | 21.67                                          | 645                               |
| 63                         | 7365.3                           | 5142.                                                                                              | 0.011                                                                      | 788.7                         | 1311.1              | 88.21                | 13.32                                          | 21.74                                          | 650                               |
| 64                         | 7483.3                           | 5225.                                                                                              | 0.011                                                                      | 802.1                         | 1332.9              | 88.55                | 13.40                                          | 21.82                                          | 654                               |
| 65                         | 7601.3                           | 5308.                                                                                              | 0.011                                                                      | 815.6                         | 1354.8              | 88.89                | 13.48                                          | 21.90                                          | 658                               |
| 66                         | 7719.2                           | 5391.                                                                                              | 0.011                                                                      | 829.2                         | 1376.7              | 89.23                | 13.58                                          | 21.99                                          | 663                               |
| 67                         | 7837.2                           | 5474.                                                                                              | 0.011                                                                      | 842.9                         | 1398.7              | 89.56                | 13.67                                          | 22.08                                          | 667                               |
| 68                         | 7955.1                           | 5557.                                                                                              | 0.010                                                                      | 856.6                         | 1420.9              | 89.89                | 13.77                                          | 22.18                                          | 671                               |
| 69                         | 8072.9                           | 5640.                                                                                              | 0.010                                                                      | 870.5                         | 1443.1              | 90.21                | 13.88                                          | 22.28                                          | 675                               |
| 70                         | 8190.8                           | 5723.                                                                                              | 0.010                                                                      | 884.5                         | 1465.5              | 90.53                | 13.99                                          | 22.39                                          | 679                               |
| 71                         | 8308.7                           | 5806.                                                                                              | 0.010                                                                      | 898.6                         | 1487.9              | 90.85                | 14.10                                          | 22.50                                          | 682                               |
| 72                         | 8426.5                           | 5889.                                                                                              | 0.010                                                                      | 912.8                         | 1510.5              | 91.17                | 14.22                                          | 22.62                                          | 686                               |
| 73                         | 8544.3                           | 5972.                                                                                              | 0.010                                                                      | 927.1                         | 1533.1              | 91.48                | 14.34                                          | 22.74                                          | 690                               |
| 74                         | 8662.1                           | 6055.                                                                                              | 0.010                                                                      | 941.6                         | 1555.9              | 91.79                | 14.47                                          | 22.86                                          | 693                               |
| 75                         | 8779.8                           | 6137.                                                                                              | 0.009                                                                      | 956.1                         | 1578.9              | 92.10                | 14.60                                          | 22.99                                          | 697                               |
| 76                         | 8897.6                           | 6220.                                                                                              | 0.009                                                                      | 970.9                         | 1601.9              | 92.40                | 14.74                                          | 23.13                                          | 700                               |
| 77                         | 9015.3                           | 6303.                                                                                              | 0.009                                                                      | 985.7                         | 1625.1              | 92.70                | 14.88                                          | 23.26                                          | 704                               |
| 78                         | 9133.1                           | 6386.                                                                                              | 0.009                                                                      | 1000.7                        | 1648.5              | 93.01                | 15.02                                          | 23.40                                          | 707                               |
| 79                         | 9250.8                           | 6468.                                                                                              | 0.009                                                                      | 1015.8                        | 1671.9              | 93.30                | 15.17                                          | 23.55                                          | 710                               |
| 80                         | 9368.5                           | 6551.                                                                                              | 0.009                                                                      | 1031.1                        | 1695.6              | 93.60                | 15.32                                          | 23.70                                          | 714                               |
| 81                         | 9486.2                           | 6634.                                                                                              | 0.009                                                                      | 1046.5                        | 1719.3              | 93.90                | 15.47                                          | 23.85                                          | 717                               |
| 82                         | 9603.9                           | 6717.                                                                                              | 0.009                                                                      | 1062.1                        | 1743.3              | 94.19                | 15.62                                          | 24.00                                          | 720                               |
| 83                         | 9721.5                           | 6799.                                                                                              | 0.008                                                                      | 1077.8                        | 1767.3              | 94.48                | 15.78                                          | 24.16                                          | 723                               |
| 84                         | 9839.2                           | 6882.                                                                                              | 0.008                                                                      | 1093.7                        | 1791.6              | 94.77                | 15.94                                          | 24.32                                          | 726                               |
| 85                         | 9956.8                           | 6965.                                                                                              | 0.008                                                                      | 1109.8                        | 1816.0              | 95.06                | 16.11                                          | 24.48                                          | 729                               |
| 86                         | 10074.                           | 7047.                                                                                              | 0.008                                                                      | 1126.0                        | 1840.5              | 95.35                | 16.27                                          | 24.64                                          | 732                               |
| 87                         | 10192.                           | 7130.                                                                                              | 0.008                                                                      | 1142.4                        | 1865.3              | 95.63                | 16.44                                          | 24.81                                          | 735                               |
| 88                         | 10310.                           | 7212.                                                                                              | 0.008                                                                      | 1158.9                        | 1890.1              | 95.92                | 16.61                                          | 24.97                                          | 738                               |
| 89                         | 10427.                           | 7295.                                                                                              | 0.008                                                                      | 1175.6                        | 1915.2              | 96.20                | 16.78                                          | 25.14                                          | 741                               |
| 90                         | 10545.                           | 7377.                                                                                              | 0.008                                                                      | 1192.5                        | 1940.4              | 96.48                | 16.95                                          | 25.31                                          | 744                               |
| 91                         | 10662.                           | 7460.                                                                                              | 0.008                                                                      | 1209.6                        | 1965.8              | 96.76                | 17.12                                          | 25.49                                          | 747                               |
| 92                         | 10780.                           | 7543.                                                                                              | 0.008                                                                      | 1226.8                        | 1991.4              | 97.04                | 17.29                                          | 25.66                                          | 750                               |
| 93                         | 10898.                           | 7625.                                                                                              | 0.008                                                                      | 1244.2                        | 2017.2              | 97.32                | 17.47                                          | 25.83                                          | 753                               |
| 94                         | 11015.                           | 7708.                                                                                              | 0.007                                                                      | 1261.8                        | 2043.1              | 97.60                | 17.64                                          | 26.00                                          | 756                               |
| 95                         | 11133.                           | 7790.                                                                                              | 0.007                                                                      | 1279.4                        | 2069.2              | 97.88                | 17.82                                          | 26.18                                          | 758                               |
| 96                         | 11250.                           | 7873.                                                                                              | 0.007                                                                      | 1297.5                        | 2095.4              | 98.15                | 18.00                                          | 26.35                                          | 761                               |
| 97                         | 11368.                           | 7955.                                                                                              | 0.007                                                                      | 1315.6                        | 2121.9              | 98.43                | 18.17                                          | 26.53                                          | 764                               |
| 98                         | 11485.                           | 8038.                                                                                              | 0.007                                                                      | 1333.9                        | 2148.5              | 98.70                | 18.35                                          | 26.70                                          | 767                               |
| 99                         | 11603.                           | 8120.                                                                                              | 0.007                                                                      | 1352.3                        | 2175.3              | 98.97                | 18.52                                          | 26.88                                          | 770                               |
| 100                        | 11720.                           | 8203.                                                                                              | 0.007                                                                      | 1371.0                        | 2202.2              | 99.24                | 18.69                                          | 27.05                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBAR5-CONTINUED

0.80 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOTHERM<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.828                   | 26.16                            | 23385.                                                                                             | 9.404                                                                       | -622.8                        | -620.7              | 10.01                | 9.51                                           | 13.14                                          | 1274                              |
| 14                         | 26.21                            | 22971.                                                                                             | 9.376                                                                       | -620.5                        | -618.4              | 10.17                | 9.56                                           | 13.29                                          | 1267                              |
| 15                         | 26.50                            | 21505.                                                                                             | 9.151                                                                       | -606.9                        | -604.7              | 11.12                | 9.90                                           | 14.06                                          | 1239                              |
| 16                         | 26.82                            | 20077.                                                                                             | 8.937                                                                       | -592.3                        | -590.1              | 12.06                | 10.26                                          | 14.90                                          | 1210                              |
| 17                         | 27.16                            | 18437.                                                                                             | 8.760                                                                       | -576.9                        | -574.7              | 12.99                | 10.61                                          | 15.90                                          | 1178                              |
| 18                         | 27.53                            | 16987.                                                                                             | 8.598                                                                       | -560.5                        | -558.2              | 13.93                | 10.94                                          | 16.96                                          | 1150                              |
| 19                         | 27.93                            | 15690.                                                                                             | 8.427                                                                       | -543.0                        | -540.8              | 14.88                | 11.24                                          | 18.04                                          | 1125                              |
| * 19.538                   | 28.16                            | 15077.                                                                                             | 8.329                                                                       | -533.2                        | -530.9              | 15.39                | 11.39                                          | 18.62                                          | 1113                              |
| * 19.538                   | 1837.1                           | 1335.                                                                                              | 0.047                                                                       | 224.0                         | 372.9               | 61.66                | 13.03                                          | 23.91                                          | 351                               |
| 20                         | 1891.6                           | 1385.                                                                                              | 0.045                                                                       | 230.6                         | 383.9               | 62.22                | 12.94                                          | 23.61                                          | 356                               |
| 21                         | 2007.0                           | 1488.                                                                                              | 0.042                                                                       | 244.5                         | 407.2               | 63.35                | 12.82                                          | 23.11                                          | 367                               |
| 22                         | 2120.6                           | 1588.                                                                                              | 0.040                                                                       | 258.3                         | 430.2               | 64.42                | 12.74                                          | 22.75                                          | 378                               |
| 23                         | 2232.8                           | 1685.                                                                                              | 0.038                                                                       | 271.8                         | 452.8               | 65.43                | 12.68                                          | 22.49                                          | 388                               |
| 24                         | 2343.8                           | 1781.                                                                                              | 0.036                                                                       | 285.2                         | 475.1               | 66.38                | 12.65                                          | 22.28                                          | 397                               |
| 25                         | 2453.9                           | 1875.                                                                                              | 0.034                                                                       | 298.4                         | 497.3               | 67.28                | 12.63                                          | 22.12                                          | 406                               |
| 26                         | 2563.2                           | 1968.                                                                                              | 0.033                                                                       | 311.6                         | 519.4               | 68.15                | 12.61                                          | 21.98                                          | 415                               |
| 27                         | 2671.9                           | 2060.                                                                                              | 0.031                                                                       | 324.7                         | 541.3               | 68.98                | 12.59                                          | 21.87                                          | 424                               |
| 28                         | 2780.0                           | 2151.                                                                                              | 0.030                                                                       | 337.8                         | 563.1               | 69.77                | 12.58                                          | 21.77                                          | 432                               |
| 29                         | 2887.7                           | 2241.                                                                                              | 0.029                                                                       | 350.8                         | 584.9               | 70.53                | 12.57                                          | 21.69                                          | 441                               |
| 30                         | 2994.9                           | 2331.                                                                                              | 0.028                                                                       | 363.7                         | 606.5               | 71.27                | 12.57                                          | 21.61                                          | 449                               |
| 31                         | 3101.8                           | 2419.                                                                                              | 0.027                                                                       | 376.7                         | 628.1               | 71.97                | 12.56                                          | 21.55                                          | 457                               |
| 32                         | 3208.3                           | 2508.                                                                                              | 0.026                                                                       | 389.6                         | 649.6               | 72.66                | 12.55                                          | 21.49                                          | 465                               |
| 33                         | 3314.5                           | 2596.                                                                                              | 0.025                                                                       | 402.4                         | 671.1               | 73.32                | 12.55                                          | 21.44                                          | 472                               |
| 34                         | 3420.5                           | 2683.                                                                                              | 0.024                                                                       | 415.2                         | 692.5               | 73.96                | 12.54                                          | 21.40                                          | 480                               |
| 35                         | 3526.3                           | 2770.                                                                                              | 0.024                                                                       | 428.0                         | 713.9               | 74.58                | 12.54                                          | 21.36                                          | 487                               |
| 36                         | 3631.8                           | 2857.                                                                                              | 0.023                                                                       | 440.8                         | 735.2               | 75.18                | 12.54                                          | 21.32                                          | 494                               |
| 37                         | 3737.2                           | 2944.                                                                                              | 0.022                                                                       | 453.6                         | 756.5               | 75.76                | 12.54                                          | 21.29                                          | 501                               |
| 38                         | 3842.3                           | 3030.                                                                                              | 0.022                                                                       | 466.3                         | 777.8               | 76.33                | 12.53                                          | 21.26                                          | 508                               |
| 39                         | 3947.4                           | 3116.                                                                                              | 0.021                                                                       | 479.1                         | 799.1               | 76.88                | 12.54                                          | 21.24                                          | 515                               |
| 40                         | 4052.2                           | 3201.                                                                                              | 0.020                                                                       | 491.8                         | 820.3               | 77.42                | 12.54                                          | 21.22                                          | 522                               |
| 41                         | 4157.0                           | 3287.                                                                                              | 0.020                                                                       | 504.5                         | 841.5               | 77.94                | 12.54                                          | 21.20                                          | 528                               |
| 42                         | 4261.6                           | 3372.                                                                                              | 0.019                                                                       | 517.2                         | 862.7               | 78.45                | 12.54                                          | 21.19                                          | 535                               |
| 43                         | 4366.1                           | 3457.                                                                                              | 0.019                                                                       | 529.9                         | 883.9               | 78.95                | 12.55                                          | 21.17                                          | 541                               |
| 44                         | 4470.5                           | 3542.                                                                                              | 0.018                                                                       | 542.7                         | 905.0               | 79.44                | 12.56                                          | 21.17                                          | 548                               |
| 45                         | 4574.9                           | 3627.                                                                                              | 0.018                                                                       | 555.4                         | 926.2               | 79.91                | 12.57                                          | 21.16                                          | 554                               |
| 46                         | 4679.1                           | 3712.                                                                                              | 0.018                                                                       | 568.1                         | 947.4               | 80.38                | 12.58                                          | 21.16                                          | 560                               |
| 47                         | 4783.2                           | 3797.                                                                                              | 0.017                                                                       | 580.8                         | 968.5               | 80.83                | 12.60                                          | 21.16                                          | 566                               |
| 48                         | 4887.3                           | 3881.                                                                                              | 0.017                                                                       | 593.5                         | 989.7               | 81.28                | 12.62                                          | 21.17                                          | 572                               |
| 49                         | 4991.3                           | 3965.                                                                                              | 0.017                                                                       | 606.3                         | 1010.9              | 81.72                | 12.64                                          | 21.18                                          | 578                               |
| 50                         | 5095.3                           | 4050.                                                                                              | 0.016                                                                       | 619.0                         | 1032.1              | 82.14                | 12.66                                          | 21.19                                          | 584                               |
| 51                         | 5199.2                           | 4134.                                                                                              | 0.016                                                                       | 631.8                         | 1053.3              | 82.56                | 12.69                                          | 21.21                                          | 589                               |
| 52                         | 5303.0                           | 4218.                                                                                              | 0.016                                                                       | 644.6                         | 1074.5              | 82.98                | 12.72                                          | 21.23                                          | 595                               |
| 53                         | 5406.7                           | 4302.                                                                                              | 0.015                                                                       | 657.4                         | 1095.7              | 83.38                | 12.75                                          | 21.25                                          | 600                               |
| 54                         | 5510.5                           | 4386.                                                                                              | 0.015                                                                       | 670.3                         | 1117.0              | 83.78                | 12.79                                          | 21.28                                          | 606                               |
| 55                         | 5614.1                           | 4469.                                                                                              | 0.015                                                                       | 683.2                         | 1138.3              | 84.17                | 12.83                                          | 21.32                                          | 611                               |
| 56                         | 5717.8                           | 4553.                                                                                              | 0.014                                                                       | 696.1                         | 1159.6              | 84.55                | 12.87                                          | 21.36                                          | 616                               |
| 57                         | 5821.4                           | 4637.                                                                                              | 0.014                                                                       | 709.1                         | 1181.0              | 84.93                | 12.92                                          | 21.40                                          | 621                               |
| 58                         | 5924.9                           | 4720.                                                                                              | 0.014                                                                       | 722.2                         | 1202.4              | 85.31                | 12.98                                          | 21.45                                          | 626                               |
| 59                         | 6028.4                           | 4804.                                                                                              | 0.014                                                                       | 735.2                         | 1223.9              | 85.67                | 13.04                                          | 21.50                                          | 631                               |
| 60                         | 6131.9                           | 4888.                                                                                              | 0.013                                                                       | 748.4                         | 1245.4              | 86.03                | 13.10                                          | 21.56                                          | 636                               |
| 61                         | 6235.3                           | 4971.                                                                                              | 0.013                                                                       | 761.6                         | 1267.0              | 86.39                | 13.17                                          | 21.62                                          | 640                               |
| 62                         | 6338.7                           | 5054.                                                                                              | 0.013                                                                       | 774.9                         | 1288.7              | 86.74                | 13.24                                          | 21.69                                          | 645                               |
| 63                         | 6442.1                           | 5138.                                                                                              | 0.013                                                                       | 788.2                         | 1310.4              | 87.09                | 13.32                                          | 21.76                                          | 650                               |
| 64                         | 6545.5                           | 5221.                                                                                              | 0.013                                                                       | 801.6                         | 1332.2              | 87.43                | 13.40                                          | 21.84                                          | 654                               |
| 65                         | 6648.8                           | 5304.                                                                                              | 0.012                                                                       | 815.1                         | 1354.1              | 87.77                | 13.49                                          | 21.92                                          | 658                               |
| 66                         | 6752.1                           | 5388.                                                                                              | 0.012                                                                       | 828.7                         | 1376.1              | 88.11                | 13.58                                          | 22.01                                          | 663                               |
| 67                         | 6855.4                           | 5471.                                                                                              | 0.012                                                                       | 842.4                         | 1398.1              | 88.44                | 13.67                                          | 22.10                                          | 667                               |
| 68                         | 6958.6                           | 5555.                                                                                              | 0.012                                                                       | 856.2                         | 1420.3              | 88.77                | 13.77                                          | 22.20                                          | 671                               |
| 69                         | 7061.9                           | 5637.                                                                                              | 0.012                                                                       | 870.1                         | 1442.5              | 89.09                | 13.88                                          | 22.30                                          | 675                               |
| 70                         | 7165.1                           | 5720.                                                                                              | 0.011                                                                       | 884.1                         | 1464.9              | 89.41                | 13.99                                          | 22.40                                          | 679                               |
| 71                         | 7268.3                           | 5803.                                                                                              | 0.011                                                                       | 898.2                         | 1487.3              | 89.73                | 14.10                                          | 22.52                                          | 682                               |
| 72                         | 7371.4                           | 5886.                                                                                              | 0.011                                                                       | 912.4                         | 1509.9              | 90.05                | 14.22                                          | 22.63                                          | 686                               |
| 73                         | 7474.6                           | 5969.                                                                                              | 0.011                                                                       | 926.7                         | 1532.6              | 90.36                | 14.35                                          | 22.75                                          | 690                               |
| 74                         | 7577.7                           | 6052.                                                                                              | 0.011                                                                       | 941.1                         | 1555.4              | 90.67                | 14.47                                          | 22.88                                          | 693                               |
| 75                         | 7680.8                           | 6135.                                                                                              | 0.011                                                                       | 955.7                         | 1578.3              | 90.98                | 14.60                                          | 23.01                                          | 697                               |
| 76                         | 7783.9                           | 6218.                                                                                              | 0.011                                                                       | 970.4                         | 1601.4              | 91.29                | 14.74                                          | 23.14                                          | 700                               |
| 77                         | 7887.0                           | 6301.                                                                                              | 0.010                                                                       | 985.3                         | 1624.6              | 91.59                | 14.88                                          | 23.27                                          | 704                               |
| 78                         | 7990.1                           | 6384.                                                                                              | 0.010                                                                       | 1000.3                        | 1648.0              | 91.89                | 15.02                                          | 23.42                                          | 707                               |
| 79                         | 8093.2                           | 6466.                                                                                              | 0.010                                                                       | 1015.4                        | 1671.5              | 92.19                | 15.17                                          | 23.56                                          | 711                               |
| 80                         | 8196.2                           | 6549.                                                                                              | 0.010                                                                       | 1030.7                        | 1695.1              | 92.49                | 15.32                                          | 23.71                                          | 714                               |
| 81                         | 8299.3                           | 6632.                                                                                              | 0.010                                                                       | 1046.1                        | 1718.9              | 92.78                | 15.47                                          | 23.86                                          | 717                               |
| 82                         | 8402.3                           | 6715.                                                                                              | 0.010                                                                       | 1061.7                        | 1742.8              | 93.08                | 15.62                                          | 24.01                                          | 720                               |
| 83                         | 8505.3                           | 6798.                                                                                              | 0.010                                                                       | 1077.5                        | 1766.9              | 93.37                | 15.78                                          | 24.17                                          | 723                               |
| 84                         | 8608.3                           | 6880.                                                                                              | 0.010                                                                       | 1093.4                        | 1791.1              | 93.66                | 15.94                                          | 24.33                                          | 726                               |
| 85                         | 8711.3                           | 6963.                                                                                              | 0.009                                                                       | 1109.4                        | 1815.5              | 93.95                | 16.11                                          | 24.49                                          | 729                               |
| 86                         | 8814.2                           | 7046.                                                                                              | 0.009                                                                       | 1125.6                        | 1840.1              | 94.23                | 16.27                                          | 24.65                                          | 732                               |
| 87                         | 8917.2                           | 7128.                                                                                              | 0.009                                                                       | 1142.0                        | 1864.8              | 94.52                | 16.44                                          | 24.82                                          | 735                               |
| 88                         | 9020.2                           | 7211.                                                                                              | 0.009                                                                       | 1158.6                        | 1889.7              | 94.81                | 16.61                                          | 24.98                                          | 738                               |
| 89                         | 9123.1                           | 7294.                                                                                              | 0.009                                                                       | 1175.3                        | 1914.8              | 95.09                | 16.78                                          | 25.15                                          | 741                               |
| 90                         | 9226.1                           | 7376.                                                                                              | 0.009                                                                       | 1192.2                        | 1940.1              | 95.37                | 16.95                                          | 25.32                                          | 744                               |
| 91                         | 9329.0                           | 7459.                                                                                              | 0.009                                                                       | 1209.3                        | 1965.5              | 95.65                | 17.12                                          | 25.49                                          | 747                               |
| 92                         | 9431.9                           | 7542.                                                                                              | 0.009                                                                       | 1226.5                        | 1991.0              | 95.93                | 17.30                                          | 25.67                                          | 750                               |
| 93                         | 9534.8                           | 7624.                                                                                              | 0.009                                                                       | 1243.9                        | 2016.8              | 96.21                | 17.47                                          | 25.84                                          | 753                               |
| 94                         | 9637.7                           | 7707.                                                                                              | 0.009                                                                       | 1261.5                        | 2042.7              | 96.49                | 17.64                                          | 26.01                                          | 756                               |
| 95                         | 9740.6                           | 7789.                                                                                              | 0.008                                                                       | 1279.2                        | 2068.8              | 96.76                | 17.82                                          | 26.19                                          | 758                               |
| 96                         | 9843.5                           | 7872.                                                                                              | 0.008                                                                       | 1297.2                        | 2095.1              | 97.04                | 18.00                                          | 26.36                                          | 761                               |
| 97                         | 9946.4                           | 7955.                                                                                              | 0.008                                                                       | 1315.3                        | 2121.5              | 97.31                | 18.17                                          | 26.53                                          | 764                               |
| 98                         | 10049.                           | 8037.                                                                                              | 0.008                                                                       | 1333.6                        | 2148.2              | 97.58                | 18.35                                          | 26.71                                          | 767                               |
| 99                         | 10152.                           | 8120.                                                                                              | 0.008                                                                       | 1352.0                        | 2175.0              | 97.86                | 18.52                                          | 26.88                                          | 770                               |
| 100                        | 10255.                           | 8202.                                                                                              | 0.008                                                                       | 1370.7                        | 2201.9              | 98.13                | 18.70                                          | 27.06                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

0.90 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.831                   | 26.16                            | 2339 <sup>5</sup> .                                                                                | 9.404                                                                       | -622.8                        | -620.4              | 10.01                | 9.51                                           | 13.14                                          | 1274                              |
| 14                         | 26.21                            | 2298 <sup>5</sup> .                                                                                | 9.377                                                                       | -620.6                        | -618.2              | 10.17                | 9.57                                           | 13.29                                          | 1267                              |
| 15                         | 26.50                            | 2152 <sup>4</sup> .                                                                                | 9.154                                                                       | -606.9                        | -604.5              | 11.11                | 9.90                                           | 14.06                                          | 1239                              |
| 16                         | 26.82                            | 2009 <sup>1</sup> .                                                                                | 8.939                                                                       | -592.4                        | -589.9              | 12.05                | 10.26                                          | 14.89                                          | 1211                              |
| 17                         | 27.16                            | 1853 <sup>3</sup> .                                                                                | 8.762                                                                       | -576.9                        | -574.5              | 12.99                | 10.61                                          | 15.90                                          | 1179                              |
| 18                         | 27.52                            | 1700 <sup>6</sup> .                                                                                | 8.601                                                                       | -560.5                        | -558.0              | 13.93                | 10.94                                          | 16.95                                          | 1151                              |
| 19                         | 27.92                            | 1571 <sup>2</sup> .                                                                                | 8.430                                                                       | -543.1                        | -540.6              | 14.87                | 11.24                                          | 18.03                                          | 1125                              |
| * 19.918                   | 28.32                            | 1462 <sup>6</sup> .                                                                                | 8.266                                                                       | -526.1                        | -523.5              | 15.75                | 11.49                                          | 19.05                                          | 1104                              |
| * 19.918                   | 1652.7                           | 1340.                                                                                              | 0.052                                                                       | 226.6                         | 377.4               | 60.99                | 13.07                                          | 24.21                                          | 353                               |
| 20                         | 1661.6                           | 1349.                                                                                              | 0.052                                                                       | 227.8                         | 379.3               | 61.09                | 13.05                                          | 24.15                                          | 354                               |
| 21                         | 1766.2                           | 1456.                                                                                              | 0.048                                                                       | 242.1                         | 403.2               | 62.25                | 12.89                                          | 23.52                                          | 365                               |
| 22                         | 1868.7                           | 1559.                                                                                              | 0.045                                                                       | 256.0                         | 426.5               | 63.34                | 12.79                                          | 23.08                                          | 376                               |
| 23                         | 1969.7                           | 1659.                                                                                              | 0.043                                                                       | 269.7                         | 449.4               | 64.35                | 12.72                                          | 22.76                                          | 386                               |
| 24                         | 2069.6                           | 1756.                                                                                              | 0.041                                                                       | 283.3                         | 472.0               | 65.32                | 12.68                                          | 22.51                                          | 396                               |
| 25                         | 2168.4                           | 1857.                                                                                              | 0.039                                                                       | 296.7                         | 494.4               | 66.23                | 12.65                                          | 22.31                                          | 405                               |
| 26                         | 2266.4                           | 1947.                                                                                              | 0.037                                                                       | 310.0                         | 516.6               | 67.10                | 12.63                                          | 22.15                                          | 414                               |
| 27                         | 2363.8                           | 2040.                                                                                              | 0.035                                                                       | 323.2                         | 538.7               | 67.94                | 12.61                                          | 22.02                                          | 423                               |
| 28                         | 2460.6                           | 2137.                                                                                              | 0.034                                                                       | 336.3                         | 560.7               | 68.74                | 12.60                                          | 21.91                                          | 432                               |
| 29                         | 2556.9                           | 2227.                                                                                              | 0.033                                                                       | 349.4                         | 582.5               | 69.50                | 12.59                                          | 21.81                                          | 440                               |
| 30                         | 2652.8                           | 2314.                                                                                              | 0.031                                                                       | 362.4                         | 604.3               | 70.24                | 12.58                                          | 21.73                                          | 448                               |
| 31                         | 2748.3                           | 2404.                                                                                              | 0.030                                                                       | 375.4                         | 626.0               | 70.95                | 12.57                                          | 21.65                                          | 456                               |
| 32                         | 2843.4                           | 2497.                                                                                              | 0.029                                                                       | 388.3                         | 647.6               | 71.64                | 12.56                                          | 21.59                                          | 464                               |
| 33                         | 2938.3                           | 2581.                                                                                              | 0.028                                                                       | 401.2                         | 669.2               | 72.30                | 12.56                                          | 21.53                                          | 472                               |
| 34                         | 3032.9                           | 2670.                                                                                              | 0.027                                                                       | 414.1                         | 690.7               | 72.94                | 12.55                                          | 21.48                                          | 479                               |
| 35                         | 3127.3                           | 2757.                                                                                              | 0.027                                                                       | 427.0                         | 712.1               | 73.57                | 12.55                                          | 21.43                                          | 487                               |
| 36                         | 3221.4                           | 2845.                                                                                              | 0.026                                                                       | 439.8                         | 733.6               | 74.17                | 12.54                                          | 21.39                                          | 494                               |
| 37                         | 3315.4                           | 2937.                                                                                              | 0.025                                                                       | 452.6                         | 754.9               | 74.76                | 12.54                                          | 21.35                                          | 501                               |
| 38                         | 3409.2                           | 3019.                                                                                              | 0.024                                                                       | 465.4                         | 776.3               | 75.32                | 12.54                                          | 21.32                                          | 508                               |
| 39                         | 3502.8                           | 3105.                                                                                              | 0.024                                                                       | 478.1                         | 797.6               | 75.88                | 12.54                                          | 21.29                                          | 515                               |
| 40                         | 3596.3                           | 3191.                                                                                              | 0.023                                                                       | 490.9                         | 818.9               | 76.42                | 12.54                                          | 21.27                                          | 522                               |
| 41                         | 3689.7                           | 3277.                                                                                              | 0.022                                                                       | 503.7                         | 840.1               | 76.94                | 12.55                                          | 21.25                                          | 528                               |
| 42                         | 3782.9                           | 3363.                                                                                              | 0.022                                                                       | 516.4                         | 861.4               | 77.45                | 12.55                                          | 21.23                                          | 535                               |
| 43                         | 3876.0                           | 3449.                                                                                              | 0.021                                                                       | 529.1                         | 882.6               | 77.95                | 12.56                                          | 21.22                                          | 541                               |
| 44                         | 3969.0                           | 3534.                                                                                              | 0.021                                                                       | 541.9                         | 903.8               | 78.44                | 12.56                                          | 21.21                                          | 548                               |
| 45                         | 4062.0                           | 3619.                                                                                              | 0.020                                                                       | 554.6                         | 925.0               | 78.92                | 12.57                                          | 21.20                                          | 554                               |
| 46                         | 4154.8                           | 3704.                                                                                              | 0.020                                                                       | 567.3                         | 946.2               | 79.38                | 12.59                                          | 21.20                                          | 560                               |
| 47                         | 4247.6                           | 3789.                                                                                              | 0.019                                                                       | 580.1                         | 967.4               | 79.84                | 12.60                                          | 21.20                                          | 566                               |
| 48                         | 4340.3                           | 3874.                                                                                              | 0.019                                                                       | 592.8                         | 988.6               | 80.29                | 12.62                                          | 21.20                                          | 572                               |
| 49                         | 4432.9                           | 3958.                                                                                              | 0.019                                                                       | 605.6                         | 1009.8              | 80.72                | 12.64                                          | 21.21                                          | 578                               |
| 50                         | 4525.4                           | 4043.                                                                                              | 0.018                                                                       | 618.4                         | 1031.0              | 81.15                | 12.66                                          | 21.22                                          | 584                               |
| 51                         | 4617.9                           | 4127.                                                                                              | 0.018                                                                       | 631.1                         | 1052.3              | 81.57                | 12.69                                          | 21.24                                          | 589                               |
| 52                         | 4710.3                           | 4212.                                                                                              | 0.018                                                                       | 644.0                         | 1073.5              | 81.98                | 12.72                                          | 21.26                                          | 595                               |
| 53                         | 4802.7                           | 4296.                                                                                              | 0.017                                                                       | 656.8                         | 1094.8              | 82.39                | 12.75                                          | 21.28                                          | 600                               |
| 54                         | 4895.0                           | 4380.                                                                                              | 0.017                                                                       | 669.7                         | 1116.1              | 82.79                | 12.79                                          | 21.31                                          | 606                               |
| 55                         | 4987.3                           | 4464.                                                                                              | 0.017                                                                       | 682.6                         | 1137.4              | 83.18                | 12.83                                          | 21.34                                          | 611                               |
| 56                         | 5079.5                           | 4548.                                                                                              | 0.016                                                                       | 695.6                         | 1158.8              | 83.56                | 12.88                                          | 21.38                                          | 616                               |
| 57                         | 5171.7                           | 4632.                                                                                              | 0.016                                                                       | 708.6                         | 1180.2              | 83.94                | 12.93                                          | 21.42                                          | 621                               |
| 58                         | 5263.9                           | 4716.                                                                                              | 0.016                                                                       | 721.6                         | 1201.6              | 84.32                | 12.98                                          | 21.47                                          | 626                               |
| 59                         | 5356.0                           | 4799.                                                                                              | 0.015                                                                       | 734.7                         | 1223.1              | 84.68                | 13.04                                          | 21.52                                          | 631                               |
| 60                         | 5448.1                           | 4883.                                                                                              | 0.015                                                                       | 747.8                         | 1244.7              | 85.05                | 13.10                                          | 21.58                                          | 636                               |
| 61                         | 5540.1                           | 4967.                                                                                              | 0.015                                                                       | 761.1                         | 1266.3              | 85.40                | 13.17                                          | 21.64                                          | 640                               |
| 62                         | 5632.1                           | 5050.                                                                                              | 0.015                                                                       | 774.3                         | 1288.0              | 85.76                | 13.24                                          | 21.71                                          | 645                               |
| 63                         | 5724.1                           | 5134.                                                                                              | 0.014                                                                       | 787.7                         | 1309.7              | 86.10                | 13.32                                          | 21.78                                          | 650                               |
| 64                         | 5816.1                           | 5217.                                                                                              | 0.014                                                                       | 801.1                         | 1331.5              | 86.45                | 13.40                                          | 21.85                                          | 654                               |
| 65                         | 5908.0                           | 5301.                                                                                              | 0.014                                                                       | 814.6                         | 1353.4              | 86.79                | 13.49                                          | 21.94                                          | 658                               |
| 66                         | 5999.9                           | 5384.                                                                                              | 0.014                                                                       | 828.2                         | 1375.4              | 87.12                | 13.58                                          | 22.02                                          | 662                               |
| 67                         | 6091.8                           | 5467.                                                                                              | 0.014                                                                       | 841.9                         | 1397.5              | 87.45                | 13.67                                          | 22.11                                          | 667                               |
| 68                         | 6183.6                           | 5551.                                                                                              | 0.013                                                                       | 855.7                         | 1419.6              | 87.78                | 13.78                                          | 22.21                                          | 671                               |
| 69                         | 6275.5                           | 5634.                                                                                              | 0.013                                                                       | 869.6                         | 1441.9              | 88.11                | 13.88                                          | 22.31                                          | 675                               |
| 70                         | 6367.3                           | 5717.                                                                                              | 0.013                                                                       | 883.6                         | 1464.3              | 88.43                | 13.99                                          | 22.42                                          | 679                               |
| 71                         | 6459.1                           | 5800.                                                                                              | 0.013                                                                       | 897.7                         | 1486.7              | 88.75                | 14.10                                          | 22.53                                          | 682                               |
| 72                         | 6550.8                           | 5883.                                                                                              | 0.013                                                                       | 911.9                         | 1509.3              | 89.06                | 14.22                                          | 22.65                                          | 686                               |
| 73                         | 6642.6                           | 5966.                                                                                              | 0.012                                                                       | 926.3                         | 1532.0              | 89.38                | 14.35                                          | 22.76                                          | 690                               |
| 74                         | 6734.3                           | 6049.                                                                                              | 0.012                                                                       | 940.7                         | 1554.9              | 89.69                | 14.47                                          | 22.89                                          | 693                               |
| 75                         | 6826.1                           | 6133.                                                                                              | 0.012                                                                       | 955.3                         | 1577.8              | 90.00                | 14.61                                          | 23.02                                          | 697                               |
| 76                         | 6917.8                           | 6216.                                                                                              | 0.012                                                                       | 970.0                         | 1600.9              | 90.30                | 14.74                                          | 23.15                                          | 700                               |
| 77                         | 7009.5                           | 6299.                                                                                              | 0.012                                                                       | 984.9                         | 1624.1              | 90.60                | 14.88                                          | 23.29                                          | 704                               |
| 78                         | 7101.1                           | 6381.                                                                                              | 0.012                                                                       | 999.9                         | 1647.5              | 90.91                | 15.02                                          | 23.43                                          | 707                               |
| 79                         | 7192.8                           | 6464.                                                                                              | 0.011                                                                       | 1015.0                        | 1671.0              | 91.21                | 15.17                                          | 23.57                                          | 711                               |
| 80                         | 7284.5                           | 6547.                                                                                              | 0.011                                                                       | 1030.3                        | 1694.6              | 91.50                | 15.32                                          | 23.72                                          | 714                               |
| 81                         | 7376.1                           | 6630.                                                                                              | 0.011                                                                       | 1045.8                        | 1718.4              | 91.80                | 15.47                                          | 23.87                                          | 717                               |
| 82                         | 7467.7                           | 6713.                                                                                              | 0.011                                                                       | 1061.4                        | 1742.3              | 92.09                | 15.62                                          | 24.02                                          | 720                               |
| 83                         | 7559.3                           | 6796.                                                                                              | 0.011                                                                       | 1077.1                        | 1766.4              | 92.38                | 15.78                                          | 24.18                                          | 723                               |
| 84                         | 7650.9                           | 6879.                                                                                              | 0.011                                                                       | 1093.0                        | 1790.7              | 92.67                | 15.94                                          | 24.33                                          | 726                               |
| 85                         | 7742.5                           | 6962.                                                                                              | 0.011                                                                       | 1109.1                        | 1815.1              | 92.96                | 16.11                                          | 24.50                                          | 729                               |
| 86                         | 7834.1                           | 7044.                                                                                              | 0.011                                                                       | 1125.3                        | 1839.7              | 93.25                | 16.27                                          | 24.66                                          | 732                               |
| 87                         | 7925.7                           | 7127.                                                                                              | 0.010                                                                       | 1141.7                        | 1864.4              | 93.54                | 16.44                                          | 24.82                                          | 735                               |
| 88                         | 8017.2                           | 7210.                                                                                              | 0.010                                                                       | 1158.2                        | 1889.3              | 93.82                | 16.61                                          | 24.99                                          | 738                               |
| 89                         | 8108.8                           | 7293.                                                                                              | 0.010                                                                       | 1175.0                        | 1914.4              | 94.11                | 16.78                                          | 25.16                                          | 741                               |
| 90                         | 8200.3                           | 7375.                                                                                              | 0.010                                                                       | 1191.9                        | 1939.7              | 94.39                | 16.95                                          | 25.33                                          | 744                               |
| 91                         | 8291.9                           | 7458.                                                                                              | 0.010                                                                       | 1208.9                        | 1965.1              | 94.67                | 17.12                                          | 25.50                                          | 747                               |
| 92                         | 8383.4                           | 7541.                                                                                              | 0.010                                                                       | 1226.2                        | 1990.7              | 94.95                | 17.30                                          | 25.67                                          | 750                               |
| 93                         | 8474.9                           | 7623.                                                                                              | 0.010                                                                       | 1243.6                        | 2016.4              | 95.23                | 17.47                                          | 25.85                                          | 753                               |
| 94                         | 8566.4                           | 7706.                                                                                              | 0.010                                                                       | 1261.2                        | 2042.4              | 95.50                | 17.65                                          | 26.02                                          | 756                               |
| 95                         | 8657.9                           | 7789.                                                                                              | 0.010                                                                       | 1278.9                        | 2068.5              | 95.78                | 17.82                                          | 26.19                                          | 759                               |
| 96                         | 8749.4                           | 7871.                                                                                              | 0.009                                                                       | 1296.9                        | 2094.8              | 96.06                | 18.00                                          | 26.37                                          | 761                               |
| 97                         | 8840.9                           | 7954.                                                                                              | 0.009                                                                       | 1315.0                        | 2121.2              | 96.33                | 18.17                                          | 26.54                                          | 764                               |
| 98                         | 8932.4                           | 8036.                                                                                              | 0.009                                                                       | 1333.3                        | 2147.8              | 96.60                | 18.35                                          | 26.72                                          | 767                               |
| 99                         | 9023.8                           | 8119.                                                                                              | 0.009                                                                       | 1351.7                        | 2174.6              | 96.87                | 18.52                                          | 26.89                                          | 770                               |
| 100                        | 9115.3                           | 8202.                                                                                              | 0.009                                                                       | 1370.4                        | 2201.6              | 97.15                | 18.70                                          | 27.06                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

1.00 ATMOSPHERE ISOBAR

| TEMPERATURE<br>OEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial p$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>p</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.835                   | 26.16                            | 2340 <sup>+</sup>                                                                                | 9.405                                                                       | -622.8                        | -620.2              | 10.01                | 9.51                                           | 13.14                                          | 1275                              |
| 14                         | 26.21                            | 2300 <sup>+</sup>                                                                                | 9.378                                                                       | -620.6                        | -618.0              | 10.17                | 9.57                                           | 13.29                                          | 1267                              |
| 15                         | 26.50                            | 2154 <sup>+</sup>                                                                                | 9.156                                                                       | -607.0                        | -604.3              | 11.11                | 9.90                                           | 14.06                                          | 1240                              |
| 16                         | 26.81                            | 2011 <sup>+</sup>                                                                                | 8.942                                                                       | -592.4                        | -589.7              | 12.05                | 10.26                                          | 14.89                                          | 1211                              |
| 17                         | 27.15                            | 1847 <sup>+</sup>                                                                                | 8.765                                                                       | -577.0                        | -574.2              | 12.99                | 10.61                                          | 15.89                                          | 1179                              |
| 18                         | 27.52                            | 1702 <sup>+</sup>                                                                                | 8.603                                                                       | -560.6                        | -557.8              | 13.93                | 10.94                                          | 16.94                                          | 1151                              |
| 19                         | 27.92                            | 1573 <sup>+</sup>                                                                                | 8.433                                                                       | -543.2                        | -540.4              | 14.87                | 11.24                                          | 18.02                                          | 1126                              |
| 20                         | 28.35                            | 1454 <sup>+</sup>                                                                                | 8.254                                                                       | -524.7                        | -521.8              | 15.82                | 11.51                                          | 19.14                                          | 1103                              |
| * 20.268                   | 28.48                            | 1409 <sup>+</sup>                                                                                | 8.204                                                                       | -519.5                        | -516.6              | 16.08                | 11.57                                          | 19.53                                          | 1093                              |
| * 20.268                   | 1506.9                           | 1343.                                                                                            | 0.057                                                                       | 229.0                         | 381.7               | 60.41                | 13.11                                          | 24.50                                          | 355                               |
| 21                         | 1573.1                           | 1423.                                                                                            | 0.055                                                                       | 239.6                         | 399.0               | 61.25                | 12.97                                          | 23.97                                          | 363                               |
| 22                         | 1667.0                           | 1529.                                                                                            | 0.051                                                                       | 253.8                         | 422.7               | 62.35                | 12.85                                          | 23.43                                          | 374                               |
| 23                         | 1759.1                           | 1631.                                                                                            | 0.048                                                                       | 267.7                         | 445.9               | 63.38                | 12.77                                          | 23.04                                          | 385                               |
| 24                         | 1850.0                           | 1731.                                                                                            | 0.046                                                                       | 281.3                         | 468.8               | 64.36                | 12.71                                          | 22.75                                          | 395                               |
| 25                         | 1939.9                           | 1829.                                                                                            | 0.043                                                                       | 294.9                         | 491.4               | 65.28                | 12.68                                          | 22.52                                          | 404                               |
| 26                         | 2028.9                           | 1925.                                                                                            | 0.041                                                                       | 308.3                         | 513.9               | 66.16                | 12.65                                          | 22.33                                          | 413                               |
| 27                         | 2117.2                           | 2021.                                                                                            | 0.040                                                                       | 321.6                         | 536.1               | 67.00                | 12.63                                          | 22.18                                          | 422                               |
| 28                         | 2205.0                           | 2113.                                                                                            | 0.038                                                                       | 334.8                         | 558.2               | 67.81                | 12.61                                          | 22.05                                          | 431                               |
| 29                         | 2292.2                           | 2205.                                                                                            | 0.037                                                                       | 348.0                         | 580.2               | 68.58                | 12.60                                          | 21.94                                          | 439                               |
| 30                         | 2379.0                           | 2297.                                                                                            | 0.035                                                                       | 361.1                         | 602.1               | 69.32                | 12.59                                          | 21.84                                          | 448                               |
| 31                         | 2465.4                           | 2388.                                                                                            | 0.034                                                                       | 374.1                         | 623.9               | 70.03                | 12.58                                          | 21.76                                          | 456                               |
| 32                         | 2551.5                           | 2478.                                                                                            | 0.033                                                                       | 387.1                         | 645.6               | 70.72                | 12.57                                          | 21.68                                          | 463                               |
| 33                         | 2637.3                           | 2567.                                                                                            | 0.032                                                                       | 400.1                         | 667.3               | 71.39                | 12.57                                          | 21.62                                          | 471                               |
| 34                         | 2722.8                           | 2656.                                                                                            | 0.031                                                                       | 413.0                         | 688.9               | 72.04                | 12.56                                          | 21.56                                          | 479                               |
| 35                         | 2808.1                           | 2745.                                                                                            | 0.030                                                                       | 425.9                         | 710.4               | 72.66                | 12.56                                          | 21.51                                          | 486                               |
| 36                         | 2893.1                           | 2833.                                                                                            | 0.029                                                                       | 438.7                         | 731.9               | 73.26                | 12.55                                          | 21.46                                          | 493                               |
| 37                         | 2978.0                           | 2920.                                                                                            | 0.028                                                                       | 451.6                         | 753.3               | 73.85                | 12.55                                          | 21.42                                          | 501                               |
| 38                         | 3062.7                           | 3007.                                                                                            | 0.027                                                                       | 464.4                         | 774.7               | 74.42                | 12.55                                          | 21.38                                          | 508                               |
| 39                         | 3147.2                           | 3094.                                                                                            | 0.026                                                                       | 477.2                         | 796.1               | 74.98                | 12.55                                          | 21.35                                          | 514                               |
| 40                         | 3231.6                           | 3181.                                                                                            | 0.026                                                                       | 490.0                         | 817.4               | 75.52                | 12.55                                          | 21.32                                          | 521                               |
| 41                         | 3315.8                           | 3268.                                                                                            | 0.025                                                                       | 502.8                         | 838.7               | 76.04                | 12.55                                          | 21.30                                          | 528                               |
| 42                         | 3399.9                           | 3354.                                                                                            | 0.024                                                                       | 515.5                         | 860.0               | 76.56                | 12.55                                          | 21.28                                          | 535                               |
| 43                         | 3483.9                           | 3440.                                                                                            | 0.024                                                                       | 528.3                         | 881.3               | 77.06                | 12.56                                          | 21.26                                          | 541                               |
| 44                         | 3567.8                           | 3525.                                                                                            | 0.023                                                                       | 541.1                         | 902.6               | 77.55                | 12.57                                          | 21.25                                          | 547                               |
| 45                         | 3651.7                           | 3611.                                                                                            | 0.023                                                                       | 553.8                         | 923.8               | 78.02                | 12.58                                          | 21.24                                          | 554                               |
| 46                         | 3735.4                           | 3696.                                                                                            | 0.022                                                                       | 566.6                         | 945.1               | 78.49                | 12.59                                          | 21.24                                          | 560                               |
| 47                         | 3819.0                           | 3782.                                                                                            | 0.022                                                                       | 579.3                         | 966.3               | 78.95                | 12.60                                          | 21.23                                          | 566                               |
| 48                         | 3902.6                           | 3867.                                                                                            | 0.021                                                                       | 592.1                         | 987.5               | 79.39                | 12.62                                          | 21.24                                          | 572                               |
| 49                         | 3986.1                           | 3952.                                                                                            | 0.021                                                                       | 604.9                         | 1008.8              | 79.83                | 12.64                                          | 21.24                                          | 578                               |
| 50                         | 4069.5                           | 4036.                                                                                            | 0.020                                                                       | 617.7                         | 1030.0              | 80.26                | 12.67                                          | 21.25                                          | 583                               |
| 51                         | 4152.9                           | 4121.                                                                                            | 0.020                                                                       | 630.5                         | 1051.3              | 80.68                | 12.69                                          | 21.27                                          | 589                               |
| 52                         | 4236.2                           | 4206.                                                                                            | 0.020                                                                       | 643.3                         | 1072.6              | 81.10                | 12.72                                          | 21.29                                          | 595                               |
| 53                         | 4319.5                           | 4290.                                                                                            | 0.019                                                                       | 656.2                         | 1093.9              | 81.50                | 12.76                                          | 21.31                                          | 600                               |
| 54                         | 4402.7                           | 4374.                                                                                            | 0.019                                                                       | 669.1                         | 1115.2              | 81.90                | 12.79                                          | 21.34                                          | 606                               |
| 55                         | 4485.8                           | 4459.                                                                                            | 0.018                                                                       | 682.0                         | 1136.5              | 82.29                | 12.83                                          | 21.37                                          | 611                               |
| 56                         | 4568.9                           | 4543.                                                                                            | 0.018                                                                       | 695.0                         | 1157.9              | 82.68                | 12.88                                          | 21.40                                          | 616                               |
| 57                         | 4652.0                           | 4627.                                                                                            | 0.018                                                                       | 708.0                         | 1179.3              | 83.06                | 12.93                                          | 21.45                                          | 621                               |
| 58                         | 4735.0                           | 4711.                                                                                            | 0.017                                                                       | 721.0                         | 1200.8              | 83.43                | 12.98                                          | 21.49                                          | 626                               |
| 59                         | 4818.0                           | 4795.                                                                                            | 0.017                                                                       | 734.1                         | 1222.3              | 83.80                | 13.04                                          | 21.54                                          | 631                               |
| 60                         | 4901.0                           | 4879.                                                                                            | 0.017                                                                       | 747.3                         | 1243.9              | 84.16                | 13.10                                          | 21.60                                          | 636                               |
| 61                         | 4983.9                           | 4967.                                                                                            | 0.017                                                                       | 760.5                         | 1265.5              | 84.52                | 13.17                                          | 21.66                                          | 640                               |
| 62                         | 5066.8                           | 5046.                                                                                            | 0.016                                                                       | 773.8                         | 1287.2              | 84.87                | 13.24                                          | 21.73                                          | 645                               |
| 63                         | 5149.7                           | 5130.                                                                                            | 0.016                                                                       | 787.2                         | 1309.0              | 85.22                | 13.32                                          | 21.80                                          | 650                               |
| 64                         | 5232.5                           | 5213.                                                                                            | 0.016                                                                       | 800.6                         | 1330.8              | 85.56                | 13.40                                          | 21.87                                          | 654                               |
| 65                         | 5315.3                           | 5297.                                                                                            | 0.016                                                                       | 814.2                         | 1352.7              | 85.90                | 13.49                                          | 21.95                                          | 658                               |
| 66                         | 5398.1                           | 5380.                                                                                            | 0.015                                                                       | 827.8                         | 1374.7              | 86.24                | 13.58                                          | 22.04                                          | 662                               |
| 67                         | 5480.9                           | 5464.                                                                                            | 0.015                                                                       | 841.5                         | 1396.8              | 86.57                | 13.68                                          | 22.13                                          | 667                               |
| 68                         | 5563.6                           | 5547.                                                                                            | 0.015                                                                       | 855.3                         | 1419.0              | 86.90                | 13.78                                          | 22.23                                          | 671                               |
| 69                         | 5646.3                           | 5631.                                                                                            | 0.015                                                                       | 869.2                         | 1441.3              | 87.22                | 13.88                                          | 22.33                                          | 675                               |
| 70                         | 5729.0                           | 5714.                                                                                            | 0.014                                                                       | 883.2                         | 1463.7              | 87.55                | 13.99                                          | 22.43                                          | 679                               |
| 71                         | 5811.7                           | 5797.                                                                                            | 0.014                                                                       | 897.3                         | 1486.1              | 87.87                | 14.11                                          | 22.54                                          | 682                               |
| 72                         | 5894.4                           | 5881.                                                                                            | 0.014                                                                       | 911.5                         | 1508.8              | 88.18                | 14.22                                          | 22.66                                          | 686                               |
| 73                         | 5977.0                           | 5964.                                                                                            | 0.014                                                                       | 925.8                         | 1531.5              | 88.50                | 14.35                                          | 22.78                                          | 690                               |
| 74                         | 6059.6                           | 6047.                                                                                            | 0.014                                                                       | 940.3                         | 1554.3              | 88.81                | 14.47                                          | 22.90                                          | 693                               |
| 75                         | 6142.2                           | 6130.                                                                                            | 0.013                                                                       | 954.9                         | 1577.3              | 89.11                | 14.61                                          | 23.03                                          | 697                               |
| 76                         | 6224.8                           | 6213.                                                                                            | 0.013                                                                       | 969.6                         | 1600.4              | 89.42                | 14.74                                          | 23.16                                          | 700                               |
| 77                         | 6307.4                           | 6296.                                                                                            | 0.013                                                                       | 984.5                         | 1623.6              | 89.72                | 14.88                                          | 23.30                                          | 704                               |
| 78                         | 6390.0                           | 6379.                                                                                            | 0.013                                                                       | 999.5                         | 1647.0              | 90.03                | 15.02                                          | 23.44                                          | 707                               |
| 79                         | 6472.5                           | 6462.                                                                                            | 0.013                                                                       | 1014.7                        | 1670.5              | 90.32                | 15.17                                          | 23.58                                          | 711                               |
| 80                         | 6555.0                           | 6545.                                                                                            | 0.013                                                                       | 1029.9                        | 1694.1              | 90.62                | 15.32                                          | 23.73                                          | 714                               |
| 81                         | 6637.6                           | 6628.                                                                                            | 0.012                                                                       | 1045.4                        | 1717.9              | 90.92                | 15.47                                          | 23.88                                          | 717                               |
| 82                         | 6720.1                           | 6711.                                                                                            | 0.012                                                                       | 1061.0                        | 1741.9              | 91.21                | 15.63                                          | 24.03                                          | 720                               |
| 83                         | 6802.6                           | 6794.                                                                                            | 0.012                                                                       | 1076.7                        | 1766.0              | 91.50                | 15.79                                          | 24.19                                          | 723                               |
| 84                         | 6885.0                           | 6877.                                                                                            | 0.012                                                                       | 1092.6                        | 1790.3              | 91.79                | 15.94                                          | 24.34                                          | 726                               |
| 85                         | 6967.5                           | 6960.                                                                                            | 0.012                                                                       | 1108.7                        | 1814.7              | 92.08                | 16.11                                          | 24.50                                          | 730                               |
| 86                         | 7050.0                           | 7043.                                                                                            | 0.012                                                                       | 1124.9                        | 1839.3              | 92.37                | 16.27                                          | 24.67                                          | 733                               |
| 87                         | 7132.4                           | 7126.                                                                                            | 0.012                                                                       | 1141.3                        | 1864.0              | 92.66                | 16.44                                          | 24.83                                          | 736                               |
| 88                         | 7214.9                           | 7209.                                                                                            | 0.011                                                                       | 1157.9                        | 1888.9              | 92.94                | 16.61                                          | 25.00                                          | 738                               |
| 89                         | 7297.3                           | 7291.                                                                                            | 0.011                                                                       | 1174.6                        | 1914.0              | 93.23                | 16.78                                          | 25.17                                          | 741                               |
| 90                         | 7379.7                           | 7374.                                                                                            | 0.011                                                                       | 1191.5                        | 1939.3              | 93.51                | 16.95                                          | 25.34                                          | 744                               |
| 91                         | 7462.1                           | 7457.                                                                                            | 0.011                                                                       | 1208.6                        | 1964.7              | 93.79                | 17.12                                          | 25.51                                          | 747                               |
| 92                         | 7544.6                           | 7540.                                                                                            | 0.011                                                                       | 1225.9                        | 1990.3              | 94.07                | 17.30                                          | 25.68                                          | 750                               |
| 93                         | 7627.0                           | 7623.                                                                                            | 0.011                                                                       | 1243.3                        | 2016.1              | 94.35                | 17.47                                          | 25.85                                          | 753                               |
| 94                         | 7709.3                           | 7705.                                                                                            | 0.011                                                                       | 1260.9                        | 2042.0              | 94.62                | 17.65                                          | 26.03                                          | 756                               |
| 95                         | 7791.7                           | 7788.                                                                                            | 0.011                                                                       | 1278.6                        | 2068.1              | 94.90                | 17.82                                          | 26.20                                          | 759                               |
| 96                         | 7874.1                           | 7871.                                                                                            | 0.010                                                                       | 1296.6                        | 2094.4              | 95.18                | 18.00                                          | 26.37                                          | 761                               |
| 97                         | 7956.5                           | 7953.                                                                                            | 0.010                                                                       | 1314.7                        | 2120.9              | 95.45                | 18.17                                          | 26.55                                          | 764                               |
| 98                         | 8038.8                           | 8036.                                                                                            | 0.010                                                                       | 1333.0                        | 2147.5              | 95.72                | 18.35                                          | 26.72                                          | 767                               |
| 99                         | 8121.2                           | 8119.                                                                                            | 0.010                                                                       | 1351.4                        | 2174.3              | 96.00                | 18.52                                          | 26.90                                          | 770                               |
| 100                        | 8203.5                           | 8201.                                                                                            | 0.010                                                                       | 1370.1                        | 2201.3              | 96.27                | 18.70                                          | 27.07                                          | 773                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 1.50 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /MOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>OERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>OERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> + HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> + HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|---------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.852                   | 26.15                           | 23457.                                                                                             | 9.407                                                                       | -622.8                        | -618.8              | 10.01                | 9.52                                           | 13.14                                          | 1276                              |
| 14                         | 26.19                           | 2309 <sup>a</sup> .                                                                                | 9.383                                                                       | -620.8                        | -616.8              | 10.15                | 9.57                                           | 13.28                                          | 1269                              |
| 15                         | 26.48                           | 2163 <sup>a</sup> .                                                                                | 9.169                                                                       | -607.2                        | -603.2              | 11.09                | 9.90                                           | 14.04                                          | 1242                              |
| 16                         | 26.79                           | 20203.                                                                                             | 8.956                                                                       | -592.7                        | -588.6              | 12.03                | 10.26                                          | 14.88                                          | 1214                              |
| 17                         | 27.13                           | 18579.                                                                                             | 8.779                                                                       | -577.3                        | -573.2              | 12.97                | 10.61                                          | 15.87                                          | 1182                              |
| 18                         | 27.50                           | 17140.                                                                                             | 8.618                                                                       | -560.9                        | -556.8              | 13.91                | 10.94                                          | 16.91                                          | 1154                              |
| 19                         | 27.89                           | 15843.                                                                                             | 8.448                                                                       | -543.6                        | -539.3              | 14.85                | 11.24                                          | 17.99                                          | 1129                              |
| 20                         | 28.33                           | 14643.                                                                                             | 8.269                                                                       | -525.1                        | -520.8              | 15.80                | 11.51                                          | 19.10                                          | 1105                              |
| 21                         | 28.81                           | 13184.                                                                                             | 8.066                                                                       | -505.4                        | -501.0              | 16.76                | 11.74                                          | 20.45                                          | 1075                              |
| * 21.722                   | 29.19                           | 12268.                                                                                             | 7.904                                                                       | -490.3                        | -485.9              | 17.47                | 11.89                                          | 21.43                                          | 1054                              |
| * 21.722                   | 1040.8                          | 1338.                                                                                              | 0.084                                                                       | 237.2                         | 395.4               | 58.07                | 13.30                                          | 25.94                                          | 362                               |
| 22                         | 1058.5                          | 1371.                                                                                              | 0.083                                                                       | 241.5                         | 402.4               | 58.38                | 13.22                                          | 25.64                                          | 366                               |
| 23                         | 1124.9                          | 1489.                                                                                              | 0.077                                                                       | 256.6                         | 427.6               | 59.50                | 13.03                                          | 24.77                                          | 377                               |
| 24                         | 1189.6                          | 1601.                                                                                              | 0.072                                                                       | 271.2                         | 452.0               | 60.54                | 12.90                                          | 24.15                                          | 388                               |
| 25                         | 1252.9                          | 1709.                                                                                              | 0.068                                                                       | 285.5                         | 475.9               | 61.52                | 12.82                                          | 23.69                                          | 398                               |
| 26                         | 1315.2                          | 1814.                                                                                              | 0.065                                                                       | 299.6                         | 499.4               | 62.44                | 12.77                                          | 23.34                                          | 408                               |
| 27                         | 1376.7                          | 1916.                                                                                              | 0.062                                                                       | 313.4                         | 522.6               | 63.32                | 12.73                                          | 23.05                                          | 418                               |
| 28                         | 1437.4                          | 2016.                                                                                              | 0.059                                                                       | 327.1                         | 545.6               | 64.15                | 12.70                                          | 22.82                                          | 427                               |
| 29                         | 1497.6                          | 2115.                                                                                              | 0.056                                                                       | 340.7                         | 568.3               | 64.95                | 12.68                                          | 22.62                                          | 436                               |
| 30                         | 1557.3                          | 2217.                                                                                              | 0.054                                                                       | 354.1                         | 590.8               | 65.71                | 12.66                                          | 22.46                                          | 444                               |
| 31                         | 1616.5                          | 2307.                                                                                              | 0.052                                                                       | 367.5                         | 613.2               | 66.45                | 12.64                                          | 22.32                                          | 452                               |
| 32                         | 1675.4                          | 2402.                                                                                              | 0.050                                                                       | 380.8                         | 635.5               | 67.15                | 12.63                                          | 22.19                                          | 461                               |
| 33                         | 1734.0                          | 2495.                                                                                              | 0.048                                                                       | 394.1                         | 657.6               | 67.84                | 12.62                                          | 22.08                                          | 468                               |
| 34                         | 1792.2                          | 2588.                                                                                              | 0.047                                                                       | 407.3                         | 679.6               | 68.49                | 12.61                                          | 21.99                                          | 476                               |
| 35                         | 1850.2                          | 2680.                                                                                              | 0.045                                                                       | 420.4                         | 701.6               | 69.13                | 12.60                                          | 21.90                                          | 484                               |
| 36                         | 1908.0                          | 2771.                                                                                              | 0.044                                                                       | 433.5                         | 723.4               | 69.75                | 12.59                                          | 21.82                                          | 491                               |
| 37                         | 1965.6                          | 2862.                                                                                              | 0.043                                                                       | 446.5                         | 745.2               | 70.34                | 12.59                                          | 21.76                                          | 499                               |
| 38                         | 2022.9                          | 2952.                                                                                              | 0.041                                                                       | 459.5                         | 767.0               | 70.92                | 12.58                                          | 21.70                                          | 506                               |
| 39                         | 2080.2                          | 3041.                                                                                              | 0.040                                                                       | 472.5                         | 788.6               | 71.48                | 12.58                                          | 21.64                                          | 513                               |
| 40                         | 2137.2                          | 3130.                                                                                              | 0.039                                                                       | 485.4                         | 810.3               | 72.03                | 12.58                                          | 21.60                                          | 520                               |
| 41                         | 2194.1                          | 3219.                                                                                              | 0.038                                                                       | 498.4                         | 831.8               | 72.56                | 12.58                                          | 21.56                                          | 527                               |
| 42                         | 2250.9                          | 3307.                                                                                              | 0.037                                                                       | 511.3                         | 853.4               | 73.08                | 12.58                                          | 21.52                                          | 533                               |
| 43                         | 2307.6                          | 3395.                                                                                              | 0.036                                                                       | 524.2                         | 874.9               | 73.59                | 12.58                                          | 21.49                                          | 540                               |
| 44                         | 2364.2                          | 3483.                                                                                              | 0.035                                                                       | 537.0                         | 896.4               | 74.08                | 12.59                                          | 21.47                                          | 546                               |
| 45                         | 2420.7                          | 3570.                                                                                              | 0.034                                                                       | 549.9                         | 917.8               | 74.57                | 12.60                                          | 21.45                                          | 553                               |
| 46                         | 2477.1                          | 3657.                                                                                              | 0.034                                                                       | 562.8                         | 939.3               | 75.04                | 12.61                                          | 21.43                                          | 559                               |
| 47                         | 2533.4                          | 3744.                                                                                              | 0.033                                                                       | 575.6                         | 960.7               | 75.50                | 12.62                                          | 21.42                                          | 565                               |
| 48                         | 2589.6                          | 3831.                                                                                              | 0.032                                                                       | 588.5                         | 982.1               | 75.95                | 12.64                                          | 21.41                                          | 571                               |
| 49                         | 2645.8                          | 3917.                                                                                              | 0.031                                                                       | 601.4                         | 1003.5              | 76.39                | 12.66                                          | 21.41                                          | 577                               |
| 50                         | 2701.8                          | 4003.                                                                                              | 0.031                                                                       | 614.3                         | 1024.9              | 76.82                | 12.68                                          | 21.41                                          | 583                               |
| 51                         | 2757.9                          | 4089.                                                                                              | 0.030                                                                       | 627.2                         | 1046.3              | 77.25                | 12.71                                          | 21.42                                          | 589                               |
| 52                         | 2813.8                          | 4175.                                                                                              | 0.029                                                                       | 640.1                         | 1067.8              | 77.66                | 12.74                                          | 21.43                                          | 594                               |
| 53                         | 2869.7                          | 4261.                                                                                              | 0.029                                                                       | 653.0                         | 1089.2              | 78.07                | 12.77                                          | 21.45                                          | 600                               |
| 54                         | 2925.6                          | 4346.                                                                                              | 0.028                                                                       | 666.0                         | 1110.7              | 78.47                | 12.81                                          | 21.47                                          | 605                               |
| 55                         | 2981.4                          | 4431.                                                                                              | 0.028                                                                       | 679.0                         | 1132.1              | 78.87                | 12.85                                          | 21.49                                          | 610                               |
| 56                         | 3037.2                          | 4517.                                                                                              | 0.027                                                                       | 692.0                         | 1153.6              | 79.25                | 12.89                                          | 21.52                                          | 616                               |
| 57                         | 3092.9                          | 4602.                                                                                              | 0.027                                                                       | 705.1                         | 1175.2              | 79.64                | 12.94                                          | 21.56                                          | 621                               |
| 58                         | 3148.6                          | 4687.                                                                                              | 0.026                                                                       | 718.2                         | 1196.8              | 80.01                | 12.99                                          | 21.60                                          | 626                               |
| 59                         | 3204.2                          | 4777.                                                                                              | 0.026                                                                       | 731.4                         | 1218.4              | 80.38                | 13.05                                          | 21.65                                          | 631                               |
| 60                         | 3259.8                          | 4856.                                                                                              | 0.025                                                                       | 744.6                         | 1240.1              | 80.74                | 13.11                                          | 21.70                                          | 636                               |
| 61                         | 3315.4                          | 4941.                                                                                              | 0.025                                                                       | 757.9                         | 1261.8              | 81.10                | 13.18                                          | 21.76                                          | 640                               |
| 62                         | 3371.0                          | 5026.                                                                                              | 0.025                                                                       | 771.2                         | 1283.6              | 81.46                | 13.25                                          | 21.82                                          | 645                               |
| 63                         | 3426.5                          | 5111.                                                                                              | 0.024                                                                       | 784.7                         | 1305.4              | 81.81                | 13.33                                          | 21.89                                          | 649                               |
| 64                         | 3482.0                          | 5194.                                                                                              | 0.024                                                                       | 798.2                         | 1327.4              | 82.15                | 13.41                                          | 21.96                                          | 654                               |
| 65                         | 3537.4                          | 5279.                                                                                              | 0.023                                                                       | 811.7                         | 1349.4              | 82.49                | 13.50                                          | 22.04                                          | 658                               |
| 66                         | 3592.9                          | 5363.                                                                                              | 0.023                                                                       | 825.4                         | 1371.4              | 82.83                | 13.59                                          | 22.12                                          | 662                               |
| 67                         | 3648.3                          | 5447.                                                                                              | 0.023                                                                       | 839.1                         | 1393.6              | 83.16                | 13.68                                          | 22.21                                          | 667                               |
| 68                         | 3703.7                          | 5531.                                                                                              | 0.022                                                                       | 853.0                         | 1415.9              | 83.49                | 13.78                                          | 22.30                                          | 671                               |
| 69                         | 3759.0                          | 5615.                                                                                              | 0.022                                                                       | 866.9                         | 1438.2              | 83.82                | 13.89                                          | 22.40                                          | 675                               |
| 70                         | 3814.4                          | 5699.                                                                                              | 0.022                                                                       | 880.9                         | 1460.7              | 84.14                | 14.00                                          | 22.50                                          | 679                               |
| 71                         | 3869.7                          | 5783.                                                                                              | 0.021                                                                       | 895.1                         | 1483.2              | 84.46                | 14.11                                          | 22.61                                          | 682                               |
| 72                         | 3925.0                          | 5867.                                                                                              | 0.021                                                                       | 909.4                         | 1505.9              | 84.78                | 14.23                                          | 22.72                                          | 686                               |
| 73                         | 3980.3                          | 5951.                                                                                              | 0.021                                                                       | 923.7                         | 1528.7              | 85.09                | 14.35                                          | 22.84                                          | 690                               |
| 74                         | 4035.5                          | 6034.                                                                                              | 0.020                                                                       | 938.2                         | 1551.6              | 85.41                | 14.48                                          | 22.96                                          | 694                               |
| 75                         | 4090.8                          | 6118.                                                                                              | 0.020                                                                       | 952.9                         | 1574.6              | 85.72                | 14.61                                          | 23.09                                          | 697                               |
| 76                         | 4146.0                          | 6202.                                                                                              | 0.020                                                                       | 967.6                         | 1597.8              | 86.02                | 14.75                                          | 23.22                                          | 701                               |
| 77                         | 4201.3                          | 6285.                                                                                              | 0.020                                                                       | 982.5                         | 1621.1              | 86.33                | 14.89                                          | 23.35                                          | 704                               |
| 78                         | 4256.5                          | 6369.                                                                                              | 0.019                                                                       | 997.6                         | 1644.5              | 86.63                | 15.03                                          | 23.49                                          | 707                               |
| 79                         | 4311.7                          | 6452.                                                                                              | 0.019                                                                       | 1012.7                        | 1668.0              | 86.93                | 15.17                                          | 23.63                                          | 711                               |
| 80                         | 4366.8                          | 6536.                                                                                              | 0.019                                                                       | 1028.1                        | 1691.8              | 87.23                | 15.32                                          | 23.78                                          | 714                               |
| 81                         | 4422.0                          | 6619.                                                                                              | 0.019                                                                       | 1043.5                        | 1715.6              | 87.52                | 15.47                                          | 23.93                                          | 717                               |
| 82                         | 4477.1                          | 6703.                                                                                              | 0.018                                                                       | 1059.1                        | 1739.6              | 87.82                | 15.63                                          | 24.08                                          | 720                               |
| 83                         | 4532.3                          | 6786.                                                                                              | 0.018                                                                       | 1074.9                        | 1763.8              | 88.11                | 15.79                                          | 24.23                                          | 724                               |
| 84                         | 4587.4                          | 6869.                                                                                              | 0.018                                                                       | 1090.9                        | 1788.1              | 88.40                | 15.95                                          | 24.39                                          | 727                               |
| 85                         | 4642.5                          | 6953.                                                                                              | 0.018                                                                       | 1106.9                        | 1812.6              | 88.69                | 16.11                                          | 24.55                                          | 730                               |
| 86                         | 4697.6                          | 7036.                                                                                              | 0.018                                                                       | 1123.2                        | 1837.2              | 88.98                | 16.28                                          | 24.71                                          | 733                               |
| 87                         | 4752.7                          | 7119.                                                                                              | 0.017                                                                       | 1139.6                        | 1862.0              | 89.27                | 16.44                                          | 24.88                                          | 736                               |
| 88                         | 4807.8                          | 7203.                                                                                              | 0.017                                                                       | 1156.2                        | 1886.9              | 89.55                | 16.61                                          | 25.04                                          | 739                               |
| 89                         | 4862.9                          | 7286.                                                                                              | 0.017                                                                       | 1173.0                        | 1912.1              | 89.84                | 16.78                                          | 25.21                                          | 742                               |
| 90                         | 4918.0                          | 7369.                                                                                              | 0.017                                                                       | 1189.9                        | 1937.4              | 90.12                | 16.95                                          | 25.38                                          | 745                               |
| 91                         | 4973.0                          | 7452.                                                                                              | 0.017                                                                       | 1207.0                        | 1962.8              | 90.40                | 17.13                                          | 25.55                                          | 747                               |
| 92                         | 5028.1                          | 7535.                                                                                              | 0.016                                                                       | 1224.3                        | 1988.5              | 90.68                | 17.30                                          | 25.72                                          | 750                               |
| 93                         | 5083.1                          | 7618.                                                                                              | 0.016                                                                       | 1241.7                        | 2014.3              | 90.96                | 17.47                                          | 25.89                                          | 753                               |
| 94                         | 5138.2                          | 7701.                                                                                              | 0.016                                                                       | 1259.3                        | 2040.2              | 91.24                | 17.65                                          | 26.06                                          | 756                               |
| 95                         | 5193.2                          | 7784.                                                                                              | 0.016                                                                       | 1277.1                        | 2066.4              | 91.51                | 17.82                                          | 26.24                                          | 759                               |
| 96                         | 5248.2                          | 7867.                                                                                              | 0.016                                                                       | 1295.0                        | 2092.7              | 91.79                | 18.00                                          | 26.41                                          | 762                               |
| 97                         | 5303.2                          | 7950.                                                                                              | 0.016                                                                       | 1313.2                        | 2119.2              | 92.06                | 18.17                                          | 26.58                                          | 764                               |
| 98                         | 5358.3                          | 8033.                                                                                              | 0.015                                                                       | 1331.5                        | 2145.9              | 92.34                | 18.35                                          | 26.76                                          | 767                               |
| 99                         | 5413.3                          | 8116.                                                                                              | 0.015                                                                       | 1350.0                        | 2172.7              | 92.61                | 18.52                                          | 26.93                                          | 770                               |
| 100                        | 5468.2                          | 8199.                                                                                              | 0.015                                                                       | 1368.6                        | 2199.7              | 92.88                | 18.70                                          | 27.10                                          | 773                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 2.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial \rho$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> • HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>v</sub> • HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.869                   | 26.14                            | 23507.                                                                                             | 9.408                                                                         | -622.7                        | -617.4              | 10.01                | 9.53                                           | 13.14                                          | 1277                              |
| 14                         | 26.18                            | 23184.                                                                                             | 9.387                                                                         | -621.0                        | -615.7              | 10.14                | 9.57                                           | 13.26                                          | 1271                              |
| 15                         | 26.46                            | 21732.                                                                                             | 9.181                                                                         | -607.4                        | -602.0              | 11.08                | 9.90                                           | 14.03                                          | 1244                              |
| 16                         | 26.78                            | 20297.                                                                                             | 8.969                                                                         | -592.9                        | -587.5              | 12.02                | 10.26                                          | 14.86                                          | 1216                              |
| 17                         | 27.11                            | 18685.                                                                                             | 8.792                                                                         | -577.6                        | -572.1              | 12.95                | 10.60                                          | 15.84                                          | 1184                              |
| 18                         | 27.47                            | 17251.                                                                                             | 8.632                                                                         | -561.3                        | -555.7              | 13.89                | 10.93                                          | 16.88                                          | 1157                              |
| 19                         | 27.87                            | 15957.                                                                                             | 8.463                                                                         | -544.0                        | -538.3              | 14.83                | 11.23                                          | 17.95                                          | 1132                              |
| 20                         | 28.30                            | 14747.                                                                                             | 8.284                                                                         | -525.6                        | -519.8              | 15.78                | 11.50                                          | 19.06                                          | 1108                              |
| 21                         | 28.78                            | 13298.                                                                                             | 8.083                                                                         | -505.9                        | -500.1              | 16.74                | 11.73                                          | 20.39                                          | 1078                              |
| 22                         | 29.31                            | 12004.                                                                                             | 7.856                                                                         | -485.0                        | -479.0              | 17.72                | 11.94                                          | 21.78                                          | 1049                              |
| * 22.861                   | 29.82                            | 10697.                                                                                             | 7.620                                                                         | -465.7                        | -459.7              | 18.58                | 12.09                                          | 23.28                                          | 1017                              |
| * 22.861                   | 796.51                           | 1314.                                                                                              | 0.112                                                                         | 241.9                         | 403.4               | 56.36                | 13.44                                          | 27.39                                          | 367                               |
| 23                         | 804.24                           | 1337.                                                                                              | 0.110                                                                         | 244.2                         | 407.2               | 56.53                | 13.40                                          | 27.18                                          | 369                               |
| 24                         | 856.72                           | 1461.                                                                                              | 0.102                                                                         | 260.1                         | 433.7               | 57.66                | 13.16                                          | 26.00                                          | 381                               |
| 25                         | 907.42                           | 1587.                                                                                              | 0.096                                                                         | 275.4                         | 459.3               | 58.70                | 13.01                                          | 25.17                                          | 392                               |
| 26                         | 956.79                           | 1697.                                                                                              | 0.091                                                                         | 290.2                         | 484.1               | 59.67                | 12.91                                          | 24.55                                          | 403                               |
| 27                         | 1005.1                           | 1808.                                                                                              | 0.086                                                                         | 304.7                         | 508.4               | 60.59                | 12.85                                          | 24.08                                          | 413                               |
| 28                         | 1052.6                           | 1916.                                                                                              | 0.082                                                                         | 319.0                         | 532.3               | 61.46                | 12.80                                          | 23.71                                          | 422                               |
| 29                         | 1099.5                           | 2021.                                                                                              | 0.078                                                                         | 333.1                         | 555.9               | 62.29                | 12.76                                          | 23.40                                          | 432                               |
| 30                         | 1145.8                           | 2124.                                                                                              | 0.074                                                                         | 347.0                         | 579.2               | 63.08                | 12.74                                          | 23.15                                          | 441                               |
| 31                         | 1191.5                           | 2225.                                                                                              | 0.071                                                                         | 360.7                         | 602.2               | 63.83                | 12.71                                          | 22.93                                          | 449                               |
| 32                         | 1236.9                           | 2324.                                                                                              | 0.069                                                                         | 374.4                         | 625.0               | 64.56                | 12.69                                          | 22.75                                          | 458                               |
| 33                         | 1281.9                           | 2427.                                                                                              | 0.066                                                                         | 387.9                         | 647.7               | 65.25                | 12.68                                          | 22.59                                          | 466                               |
| 34                         | 1326.6                           | 2519.                                                                                              | 0.064                                                                         | 401.4                         | 670.2               | 65.93                | 12.66                                          | 22.44                                          | 474                               |
| 35                         | 1371.0                           | 2614.                                                                                              | 0.062                                                                         | 414.8                         | 692.6               | 66.57                | 12.64                                          | 22.32                                          | 482                               |
| 36                         | 1415.2                           | 2709.                                                                                              | 0.060                                                                         | 428.1                         | 714.9               | 67.20                | 12.63                                          | 22.21                                          | 489                               |
| 37                         | 1459.2                           | 2807.                                                                                              | 0.058                                                                         | 441.3                         | 737.0               | 67.81                | 12.62                                          | 22.11                                          | 497                               |
| 38                         | 1502.9                           | 2895.                                                                                              | 0.056                                                                         | 454.5                         | 759.1               | 68.40                | 12.61                                          | 22.03                                          | 504                               |
| 39                         | 1546.5                           | 2987.                                                                                              | 0.054                                                                         | 467.7                         | 781.1               | 68.97                | 12.61                                          | 21.95                                          | 511                               |
| 40                         | 1589.9                           | 3079.                                                                                              | 0.053                                                                         | 480.8                         | 803.0               | 69.52                | 12.61                                          | 21.88                                          | 518                               |
| 41                         | 1633.2                           | 3177.                                                                                              | 0.051                                                                         | 493.9                         | 824.9               | 70.06                | 12.60                                          | 21.82                                          | 525                               |
| 42                         | 1676.4                           | 3267.                                                                                              | 0.050                                                                         | 506.9                         | 846.6               | 70.59                | 12.61                                          | 21.77                                          | 532                               |
| 43                         | 1719.4                           | 3357.                                                                                              | 0.049                                                                         | 520.0                         | 868.4               | 71.10                | 12.61                                          | 21.73                                          | 539                               |
| 44                         | 1762.3                           | 3447.                                                                                              | 0.047                                                                         | 533.0                         | 890.1               | 71.60                | 12.61                                          | 21.69                                          | 545                               |
| 45                         | 1805.2                           | 3527.                                                                                              | 0.046                                                                         | 546.0                         | 911.8               | 72.09                | 12.62                                          | 21.65                                          | 552                               |
| 46                         | 1847.9                           | 3618.                                                                                              | 0.045                                                                         | 558.9                         | 933.4               | 72.56                | 12.63                                          | 21.63                                          | 558                               |
| 47                         | 1890.5                           | 3706.                                                                                              | 0.044                                                                         | 571.9                         | 955.0               | 73.03                | 12.64                                          | 21.60                                          | 564                               |
| 48                         | 1933.1                           | 3795.                                                                                              | 0.043                                                                         | 584.9                         | 976.6               | 73.48                | 12.66                                          | 21.59                                          | 570                               |
| 49                         | 1975.6                           | 3887.                                                                                              | 0.042                                                                         | 597.9                         | 998.2               | 73.93                | 12.68                                          | 21.58                                          | 576                               |
| 50                         | 2018.0                           | 3977.                                                                                              | 0.041                                                                         | 610.8                         | 1019.8              | 74.36                | 12.70                                          | 21.57                                          | 582                               |
| 51                         | 2060.4                           | 4057.                                                                                              | 0.040                                                                         | 623.8                         | 1041.4              | 74.79                | 12.72                                          | 21.57                                          | 588                               |
| 52                         | 2102.7                           | 4144.                                                                                              | 0.040                                                                         | 636.8                         | 1062.9              | 75.21                | 12.75                                          | 21.57                                          | 594                               |
| 53                         | 2144.9                           | 4231.                                                                                              | 0.039                                                                         | 649.9                         | 1084.5              | 75.62                | 12.78                                          | 21.58                                          | 599                               |
| 54                         | 2187.1                           | 4318.                                                                                              | 0.038                                                                         | 662.9                         | 1106.1              | 76.02                | 12.82                                          | 21.60                                          | 605                               |
| 55                         | 2229.2                           | 4404.                                                                                              | 0.037                                                                         | 676.0                         | 1127.7              | 76.42                | 12.86                                          | 21.62                                          | 610                               |
| 56                         | 2271.3                           | 4491.                                                                                              | 0.037                                                                         | 689.1                         | 1149.4              | 76.81                | 12.90                                          | 21.65                                          | 615                               |
| 57                         | 2313.4                           | 4577.                                                                                              | 0.036                                                                         | 702.2                         | 1171.0              | 77.19                | 12.95                                          | 21.68                                          | 620                               |
| 58                         | 2355.4                           | 4663.                                                                                              | 0.035                                                                         | 715.4                         | 1192.7              | 77.57                | 13.00                                          | 21.71                                          | 626                               |
| 59                         | 2397.3                           | 4749.                                                                                              | 0.035                                                                         | 728.6                         | 1214.4              | 77.94                | 13.06                                          | 21.76                                          | 630                               |
| 60                         | 2439.3                           | 4834.                                                                                              | 0.034                                                                         | 741.9                         | 1236.2              | 78.31                | 13.12                                          | 21.80                                          | 635                               |
| 61                         | 2481.2                           | 4920.                                                                                              | 0.033                                                                         | 755.2                         | 1258.1              | 78.67                | 13.19                                          | 21.86                                          | 640                               |
| 62                         | 2523.1                           | 5005.                                                                                              | 0.033                                                                         | 768.6                         | 1279.9              | 79.02                | 13.26                                          | 21.91                                          | 645                               |
| 63                         | 2564.9                           | 5090.                                                                                              | 0.032                                                                         | 782.1                         | 1301.9              | 79.38                | 13.34                                          | 21.98                                          | 649                               |
| 64                         | 2606.7                           | 5176.                                                                                              | 0.032                                                                         | 795.7                         | 1323.9              | 79.72                | 13.42                                          | 22.05                                          | 654                               |
| 65                         | 2648.5                           | 5261.                                                                                              | 0.031                                                                         | 809.3                         | 1346.0              | 80.06                | 13.50                                          | 22.12                                          | 658                               |
| 66                         | 2690.2                           | 5346.                                                                                              | 0.031                                                                         | 823.0                         | 1368.2              | 80.40                | 13.60                                          | 22.20                                          | 662                               |
| 67                         | 2732.0                           | 5430.                                                                                              | 0.030                                                                         | 836.8                         | 1390.4              | 80.74                | 13.69                                          | 22.29                                          | 667                               |
| 68                         | 2773.7                           | 5515.                                                                                              | 0.030                                                                         | 850.6                         | 1412.7              | 81.07                | 13.79                                          | 22.38                                          | 671                               |
| 69                         | 2815.4                           | 5600.                                                                                              | 0.029                                                                         | 864.6                         | 1435.2              | 81.40                | 13.90                                          | 22.47                                          | 675                               |
| 70                         | 2857.0                           | 5685.                                                                                              | 0.029                                                                         | 878.7                         | 1457.7              | 81.72                | 14.00                                          | 22.58                                          | 679                               |
| 71                         | 2898.7                           | 5769.                                                                                              | 0.029                                                                         | 892.9                         | 1480.3              | 82.04                | 14.12                                          | 22.68                                          | 682                               |
| 72                         | 2940.3                           | 5855.                                                                                              | 0.028                                                                         | 907.2                         | 1503.1              | 82.36                | 14.24                                          | 22.79                                          | 686                               |
| 73                         | 2981.9                           | 5938.                                                                                              | 0.028                                                                         | 921.6                         | 1525.9              | 82.67                | 14.36                                          | 22.91                                          | 690                               |
| 74                         | 3023.5                           | 6027.                                                                                              | 0.027                                                                         | 936.2                         | 1548.9              | 82.99                | 14.49                                          | 23.03                                          | 694                               |
| 75                         | 3065.1                           | 6106.                                                                                              | 0.027                                                                         | 950.8                         | 1572.0              | 83.30                | 14.62                                          | 23.15                                          | 697                               |
| 76                         | 3106.7                           | 6191.                                                                                              | 0.027                                                                         | 965.6                         | 1595.2              | 83.60                | 14.75                                          | 23.28                                          | 701                               |
| 77                         | 3148.2                           | 6275.                                                                                              | 0.026                                                                         | 980.5                         | 1618.5              | 83.91                | 14.89                                          | 23.41                                          | 704                               |
| 78                         | 3189.7                           | 6359.                                                                                              | 0.026                                                                         | 995.6                         | 1642.0              | 84.21                | 15.03                                          | 23.55                                          | 708                               |
| 79                         | 3231.2                           | 6443.                                                                                              | 0.026                                                                         | 1010.8                        | 1665.6              | 84.51                | 15.18                                          | 23.69                                          | 711                               |
| 80                         | 3272.7                           | 6527.                                                                                              | 0.025                                                                         | 1026.2                        | 1689.4              | 84.81                | 15.33                                          | 23.83                                          | 714                               |
| 81                         | 3314.2                           | 6611.                                                                                              | 0.025                                                                         | 1041.7                        | 1713.3              | 85.11                | 15.48                                          | 23.98                                          | 717                               |
| 82                         | 3355.7                           | 6694.                                                                                              | 0.025                                                                         | 1057.3                        | 1737.3              | 85.40                | 15.63                                          | 24.13                                          | 721                               |
| 83                         | 3397.2                           | 6778.                                                                                              | 0.024                                                                         | 1073.1                        | 1761.5              | 85.70                | 15.79                                          | 24.28                                          | 724                               |
| 84                         | 3438.6                           | 6867.                                                                                              | 0.024                                                                         | 1089.1                        | 1785.9              | 85.99                | 15.95                                          | 24.44                                          | 727                               |
| 85                         | 3480.1                           | 6946.                                                                                              | 0.024                                                                         | 1105.2                        | 1810.4              | 86.28                | 16.12                                          | 24.60                                          | 730                               |
| 86                         | 3521.5                           | 7029.                                                                                              | 0.023                                                                         | 1121.5                        | 1835.1              | 86.57                | 16.28                                          | 24.76                                          | 733                               |
| 87                         | 3562.9                           | 7117.                                                                                              | 0.023                                                                         | 1137.9                        | 1859.9              | 86.86                | 16.45                                          | 24.92                                          | 736                               |
| 88                         | 3604.3                           | 7196.                                                                                              | 0.023                                                                         | 1154.5                        | 1884.9              | 87.14                | 16.62                                          | 25.08                                          | 739                               |
| 89                         | 3645.7                           | 7280.                                                                                              | 0.023                                                                         | 1171.3                        | 1910.1              | 87.43                | 16.79                                          | 25.25                                          | 742                               |
| 90                         | 3687.1                           | 7363.                                                                                              | 0.022                                                                         | 1188.2                        | 1935.4              | 87.71                | 16.96                                          | 25.42                                          | 745                               |
| 91                         | 3728.5                           | 7447.                                                                                              | 0.022                                                                         | 1205.4                        | 1960.9              | 87.99                | 17.13                                          | 25.59                                          | 748                               |
| 92                         | 3769.9                           | 7530.                                                                                              | 0.022                                                                         | 1222.6                        | 1986.6              | 88.27                | 17.30                                          | 25.76                                          | 751                               |
| 93                         | 3811.3                           | 7614.                                                                                              | 0.022                                                                         | 1240.1                        | 2012.5              | 88.55                | 17.48                                          | 25.93                                          | 753                               |
| 94                         | 3852.6                           | 7697.                                                                                              | 0.021                                                                         | 1257.7                        | 2038.5              | 88.83                | 17.65                                          | 26.10                                          | 756                               |
| 95                         | 3894.0                           | 7781.                                                                                              | 0.021                                                                         | 1275.5                        | 2064.7              | 89.11                | 17.83                                          | 26.27                                          | 759                               |
| 96                         | 3935.3                           | 7864.                                                                                              | 0.021                                                                         | 1293.5                        | 2091.0              | 89.38                | 18.00                                          | 26.44                                          | 762                               |
| 97                         | 3976.6                           | 7947.                                                                                              | 0.021                                                                         | 1311.7                        | 2117.5              | 89.66                | 18.18                                          | 26.62                                          | 765                               |
| 98                         | 4018.0                           | 8030.                                                                                              | 0.021                                                                         | 1330.0                        | 2144.2              | 89.93                | 18.35                                          | 26.79                                          | 768                               |
| 99                         | 4059.3                           | 8114.                                                                                              | 0.020                                                                         | 1348.5                        | 2171.1              | 90.20                | 18.53                                          | 26.96                                          | 770                               |
| 100                        | 4100.6                           | 8197.                                                                                              | 0.020                                                                         | 1367.2                        | 2198.2              | 90.47                | 18.70                                          | 27.13                                          | 773                               |

• TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 3.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM/GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.903                   | 26.12              | 23605.                                                                                              | 9.412                                                                       | -622.7                        | -614.7              | 10.02                | 9.54                                           | 13.15                                          | 1279                              |
| 14                         | 26.15              | 23361.                                                                                              | 9.397                                                                       | -621.4                        | -613.4              | 10.11                | 9.57                                           | 13.24                                          | 1274                              |
| 15                         | 26.43              | 21927.                                                                                              | 9.206                                                                       | -607.8                        | -599.8              | 11.05                | 9.90                                           | 14.01                                          | 1248                              |
| 16                         | 26.74              | 20487.                                                                                              | 8.996                                                                       | -593.4                        | -585.3              | 11.99                | 10.25                                          | 14.83                                          | 1220                              |
| 17                         | 27.07              | 18897.                                                                                              | 8.819                                                                       | -578.2                        | -569.9              | 12.92                | 10.60                                          | 15.80                                          | 1190                              |
| 18                         | 27.43              | 17471.                                                                                              | 8.660                                                                       | -562.0                        | -553.6              | 13.85                | 10.93                                          | 16.82                                          | 1163                              |
| 19                         | 27.82              | 16168.                                                                                              | 8.493                                                                       | -544.7                        | -536.3              | 14.79                | 11.23                                          | 17.87                                          | 1137                              |
| 20                         | 28.25              | 14941.                                                                                              | 8.313                                                                       | -526.5                        | -517.9              | 15.73                | 11.50                                          | 18.97                                          | 1113                              |
| 21                         | 28.71              | 13524.                                                                                              | 8.117                                                                       | -507.0                        | -498.3              | 16.69                | 11.73                                          | 20.27                                          | 1084                              |
| 22                         | 29.24              | 12227.                                                                                              | 7.891                                                                       | -486.2                        | -477.3              | 17.66                | 11.93                                          | 21.63                                          | 1056                              |
| 23                         | 29.83              | 10739.                                                                                              | 7.621                                                                       | -463.9                        | -454.8              | 18.66                | 12.10                                          | 23.32                                          | 1020                              |
| 24                         | 30.50              | 9368.                                                                                               | 7.309                                                                       | -439.9                        | -430.7              | 19.69                | 12.25                                          | 25.15                                          | 983                               |
| * 24.632                   | 30.98              | 8848.                                                                                               | 7.088                                                                       | -423.8                        | -414.4              | 20.36                | 12.33                                          | 26.52                                          | 958                               |
| * 24.632                   | 541.72             | 1240.                                                                                               | 0.169                                                                       | 245.3                         | 410.0               | 53.85                | 13.68                                          | 30.46                                          | 373                               |
| 25                         | 556.47             | 1297.                                                                                               | 0.163                                                                       | 252.0                         | 421.2               | 54.30                | 13.56                                          | 29.65                                          | 378                               |
| 26                         | 594.35             | 1442.                                                                                               | 0.151                                                                       | 269.3                         | 449.9               | 55.43                | 13.31                                          | 27.99                                          | 390                               |
| 27                         | 630.55             | 1577.                                                                                               | 0.141                                                                       | 285.7                         | 477.3               | 56.46                | 13.15                                          | 26.84                                          | 402                               |
| 28                         | 665.51             | 1704.                                                                                               | 0.132                                                                       | 301.4                         | 503.7               | 57.42                | 13.04                                          | 25.99                                          | 413                               |
| 29                         | 699.50             | 1825.                                                                                               | 0.125                                                                       | 316.7                         | 529.4               | 58.32                | 12.97                                          | 25.33                                          | 423                               |
| 30                         | 732.73             | 1942.                                                                                               | 0.119                                                                       | 331.7                         | 554.4               | 59.17                | 12.91                                          | 24.81                                          | 433                               |
| 31                         | 765.33             | 2055.                                                                                               | 0.113                                                                       | 346.4                         | 579.0               | 59.98                | 12.87                                          | 24.39                                          | 442                               |
| 32                         | 797.42             | 2165.                                                                                               | 0.108                                                                       | 360.8                         | 603.2               | 60.75                | 12.83                                          | 24.03                                          | 451                               |
| 33                         | 829.07             | 2272.                                                                                               | 0.104                                                                       | 375.1                         | 627.1               | 61.48                | 12.80                                          | 23.73                                          | 460                               |
| 34                         | 860.34             | 2378.                                                                                               | 0.100                                                                       | 389.2                         | 650.7               | 62.19                | 12.76                                          | 23.47                                          | 469                               |
| 35                         | 891.29             | 2481.                                                                                               | 0.096                                                                       | 403.1                         | 674.1               | 62.86                | 12.74                                          | 23.24                                          | 477                               |
| 36                         | 921.96             | 2582.                                                                                               | 0.093                                                                       | 417.0                         | 697.2               | 63.52                | 12.72                                          | 23.05                                          | 485                               |
| 37                         | 952.38             | 2683.                                                                                               | 0.090                                                                       | 430.7                         | 720.2               | 64.14                | 12.70                                          | 22.88                                          | 493                               |
| 38                         | 982.59             | 2781.                                                                                               | 0.087                                                                       | 444.3                         | 743.0               | 64.75                | 12.68                                          | 22.73                                          | 501                               |
| 39                         | 1012.6             | 2879.                                                                                               | 0.084                                                                       | 457.9                         | 765.7               | 65.34                | 12.67                                          | 22.61                                          | 508                               |
| 40                         | 1042.4             | 2976.                                                                                               | 0.081                                                                       | 471.3                         | 788.2               | 65.91                | 12.66                                          | 22.49                                          | 515                               |
| 41                         | 1072.1             | 3072.                                                                                               | 0.079                                                                       | 484.8                         | 810.6               | 66.47                | 12.66                                          | 22.39                                          | 523                               |
| 42                         | 1101.7             | 3167.                                                                                               | 0.077                                                                       | 498.1                         | 833.0               | 67.01                | 12.66                                          | 22.30                                          | 530                               |
| 43                         | 1131.1             | 3261.                                                                                               | 0.075                                                                       | 511.4                         | 855.3               | 67.53                | 12.66                                          | 22.22                                          | 536                               |
| 44                         | 1160.4             | 3354.                                                                                               | 0.073                                                                       | 524.7                         | 877.4               | 68.04                | 12.66                                          | 22.15                                          | 543                               |
| 45                         | 1189.5             | 3447.                                                                                               | 0.071                                                                       | 538.0                         | 899.6               | 68.54                | 12.66                                          | 22.09                                          | 550                               |
| 46                         | 1218.6             | 3540.                                                                                               | 0.069                                                                       | 551.2                         | 921.6               | 69.02                | 12.67                                          | 22.04                                          | 556                               |
| 47                         | 1247.6             | 3631.                                                                                               | 0.068                                                                       | 564.4                         | 943.6               | 69.49                | 12.68                                          | 21.99                                          | 563                               |
| 48                         | 1276.5             | 3723.                                                                                               | 0.066                                                                       | 577.6                         | 965.6               | 69.96                | 12.69                                          | 21.96                                          | 569                               |
| 49                         | 1305.4             | 3814.                                                                                               | 0.064                                                                       | 590.8                         | 987.6               | 70.41                | 12.71                                          | 21.92                                          | 575                               |
| 50                         | 1334.1             | 3904.                                                                                               | 0.063                                                                       | 603.9                         | 1009.5              | 70.85                | 12.73                                          | 21.90                                          | 581                               |
| 51                         | 1362.8             | 3994.                                                                                               | 0.062                                                                       | 617.1                         | 1031.4              | 71.29                | 12.75                                          | 21.88                                          | 587                               |
| 52                         | 1391.5             | 4084.                                                                                               | 0.060                                                                       | 630.3                         | 1053.2              | 71.71                | 12.78                                          | 21.87                                          | 593                               |
| 53                         | 1420.0             | 4173.                                                                                               | 0.059                                                                       | 643.5                         | 1075.1              | 72.13                | 12.81                                          | 21.87                                          | 598                               |
| 54                         | 1448.6             | 4262.                                                                                               | 0.058                                                                       | 656.7                         | 1097.0              | 72.54                | 12.85                                          | 21.87                                          | 604                               |
| 55                         | 1477.0             | 4351.                                                                                               | 0.057                                                                       | 669.9                         | 1118.9              | 72.94                | 12.88                                          | 21.88                                          | 609                               |
| 56                         | 1505.5             | 4439.                                                                                               | 0.056                                                                       | 683.1                         | 1140.8              | 73.33                | 12.93                                          | 21.89                                          | 615                               |
| 57                         | 1533.9             | 4527.                                                                                               | 0.055                                                                       | 696.4                         | 1162.7              | 73.72                | 12.97                                          | 21.91                                          | 620                               |
| 58                         | 1562.2             | 4615.                                                                                               | 0.054                                                                       | 709.7                         | 1184.6              | 74.10                | 13.03                                          | 21.94                                          | 625                               |
| 59                         | 1590.5             | 4703.                                                                                               | 0.053                                                                       | 723.1                         | 1206.5              | 74.48                | 13.08                                          | 21.97                                          | 630                               |
| 60                         | 1618.8             | 4791.                                                                                               | 0.052                                                                       | 736.5                         | 1228.5              | 74.85                | 13.14                                          | 22.01                                          | 635                               |
| 61                         | 1647.0             | 4878.                                                                                               | 0.051                                                                       | 749.9                         | 1250.6              | 75.21                | 13.21                                          | 22.06                                          | 640                               |
| 62                         | 1675.2             | 4965.                                                                                               | 0.050                                                                       | 763.4                         | 1272.6              | 75.57                | 13.28                                          | 22.11                                          | 645                               |
| 63                         | 1703.4             | 5052.                                                                                               | 0.049                                                                       | 777.0                         | 1294.8              | 75.92                | 13.36                                          | 22.16                                          | 649                               |
| 64                         | 1731.5             | 5139.                                                                                               | 0.048                                                                       | 790.7                         | 1317.0              | 76.27                | 13.44                                          | 22.23                                          | 654                               |
| 65                         | 1759.6             | 5225.                                                                                               | 0.047                                                                       | 804.4                         | 1339.2              | 76.62                | 13.52                                          | 22.29                                          | 658                               |
| 66                         | 1787.7             | 5311.                                                                                               | 0.047                                                                       | 818.2                         | 1361.6              | 76.96                | 13.61                                          | 22.37                                          | 662                               |
| 67                         | 1815.7             | 5398.                                                                                               | 0.046                                                                       | 832.0                         | 1384.0              | 77.30                | 13.71                                          | 22.45                                          | 667                               |
| 68                         | 1843.8             | 5484.                                                                                               | 0.045                                                                       | 846.0                         | 1406.5              | 77.63                | 13.80                                          | 22.53                                          | 671                               |
| 69                         | 1871.8             | 5570.                                                                                               | 0.045                                                                       | 860.1                         | 1429.0              | 77.96                | 13.91                                          | 22.62                                          | 675                               |
| 70                         | 1899.8             | 5656.                                                                                               | 0.044                                                                       | 874.2                         | 1451.7              | 78.29                | 14.02                                          | 22.72                                          | 679                               |
| 71                         | 1927.7             | 5741.                                                                                               | 0.043                                                                       | 888.5                         | 1474.5              | 78.61                | 14.13                                          | 22.82                                          | 683                               |
| 72                         | 1955.7             | 5827.                                                                                               | 0.043                                                                       | 902.9                         | 1497.4              | 78.93                | 14.25                                          | 22.93                                          | 686                               |
| 73                         | 1983.6             | 5913.                                                                                               | 0.042                                                                       | 917.4                         | 1520.3              | 79.25                | 14.37                                          | 23.04                                          | 690                               |
| 74                         | 2011.5             | 5998.                                                                                               | 0.041                                                                       | 932.0                         | 1543.4              | 79.56                | 14.50                                          | 23.15                                          | 694                               |
| 75                         | 2039.4             | 6083.                                                                                               | 0.041                                                                       | 946.7                         | 1566.7              | 79.87                | 14.63                                          | 23.27                                          | 697                               |
| 76                         | 2067.3             | 6168.                                                                                               | 0.040                                                                       | 961.6                         | 1590.0              | 80.18                | 14.76                                          | 23.40                                          | 701                               |
| 77                         | 2095.2             | 6254.                                                                                               | 0.040                                                                       | 976.6                         | 1613.5              | 80.49                | 14.90                                          | 23.53                                          | 704                               |
| 78                         | 2123.0             | 6339.                                                                                               | 0.039                                                                       | 991.7                         | 1637.0              | 80.79                | 15.04                                          | 23.66                                          | 708                               |
| 79                         | 2150.9             | 6424.                                                                                               | 0.039                                                                       | 1007.0                        | 1660.8              | 81.09                | 15.19                                          | 23.80                                          | 711                               |
| 80                         | 2178.7             | 6508.                                                                                               | 0.038                                                                       | 1022.4                        | 1684.6              | 81.39                | 15.34                                          | 23.94                                          | 715                               |
| 81                         | 2206.5             | 6593.                                                                                               | 0.038                                                                       | 1037.9                        | 1708.7              | 81.69                | 15.49                                          | 24.08                                          | 718                               |
| 82                         | 2234.3             | 6678.                                                                                               | 0.037                                                                       | 1053.6                        | 1732.8              | 81.99                | 15.64                                          | 24.23                                          | 721                               |
| 83                         | 2262.1             | 6763.                                                                                               | 0.037                                                                       | 1069.5                        | 1757.1              | 82.28                | 15.80                                          | 24.38                                          | 724                               |
| 84                         | 2289.9             | 6847.                                                                                               | 0.036                                                                       | 1085.5                        | 1781.6              | 82.58                | 15.96                                          | 24.53                                          | 727                               |
| 85                         | 2317.6             | 6932.                                                                                               | 0.036                                                                       | 1101.7                        | 1806.2              | 82.87                | 16.12                                          | 24.69                                          | 730                               |
| 86                         | 2345.4             | 7016.                                                                                               | 0.035                                                                       | 1118.0                        | 1830.9              | 83.16                | 16.29                                          | 24.84                                          | 733                               |
| 87                         | 2373.1             | 7100.                                                                                               | 0.035                                                                       | 1134.5                        | 1855.9              | 83.44                | 16.45                                          | 25.00                                          | 736                               |
| 88                         | 2400.9             | 7185.                                                                                               | 0.035                                                                       | 1151.1                        | 1881.0              | 83.73                | 16.62                                          | 25.17                                          | 739                               |
| 89                         | 2428.6             | 7269.                                                                                               | 0.034                                                                       | 1168.0                        | 1906.2              | 84.02                | 16.79                                          | 25.33                                          | 742                               |
| 90                         | 2456.3             | 7353.                                                                                               | 0.034                                                                       | 1185.0                        | 1931.6              | 84.30                | 16.96                                          | 25.50                                          | 745                               |
| 91                         | 2484.0             | 7437.                                                                                               | 0.033                                                                       | 1202.1                        | 1957.2              | 84.58                | 17.14                                          | 25.66                                          | 748                               |
| 92                         | 2511.7             | 7522.                                                                                               | 0.033                                                                       | 1219.4                        | 1982.9              | 84.86                | 17.31                                          | 25.83                                          | 751                               |
| 93                         | 2539.4             | 7606.                                                                                               | 0.033                                                                       | 1236.9                        | 2008.9              | 85.14                | 17.48                                          | 26.00                                          | 754                               |
| 94                         | 2567.1             | 7690.                                                                                               | 0.032                                                                       | 1254.6                        | 2035.0              | 85.42                | 17.66                                          | 26.17                                          | 757                               |
| 95                         | 2594.8             | 7774.                                                                                               | 0.032                                                                       | 1272.5                        | 2061.2              | 85.70                | 17.83                                          | 26.34                                          | 760                               |
| 96                         | 2622.4             | 7858.                                                                                               | 0.032                                                                       | 1290.5                        | 2087.6              | 85.98                | 18.01                                          | 26.51                                          | 763                               |
| 97                         | 2650.1             | 7941.                                                                                               | 0.031                                                                       | 1308.7                        | 2114.2              | 86.25                | 18.18                                          | 26.68                                          | 765                               |
| 98                         | 2677.7             | 8025.                                                                                               | 0.031                                                                       | 1327.0                        | 2141.0              | 86.53                | 18.36                                          | 26.85                                          | 768                               |
| 99                         | 2705.4             | 8109.                                                                                               | 0.031                                                                       | 1345.6                        | 2167.9              | 86.80                | 18.53                                          | 27.02                                          | 771                               |
| 100                        | 2733.0             | 8193.                                                                                               | 0.030                                                                       | 1364.3                        | 2195.1              | 87.07                | 18.71                                          | 27.19                                          | 774                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

4.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial p$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>p</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.937                   | 26.10                            | 23700.                                                                                          | 9.416                                                                      | -622.6                        | -612.0              | 10.02                | 9.55                                           | 13.15                                          | 1281                              |
| 14                         | 26.12                            | 23538.                                                                                          | 9.406                                                                      | -621.8                        | -611.2              | 10.08                | 9.57                                           | 13.21                                          | 1278                              |
| 15                         | 26.40                            | 22110.                                                                                          | 9.231                                                                      | -608.3                        | -597.6              | 11.02                | 9.90                                           | 13.99                                          | 1253                              |
| 16                         | 26.71                            | 20668.                                                                                          | 9.023                                                                      | -593.9                        | -583.1              | 11.95                | 10.25                                          | 14.81                                          | 1225                              |
| 17                         | 27.03                            | 19100.                                                                                          | 8.845                                                                      | -578.7                        | -567.8              | 12.88                | 10.60                                          | 15.75                                          | 1195                              |
| 18                         | 27.39                            | 17693.                                                                                          | 8.687                                                                      | -562.6                        | -551.5              | 13.81                | 10.92                                          | 16.76                                          | 1168                              |
| 19                         | 27.77                            | 16383.                                                                                          | 8.522                                                                      | -545.5                        | -534.3              | 14.75                | 11.22                                          | 17.80                                          | 1143                              |
| 20                         | 28.19                            | 15140.                                                                                          | 8.341                                                                      | -527.3                        | -515.9              | 15.69                | 11.49                                          | 18.89                                          | 1119                              |
| 21                         | 28.65                            | 13748.                                                                                          | 8.150                                                                      | -508.0                        | -496.4              | 16.64                | 11.72                                          | 20.16                                          | 1090                              |
| 22                         | 29.17                            | 12449.                                                                                          | 7.925                                                                      | -487.4                        | -475.6              | 17.61                | 11.93                                          | 21.49                                          | 1062                              |
| 23                         | 29.75                            | 10989.                                                                                          | 7.663                                                                      | -465.3                        | -453.3              | 18.60                | 12.10                                          | 23.11                                          | 1027                              |
| 24                         | 30.40                            | 9621.                                                                                           | 7.358                                                                      | -441.6                        | -429.3              | 19.62                | 12.24                                          | 24.89                                          | 992                               |
| 25                         | 31.17                            | 8214.                                                                                           | 7.007                                                                      | -416.0                        | -403.4              | 20.68                | 12.37                                          | 27.07                                          | 951                               |
| 26                         | 32.08                            | 6817.                                                                                           | 6.592                                                                      | -387.9                        | -374.9              | 21.79                | 12.49                                          | 29.79                                          | 904                               |
| * 26.023                   | 32.10                            | 6787.                                                                                           | 6.582                                                                      | -387.3                        | -374.2              | 21.82                | 12.49                                          | 29.84                                          | 903                               |
| * 26.023                   | 407.74                           | 1147.                                                                                           | 0.230                                                                      | 244.1                         | 409.3               | 51.95                | 13.90                                          | 34.05                                          | 376                               |
| 27                         | 438.99                           | 1315.                                                                                           | 0.210                                                                      | 263.2                         | 441.1               | 53.15                | 13.58                                          | 31.22                                          | 390                               |
| 28                         | 468.81                           | 1474.                                                                                           | 0.194                                                                      | 281.3                         | 471.4               | 54.25                | 13.37                                          | 29.32                                          | 403                               |
| 29                         | 497.15                           | 1613.                                                                                           | 0.181                                                                      | 298.5                         | 500.0               | 55.25                | 13.23                                          | 27.99                                          | 414                               |
| 30                         | 524.39                           | 1744.                                                                                           | 0.170                                                                      | 314.9                         | 527.5               | 56.18                | 13.13                                          | 27.00                                          | 425                               |
| 31                         | 550.80                           | 1876.                                                                                           | 0.161                                                                      | 330.8                         | 554.1               | 57.06                | 13.05                                          | 26.23                                          | 435                               |
| 32                         | 576.54                           | 1999.                                                                                           | 0.153                                                                      | 346.3                         | 580.0               | 57.88                | 12.99                                          | 25.61                                          | 445                               |
| 33                         | 601.73                           | 2117.                                                                                           | 0.146                                                                      | 361.5                         | 605.3               | 58.66                | 12.94                                          | 25.11                                          | 454                               |
| 34                         | 626.46                           | 2237.                                                                                           | 0.140                                                                      | 376.3                         | 630.2               | 59.40                | 12.89                                          | 24.67                                          | 463                               |
| 35                         | 650.81                           | 2344.                                                                                           | 0.134                                                                      | 390.9                         | 654.7               | 60.11                | 12.84                                          | 24.31                                          | 472                               |
| 36                         | 674.83                           | 2453.                                                                                           | 0.129                                                                      | 405.4                         | 678.9               | 60.79                | 12.81                                          | 24.01                                          | 481                               |
| 37                         | 698.57                           | 2561.                                                                                           | 0.124                                                                      | 419.6                         | 702.7               | 61.45                | 12.78                                          | 23.75                                          | 489                               |
| 38                         | 722.07                           | 2666.                                                                                           | 0.120                                                                      | 433.7                         | 726.4               | 62.08                | 12.75                                          | 23.52                                          | 497                               |
| 39                         | 745.35                           | 2770.                                                                                           | 0.116                                                                      | 447.7                         | 749.8               | 62.68                | 12.74                                          | 23.32                                          | 505                               |
| 40                         | 768.44                           | 2872.                                                                                           | 0.112                                                                      | 461.6                         | 773.0               | 63.27                | 12.72                                          | 23.15                                          | 512                               |
| 41                         | 791.36                           | 2973.                                                                                           | 0.108                                                                      | 475.4                         | 796.1               | 63.84                | 12.71                                          | 23.00                                          | 520                               |
| 42                         | 814.13                           | 3072.                                                                                           | 0.105                                                                      | 489.1                         | 819.0               | 64.40                | 12.71                                          | 22.87                                          | 527                               |
| 43                         | 836.76                           | 3171.                                                                                           | 0.102                                                                      | 502.7                         | 841.9               | 64.93                | 12.70                                          | 22.75                                          | 534                               |
| 44                         | 859.26                           | 3269.                                                                                           | 0.099                                                                      | 516.3                         | 864.6               | 65.45                | 12.70                                          | 22.64                                          | 541                               |
| 45                         | 881.65                           | 3364.                                                                                           | 0.097                                                                      | 529.8                         | 887.1               | 65.96                | 12.70                                          | 22.55                                          | 548                               |
| 46                         | 903.93                           | 3467.                                                                                           | 0.094                                                                      | 543.3                         | 909.7               | 66.46                | 12.71                                          | 22.47                                          | 555                               |
| 47                         | 926.12                           | 3557.                                                                                           | 0.092                                                                      | 556.7                         | 932.1               | 66.94                | 12.72                                          | 22.40                                          | 561                               |
| 48                         | 948.23                           | 3651.                                                                                           | 0.090                                                                      | 570.2                         | 954.5               | 67.41                | 12.73                                          | 22.34                                          | 568                               |
| 49                         | 970.25                           | 3745.                                                                                           | 0.087                                                                      | 583.5                         | 976.8               | 67.87                | 12.74                                          | 22.29                                          | 574                               |
| 50                         | 992.19                           | 3839.                                                                                           | 0.085                                                                      | 596.9                         | 999.0               | 68.32                | 12.76                                          | 22.24                                          | 580                               |
| 51                         | 1014.1                           | 3931.                                                                                           | 0.084                                                                      | 610.3                         | 1021.3              | 68.76                | 12.78                                          | 22.21                                          | 586                               |
| 52                         | 1035.9                           | 4024.                                                                                           | 0.082                                                                      | 623.6                         | 1043.5              | 69.19                | 12.81                                          | 22.18                                          | 592                               |
| 53                         | 1057.6                           | 4115.                                                                                           | 0.080                                                                      | 637.0                         | 1065.6              | 69.61                | 12.84                                          | 22.16                                          | 598                               |
| 54                         | 1079.3                           | 4207.                                                                                           | 0.078                                                                      | 650.3                         | 1087.8              | 70.03                | 12.87                                          | 22.15                                          | 603                               |
| 55                         | 1101.0                           | 4298.                                                                                           | 0.077                                                                      | 663.7                         | 1109.9              | 70.43                | 12.91                                          | 22.15                                          | 609                               |
| 56                         | 1122.6                           | 4388.                                                                                           | 0.075                                                                      | 677.1                         | 1132.1              | 70.83                | 12.95                                          | 22.15                                          | 614                               |
| 57                         | 1144.1                           | 4479.                                                                                           | 0.074                                                                      | 690.5                         | 1154.3              | 71.23                | 13.00                                          | 22.16                                          | 619                               |
| 58                         | 1165.6                           | 4569.                                                                                           | 0.072                                                                      | 704.0                         | 1176.4              | 71.61                | 13.05                                          | 22.17                                          | 625                               |
| 59                         | 1187.1                           | 4658.                                                                                           | 0.071                                                                      | 717.5                         | 1198.6              | 71.99                | 13.10                                          | 22.19                                          | 630                               |
| 60                         | 1208.5                           | 4747.                                                                                           | 0.070                                                                      | 731.0                         | 1220.8              | 72.36                | 13.16                                          | 22.22                                          | 635                               |
| 61                         | 1229.9                           | 4837.                                                                                           | 0.068                                                                      | 744.6                         | 1243.1              | 72.73                | 13.23                                          | 22.26                                          | 640                               |
| 62                         | 1251.3                           | 4925.                                                                                           | 0.067                                                                      | 758.2                         | 1265.3              | 73.09                | 13.30                                          | 22.30                                          | 644                               |
| 63                         | 1272.6                           | 5014.                                                                                           | 0.066                                                                      | 771.9                         | 1287.7              | 73.45                | 13.37                                          | 22.35                                          | 649                               |
| 64                         | 1293.9                           | 5102.                                                                                           | 0.065                                                                      | 785.6                         | 1310.0              | 73.80                | 13.45                                          | 22.41                                          | 654                               |
| 65                         | 1315.2                           | 5190.                                                                                           | 0.064                                                                      | 799.4                         | 1332.5              | 74.15                | 13.54                                          | 22.47                                          | 658                               |
| 66                         | 1336.4                           | 5278.                                                                                           | 0.063                                                                      | 813.3                         | 1355.0              | 74.49                | 13.63                                          | 22.54                                          | 662                               |
| 67                         | 1357.7                           | 5366.                                                                                           | 0.062                                                                      | 827.3                         | 1377.6              | 74.83                | 13.72                                          | 22.61                                          | 667                               |
| 68                         | 1378.9                           | 5453.                                                                                           | 0.061                                                                      | 841.4                         | 1400.2              | 75.17                | 13.82                                          | 22.69                                          | 671                               |
| 69                         | 1400.0                           | 5540.                                                                                           | 0.060                                                                      | 855.5                         | 1422.9              | 75.50                | 13.92                                          | 22.77                                          | 675                               |
| 70                         | 1421.2                           | 5627.                                                                                           | 0.059                                                                      | 869.8                         | 1445.8              | 75.83                | 14.03                                          | 22.86                                          | 679                               |
| 71                         | 1442.3                           | 5714.                                                                                           | 0.058                                                                      | 884.1                         | 1468.7              | 76.15                | 14.14                                          | 22.96                                          | 683                               |
| 72                         | 1463.4                           | 5801.                                                                                           | 0.057                                                                      | 898.6                         | 1491.7              | 76.48                | 14.26                                          | 23.06                                          | 687                               |
| 73                         | 1484.5                           | 5888.                                                                                           | 0.056                                                                      | 913.1                         | 1514.8              | 76.80                | 14.38                                          | 23.17                                          | 690                               |
| 74                         | 1505.6                           | 5974.                                                                                           | 0.056                                                                      | 927.8                         | 1538.0              | 77.11                | 14.51                                          | 23.28                                          | 694                               |
| 75                         | 1526.7                           | 6061.                                                                                           | 0.055                                                                      | 942.6                         | 1561.4              | 77.42                | 14.64                                          | 23.40                                          | 698                               |
| 76                         | 1547.7                           | 6147.                                                                                           | 0.054                                                                      | 957.5                         | 1584.8              | 77.74                | 14.77                                          | 23.52                                          | 701                               |
| 77                         | 1568.7                           | 6233.                                                                                           | 0.053                                                                      | 972.6                         | 1608.4              | 78.04                | 14.91                                          | 23.64                                          | 705                               |
| 78                         | 1589.8                           | 6319.                                                                                           | 0.053                                                                      | 987.8                         | 1632.1              | 78.35                | 15.05                                          | 23.77                                          | 708                               |
| 79                         | 1610.8                           | 6405.                                                                                           | 0.052                                                                      | 1003.1                        | 1655.9              | 78.65                | 15.20                                          | 23.90                                          | 712                               |
| 80                         | 1631.7                           | 6491.                                                                                           | 0.051                                                                      | 1018.6                        | 1679.9              | 78.95                | 15.35                                          | 24.04                                          | 715                               |
| 81                         | 1652.7                           | 6576.                                                                                           | 0.050                                                                      | 1034.2                        | 1704.0              | 79.25                | 15.50                                          | 24.18                                          | 718                               |
| 82                         | 1673.7                           | 6667.                                                                                           | 0.050                                                                      | 1049.9                        | 1728.3              | 79.55                | 15.65                                          | 24.33                                          | 721                               |
| 83                         | 1694.6                           | 6748.                                                                                           | 0.049                                                                      | 1065.9                        | 1752.7              | 79.85                | 15.81                                          | 24.47                                          | 725                               |
| 84                         | 1715.6                           | 6833.                                                                                           | 0.049                                                                      | 1081.9                        | 1777.2              | 80.14                | 15.97                                          | 24.62                                          | 728                               |
| 85                         | 1736.5                           | 6918.                                                                                           | 0.048                                                                      | 1098.1                        | 1801.9              | 80.43                | 16.13                                          | 24.78                                          | 731                               |
| 86                         | 1757.4                           | 7004.                                                                                           | 0.047                                                                      | 1114.5                        | 1826.8              | 80.72                | 16.29                                          | 24.93                                          | 734                               |
| 87                         | 1778.3                           | 7089.                                                                                           | 0.047                                                                      | 1131.1                        | 1851.8              | 81.01                | 16.46                                          | 25.09                                          | 737                               |
| 88                         | 1799.2                           | 7174.                                                                                           | 0.046                                                                      | 1147.8                        | 1877.0              | 81.30                | 16.63                                          | 25.25                                          | 740                               |
| 89                         | 1820.1                           | 7259.                                                                                           | 0.046                                                                      | 1164.6                        | 1902.3              | 81.59                | 16.80                                          | 25.41                                          | 743                               |
| 90                         | 1841.0                           | 7344.                                                                                           | 0.045                                                                      | 1181.7                        | 1927.8              | 81.87                | 16.97                                          | 25.58                                          | 746                               |
| 91                         | 1861.8                           | 7429.                                                                                           | 0.045                                                                      | 1198.9                        | 1953.5              | 82.16                | 17.14                                          | 25.74                                          | 749                               |
| 92                         | 1882.7                           | 7513.                                                                                           | 0.044                                                                      | 1216.2                        | 1979.3              | 82.44                | 17.31                                          | 25.91                                          | 752                               |
| 93                         | 1903.5                           | 7598.                                                                                           | 0.044                                                                      | 1233.8                        | 2005.3              | 82.72                | 17.49                                          | 26.08                                          | 755                               |
| 94                         | 1924.4                           | 7683.                                                                                           | 0.043                                                                      | 1251.5                        | 2031.4              | 83.00                | 17.66                                          | 26.24                                          | 757                               |
| 95                         | 1945.2                           | 7767.                                                                                           | 0.043                                                                      | 1269.4                        | 2057.8              | 83.28                | 17.84                                          | 26.41                                          | 760                               |
| 96                         | 1966.0                           | 7852.                                                                                           | 0.042                                                                      | 1287.4                        | 2084.3              | 83.56                | 18.01                                          | 26.58                                          | 763                               |
| 97                         | 1986.9                           | 7936.                                                                                           | 0.042                                                                      | 1305.7                        | 2110.9              | 83.83                | 18.19                                          | 26.75                                          | 766                               |
| 98                         | 2007.7                           | 8021.                                                                                           | 0.041                                                                      | 1324.1                        | 2137.8              | 84.11                | 18.36                                          | 26.92                                          | 769                               |
| 99                         | 2028.5                           | 8105.                                                                                           | 0.041                                                                      | 1342.6                        | 2164.8              | 84.38                | 18.54                                          | 27.09                                          | 772                               |
| 100                        | 2049.3                           | 8189.                                                                                           | 0.041                                                                      | 1361.4                        | 2192.0              | 84.65                | 18.71                                          | 27.26                                          | 774                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

5.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOBORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 13.970                   | 26.08                            | 23791.                                                                                             | 9.420                                                                      | -622.5                        | -609.3              | 10.03                | 9.57                                           | 13.16                                          | 1282                              |
| 14                         | 26.09                            | 23714.                                                                                             | 9.416                                                                      | -622.1                        | -608.9              | 10.06                | 9.58                                           | 13.19                                          | 1281                              |
| 15                         | 26.37                            | 22298.                                                                                             | 9.256                                                                      | -608.7                        | -595.3              | 10.99                | 9.90                                           | 13.96                                          | 1257                              |
| 16                         | 26.67                            | 20852.                                                                                             | 9.049                                                                      | -594.4                        | -580.9              | 11.92                | 10.25                                          | 14.78                                          | 1229                              |
| 17                         | 27.00                            | 19314.                                                                                             | 8.872                                                                      | -579.3                        | -565.6              | 12.85                | 10.59                                          | 15.71                                          | 1200                              |
| 18                         | 27.35                            | 17908.                                                                                             | 8.713                                                                      | -563.3                        | -549.4              | 13.77                | 10.92                                          | 16.70                                          | 1173                              |
| 19                         | 27.73                            | 16595.                                                                                             | 8.550                                                                      | -546.3                        | -532.2              | 14.71                | 11.22                                          | 17.73                                          | 1148                              |
| 20                         | 28.14                            | 15338.                                                                                             | 8.370                                                                      | -528.2                        | -513.9              | 15.64                | 11.48                                          | 18.81                                          | 1124                              |
| 21                         | 28.59                            | 13970.                                                                                             | 8.183                                                                      | -509.0                        | -494.5              | 16.59                | 11.72                                          | 20.05                                          | 1096                              |
| 22                         | 29.10                            | 12668.                                                                                             | 7.959                                                                      | -488.6                        | -473.8              | 17.55                | 11.92                                          | 21.36                                          | 1068                              |
| 23                         | 29.67                            | 11236.                                                                                             | 7.703                                                                      | -466.7                        | -451.7              | 18.54                | 12.09                                          | 22.92                                          | 1035                              |
| 24                         | 30.31                            | 9875.                                                                                              | 7.405                                                                      | -443.3                        | -427.9              | 19.55                | 12.24                                          | 24.64                                          | 1000                              |
| 25                         | 31.05                            | 8484.                                                                                              | 7.061                                                                      | -418.0                        | -402.3              | 20.59                | 12.37                                          | 26.72                                          | 960                               |
| 26                         | 31.94                            | 7091.                                                                                              | 6.660                                                                      | -390.4                        | -374.2              | 21.69                | 12.48                                          | 29.29                                          | 914                               |
| 27                         | 33.01                            | 5663.                                                                                              | 6.196                                                                      | -359.8                        | -343.1              | 22.87                | 12.60                                          | 32.82                                          | 861                               |
| * 27.187                   | 33.24                            | 5361.                                                                                              | 6.097                                                                      | -353.7                        | -336.9              | 23.10                | 12.63                                          | 33.74                                          | 848                               |
| * 27.187                   | 323.89                           | 1043.                                                                                              | 0.296                                                                      | 239.5                         | 403.6               | 50.35                | 14.14                                          | 38.45                                          | 378                               |
| 28                         | 347.02                           | 1204.                                                                                              | 0.272                                                                      | 257.5                         | 433.3               | 51.43                | 13.82                                          | 34.79                                          | 390                               |
| 29                         | 373.10                           | 1379.                                                                                              | 0.249                                                                      | 277.6                         | 466.6               | 52.59                | 13.57                                          | 31.94                                          | 404                               |
| 30                         | 397.47                           | 1538.                                                                                              | 0.231                                                                      | 296.1                         | 497.5               | 53.64                | 13.40                                          | 30.03                                          | 416                               |
| 31                         | 420.63                           | 1685.                                                                                              | 0.216                                                                      | 313.7                         | 526.8               | 54.60                | 13.28                                          | 28.65                                          | 428                               |
| 32                         | 442.89                           | 1824.                                                                                              | 0.203                                                                      | 330.5                         | 554.9               | 55.50                | 13.18                                          | 27.61                                          | 438                               |
| 33                         | 464.45                           | 1956.                                                                                              | 0.193                                                                      | 346.9                         | 582.2               | 56.33                | 13.11                                          | 26.79                                          | 448                               |
| 34                         | 485.44                           | 2087.                                                                                              | 0.183                                                                      | 362.7                         | 608.6               | 57.12                | 13.02                                          | 26.11                                          | 458                               |
| 35                         | 505.96                           | 2203.                                                                                              | 0.175                                                                      | 378.1                         | 634.4               | 57.87                | 12.95                                          | 25.56                                          | 467                               |
| 36                         | 526.10                           | 2327.                                                                                              | 0.168                                                                      | 393.2                         | 659.7               | 58.59                | 12.90                                          | 25.10                                          | 476                               |
| 37                         | 545.92                           | 2437.                                                                                              | 0.161                                                                      | 408.1                         | 684.7               | 59.27                | 12.86                                          | 24.72                                          | 485                               |
| 38                         | 565.46                           | 2544.                                                                                              | 0.155                                                                      | 422.7                         | 709.2               | 59.92                | 12.83                                          | 24.40                                          | 494                               |
| 39                         | 584.76                           | 2659.                                                                                              | 0.149                                                                      | 437.2                         | 733.5               | 60.55                | 12.80                                          | 24.12                                          | 502                               |
| 40                         | 603.85                           | 2767.                                                                                              | 0.144                                                                      | 451.5                         | 757.5               | 61.16                | 12.78                                          | 23.87                                          | 510                               |
| 41                         | 622.75                           | 2873.                                                                                              | 0.139                                                                      | 465.7                         | 781.2               | 61.75                | 12.77                                          | 23.66                                          | 517                               |
| 42                         | 641.48                           | 2978.                                                                                              | 0.135                                                                      | 479.8                         | 804.8               | 62.32                | 12.76                                          | 23.48                                          | 525                               |
| 43                         | 660.07                           | 3081.                                                                                              | 0.131                                                                      | 493.8                         | 828.2               | 62.87                | 12.75                                          | 23.31                                          | 532                               |
| 44                         | 678.52                           | 3183.                                                                                              | 0.127                                                                      | 507.4                         | 851.4               | 63.40                | 12.75                                          | 23.17                                          | 539                               |
| 45                         | 696.85                           | 3284.                                                                                              | 0.124                                                                      | 521.5                         | 874.5               | 63.92                | 12.75                                          | 23.04                                          | 546                               |
| 46                         | 715.07                           | 3384.                                                                                              | 0.120                                                                      | 535.3                         | 897.5               | 64.43                | 12.75                                          | 22.93                                          | 553                               |
| 47                         | 733.19                           | 3482.                                                                                              | 0.117                                                                      | 549.0                         | 920.4               | 64.92                | 12.75                                          | 22.83                                          | 560                               |
| 48                         | 751.22                           | 3580.                                                                                              | 0.114                                                                      | 562.6                         | 943.2               | 65.40                | 12.76                                          | 22.74                                          | 566                               |
| 49                         | 769.16                           | 3677.                                                                                              | 0.111                                                                      | 576.2                         | 965.9               | 65.87                | 12.78                                          | 22.67                                          | 573                               |
| 50                         | 787.02                           | 3774.                                                                                              | 0.109                                                                      | 589.8                         | 988.5               | 66.32                | 12.79                                          | 22.60                                          | 579                               |
| 51                         | 804.81                           | 3869.                                                                                              | 0.106                                                                      | 603.4                         | 1011.1              | 66.77                | 12.81                                          | 22.55                                          | 585                               |
| 52                         | 822.54                           | 3964.                                                                                              | 0.104                                                                      | 616.9                         | 1033.6              | 67.21                | 12.84                                          | 22.50                                          | 591                               |
| 53                         | 840.20                           | 4059.                                                                                              | 0.101                                                                      | 630.4                         | 1056.1              | 67.64                | 12.87                                          | 22.47                                          | 597                               |
| 54                         | 857.81                           | 4152.                                                                                              | 0.099                                                                      | 644.0                         | 1078.6              | 68.05                | 12.90                                          | 22.44                                          | 603                               |
| 55                         | 875.36                           | 4246.                                                                                              | 0.097                                                                      | 657.5                         | 1101.0              | 68.47                | 12.93                                          | 22.42                                          | 608                               |
| 56                         | 892.86                           | 4338.                                                                                              | 0.095                                                                      | 671.1                         | 1123.4              | 68.87                | 12.98                                          | 22.41                                          | 614                               |
| 57                         | 910.32                           | 4431.                                                                                              | 0.093                                                                      | 684.6                         | 1145.8              | 69.27                | 13.02                                          | 22.40                                          | 619                               |
| 58                         | 927.73                           | 4523.                                                                                              | 0.091                                                                      | 698.2                         | 1168.2              | 69.66                | 13.07                                          | 22.41                                          | 624                               |
| 59                         | 945.10                           | 4614.                                                                                              | 0.090                                                                      | 711.8                         | 1190.6              | 70.04                | 13.12                                          | 22.42                                          | 629                               |
| 60                         | 962.43                           | 4705.                                                                                              | 0.088                                                                      | 725.5                         | 1213.1              | 70.42                | 13.18                                          | 22.44                                          | 634                               |
| 61                         | 979.73                           | 4796.                                                                                              | 0.086                                                                      | 739.2                         | 1235.5              | 70.79                | 13.25                                          | 22.47                                          | 639                               |
| 62                         | 996.99                           | 4886.                                                                                              | 0.085                                                                      | 752.9                         | 1258.0              | 71.15                | 13.32                                          | 22.50                                          | 644                               |
| 63                         | 1014.2                           | 4974.                                                                                              | 0.083                                                                      | 766.7                         | 1280.5              | 71.51                | 13.39                                          | 22.54                                          | 649                               |
| 64                         | 1031.4                           | 5064.                                                                                              | 0.082                                                                      | 780.6                         | 1303.1              | 71.87                | 13.47                                          | 22.59                                          | 654                               |
| 65                         | 1048.6                           | 5156.                                                                                              | 0.080                                                                      | 794.5                         | 1325.7              | 72.22                | 13.55                                          | 22.64                                          | 658                               |
| 66                         | 1065.7                           | 5246.                                                                                              | 0.079                                                                      | 808.5                         | 1348.4              | 72.57                | 13.64                                          | 22.71                                          | 662                               |
| 67                         | 1082.9                           | 5334.                                                                                              | 0.078                                                                      | 822.5                         | 1371.1              | 72.91                | 13.73                                          | 22.77                                          | 667                               |
| 68                         | 1100.0                           | 5423.                                                                                              | 0.077                                                                      | 836.7                         | 1394.0              | 73.25                | 13.83                                          | 22.85                                          | 671                               |
| 69                         | 1117.0                           | 5517.                                                                                              | 0.075                                                                      | 850.9                         | 1416.8              | 73.58                | 13.94                                          | 22.92                                          | 675                               |
| 70                         | 1134.1                           | 5600.                                                                                              | 0.074                                                                      | 865.3                         | 1439.8              | 73.91                | 14.04                                          | 23.01                                          | 679                               |
| 71                         | 1151.1                           | 5688.                                                                                              | 0.073                                                                      | 879.7                         | 1462.9              | 74.24                | 14.16                                          | 23.10                                          | 683                               |
| 72                         | 1168.1                           | 5774.                                                                                              | 0.072                                                                      | 894.2                         | 1486.0              | 74.56                | 14.27                                          | 23.20                                          | 687                               |
| 73                         | 1185.1                           | 5864.                                                                                              | 0.071                                                                      | 908.9                         | 1509.3              | 74.88                | 14.39                                          | 23.30                                          | 691                               |
| 74                         | 1202.1                           | 5951.                                                                                              | 0.070                                                                      | 923.6                         | 1532.6              | 75.20                | 14.52                                          | 23.41                                          | 694                               |
| 75                         | 1219.0                           | 6039.                                                                                              | 0.069                                                                      | 938.5                         | 1556.1              | 75.51                | 14.65                                          | 23.52                                          | 698                               |
| 76                         | 1236.0                           | 6126.                                                                                              | 0.068                                                                      | 953.5                         | 1579.7              | 75.83                | 14.78                                          | 23.64                                          | 702                               |
| 77                         | 1252.9                           | 6213.                                                                                              | 0.067                                                                      | 968.6                         | 1603.4              | 76.14                | 14.92                                          | 23.76                                          | 705                               |
| 78                         | 1269.8                           | 6300.                                                                                              | 0.066                                                                      | 983.9                         | 1627.2              | 76.44                | 15.06                                          | 23.88                                          | 709                               |
| 79                         | 1286.7                           | 6387.                                                                                              | 0.065                                                                      | 999.2                         | 1651.1              | 76.75                | 15.21                                          | 24.01                                          | 712                               |
| 80                         | 1303.6                           | 6474.                                                                                              | 0.064                                                                      | 1014.8                        | 1675.2              | 77.05                | 15.35                                          | 24.15                                          | 715                               |
| 81                         | 1320.5                           | 6560.                                                                                              | 0.063                                                                      | 1030.4                        | 1699.4              | 77.35                | 15.51                                          | 24.28                                          | 719                               |
| 82                         | 1337.3                           | 6647.                                                                                              | 0.063                                                                      | 1046.3                        | 1723.8              | 77.65                | 15.66                                          | 24.43                                          | 722                               |
| 83                         | 1354.2                           | 6733.                                                                                              | 0.062                                                                      | 1062.2                        | 1748.3              | 77.95                | 15.82                                          | 24.57                                          | 725                               |
| 84                         | 1371.0                           | 6819.                                                                                              | 0.061                                                                      | 1078.3                        | 1772.9              | 78.24                | 15.98                                          | 24.72                                          | 728                               |
| 85                         | 1387.8                           | 6905.                                                                                              | 0.060                                                                      | 1094.6                        | 1797.7              | 78.54                | 16.14                                          | 24.87                                          | 731                               |
| 86                         | 1404.6                           | 6991.                                                                                              | 0.060                                                                      | 1111.0                        | 1822.7              | 78.83                | 16.30                                          | 25.02                                          | 734                               |
| 87                         | 1421.4                           | 7077.                                                                                              | 0.059                                                                      | 1127.6                        | 1847.8              | 79.12                | 16.47                                          | 25.18                                          | 737                               |
| 88                         | 1438.2                           | 7163.                                                                                              | 0.058                                                                      | 1144.4                        | 1873.0              | 79.41                | 16.64                                          | 25.34                                          | 740                               |
| 89                         | 1455.0                           | 7249.                                                                                              | 0.057                                                                      | 1161.3                        | 1898.4              | 79.70                | 16.81                                          | 25.50                                          | 743                               |
| 90                         | 1471.8                           | 7335.                                                                                              | 0.057                                                                      | 1178.4                        | 1924.0              | 79.98                | 16.98                                          | 25.66                                          | 746                               |
| 91                         | 1488.5                           | 7420.                                                                                              | 0.056                                                                      | 1195.6                        | 1949.8              | 80.27                | 17.15                                          | 25.82                                          | 749                               |
| 92                         | 1505.3                           | 7505.                                                                                              | 0.055                                                                      | 1213.0                        | 1975.7              | 80.55                | 17.32                                          | 25.98                                          | 752                               |
| 93                         | 1522.0                           | 7591.                                                                                              | 0.055                                                                      | 1230.6                        | 2001.7              | 80.83                | 17.49                                          | 26.15                                          | 755                               |
| 94                         | 1538.8                           | 7676.                                                                                              | 0.054                                                                      | 1248.4                        | 2028.0              | 81.11                | 17.67                                          | 26.32                                          | 758                               |
| 95                         | 1555.5                           | 7761.                                                                                              | 0.054                                                                      | 1266.3                        | 2054.4              | 81.39                | 17.84                                          | 26.48                                          | 761                               |
| 96                         | 1572.2                           | 7847.                                                                                              | 0.053                                                                      | 1284.4                        | 2080.9              | 81.67                | 18.02                                          | 26.65                                          | 764                               |
| 97                         | 1588.9                           | 7932.                                                                                              | 0.053                                                                      | 1302.7                        | 2107.7              | 81.95                | 18.19                                          | 26.82                                          | 767                               |
| 98                         | 1605.7                           | 8017.                                                                                              | 0.052                                                                      | 1321.1                        | 2134.6              | 82.22                | 18.37                                          | 26.99                                          | 769                               |
| 99                         | 1622.4                           | 8102.                                                                                              | 0.051                                                                      | 1339.7                        | 2161.6              | 82.50                | 18.54                                          | 27.15                                          | 772                               |
| 100                        | 1639.1                           | 8186.                                                                                              | 0.051                                                                      | 1358.5                        | 2188.9              | 82.77                | 18.72                                          | 27.32                                          | 775                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISO8ARS-CONTINUEO

6.0 ATMOSPHERE ISO8AR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial p$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>p</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 14.004                   | 26.06                            | 23884.                                                                                          | 9.424                                                                      | -622.4                        | -606.6              | 10.03                | 9.58                                           | 13.16                                          | 1284                              |
| 15                         | 26.34                            | 22485.                                                                                          | 9.280                                                                      | -609.1                        | -593.1              | 10.96                | 9.91                                           | 13.94                                          | 1261                              |
| 16                         | 26.63                            | 21057.                                                                                          | 9.075                                                                      | -595.0                        | -578.8              | 11.89                | 10.25                                          | 14.74                                          | 1234                              |
| 17                         | 26.96                            | 19518.                                                                                          | 8.896                                                                      | -579.9                        | -563.5              | 12.81                | 10.59                                          | 15.66                                          | 1205                              |
| 18                         | 27.30                            | 18121.                                                                                          | 8.739                                                                      | -563.9                        | -547.3              | 13.74                | 10.91                                          | 16.64                                          | 1179                              |
| 19                         | 27.68                            | 16806.                                                                                          | 8.577                                                                      | -547.0                        | -530.2              | 14.67                | 11.21                                          | 17.67                                          | 1154                              |
| 20                         | 28.09                            | 15537.                                                                                          | 8.400                                                                      | -529.0                        | -512.0              | 15.60                | 11.48                                          | 18.74                                          | 1129                              |
| 21                         | 28.54                            | 14189.                                                                                          | 8.213                                                                      | -510.0                        | -492.6              | 16.54                | 11.71                                          | 19.95                                          | 1102                              |
| 22                         | 29.03                            | 12887.                                                                                          | 7.992                                                                      | -489.7                        | -472.1              | 17.50                | 11.91                                          | 21.23                                          | 1074                              |
| 23                         | 29.59                            | 11479.                                                                                          | 7.743                                                                      | -468.1                        | -450.1              | 18.48                | 12.09                                          | 22.74                                          | 1042                              |
| 24                         | 30.22                            | 10125.                                                                                          | 7.450                                                                      | -444.9                        | -426.5              | 19.48                | 12.23                                          | 24.41                                          | 1008                              |
| 25                         | 30.94                            | 8745.                                                                                           | 7.114                                                                      | -419.9                        | -401.1              | 20.51                | 12.36                                          | 26.40                                          | 969                               |
| 26                         | 31.79                            | 7364.                                                                                           | 6.726                                                                      | -392.8                        | -373.5              | 21.60                | 12.47                                          | 28.83                                          | 925                               |
| 27                         | 32.83                            | 5958.                                                                                           | 6.282                                                                      | -362.9                        | -342.9              | 22.75                | 12.59                                          | 32.12                                          | 874                               |
| 28                         | 34.14                            | 4491.                                                                                           | 5.757                                                                      | -329.1                        | -308.3              | 24.01                | 12.74                                          | 37.13                                          | 811                               |
| * 28.198                   | 34.44                            | 4211.                                                                                           | 5.640                                                                      | -321.8                        | -300.8              | 24.28                | 12.77                                          | 38.37                                          | 798                               |
| * 28.198                   | 265.73                           | 929.8                                                                                           | 0.370                                                                      | 232.3                         | 393.8               | 48.92                | 14.40                                          | 44.12                                          | 378                               |
| 29                         | 287.03                           | 1112.                                                                                           | 0.336                                                                      | 252.5                         | 427.0               | 50.08                | 14.05                                          | 38.59                                          | 392                               |
| 30                         | 310.62                           | 1307.                                                                                           | 0.305                                                                      | 274.5                         | 463.4               | 51.32                | 13.76                                          | 34.57                                          | 406                               |
| 31                         | 332.28                           | 1480.                                                                                           | 0.281                                                                      | 294.6                         | 496.6               | 52.41                | 13.56                                          | 32.01                                          | 419                               |
| 32                         | 352.64                           | 1638.                                                                                           | 0.261                                                                      | 313.3                         | 527.6               | 53.39                | 13.41                                          | 30.23                                          | 431                               |
| 33                         | 372.06                           | 1786.                                                                                           | 0.245                                                                      | 331.1                         | 557.3               | 54.30                | 13.30                                          | 28.91                                          | 442                               |
| 34                         | 390.75                           | 1926.                                                                                           | 0.232                                                                      | 348.1                         | 585.6               | 55.15                | 13.17                                          | 27.86                                          | 452                               |
| 35                         | 408.87                           | 2059.                                                                                           | 0.220                                                                      | 364.5                         | 613.0               | 55.95                | 13.08                                          | 27.04                                          | 462                               |
| 36                         | 426.53                           | 2187.                                                                                           | 0.210                                                                      | 380.4                         | 639.7               | 56.70                | 13.01                                          | 26.38                                          | 472                               |
| 37                         | 443.82                           | 2310.                                                                                           | 0.201                                                                      | 396.0                         | 665.8               | 57.41                | 12.95                                          | 25.83                                          | 481                               |
| 38                         | 460.79                           | 2430.                                                                                           | 0.193                                                                      | 411.3                         | 691.4               | 58.10                | 12.91                                          | 25.38                                          | 490                               |
| 39                         | 477.48                           | 2547.                                                                                           | 0.185                                                                      | 426.3                         | 716.6               | 58.75                | 12.87                                          | 25.00                                          | 499                               |
| 40                         | 493.95                           | 2661.                                                                                           | 0.178                                                                      | 441.2                         | 741.5               | 59.38                | 12.85                                          | 24.67                                          | 507                               |
| 41                         | 510.20                           | 2773.                                                                                           | 0.172                                                                      | 455.8                         | 766.0               | 59.98                | 12.82                                          | 24.38                                          | 515                               |
| 42                         | 526.28                           | 2883.                                                                                           | 0.166                                                                      | 470.3                         | 790.2               | 60.57                | 12.81                                          | 24.13                                          | 523                               |
| 43                         | 542.19                           | 2991.                                                                                           | 0.161                                                                      | 484.6                         | 814.3               | 61.13                | 12.80                                          | 23.92                                          | 530                               |
| 44                         | 557.96                           | 3098.                                                                                           | 0.156                                                                      | 498.9                         | 838.1               | 61.68                | 12.79                                          | 23.73                                          | 537                               |
| 45                         | 573.60                           | 3202.                                                                                           | 0.152                                                                      | 513.0                         | 861.7               | 62.21                | 12.79                                          | 23.56                                          | 545                               |
| 46                         | 589.12                           | 3306.                                                                                           | 0.147                                                                      | 527.1                         | 885.2               | 62.73                | 12.79                                          | 23.41                                          | 552                               |
| 47                         | 604.54                           | 3408.                                                                                           | 0.143                                                                      | 541.0                         | 908.6               | 63.23                | 12.79                                          | 23.28                                          | 558                               |
| 48                         | 619.86                           | 3510.                                                                                           | 0.140                                                                      | 554.9                         | 931.8               | 63.72                | 12.80                                          | 23.16                                          | 565                               |
| 49                         | 635.09                           | 3610.                                                                                           | 0.136                                                                      | 568.8                         | 954.9               | 64.20                | 12.81                                          | 23.06                                          | 572                               |
| 50                         | 650.24                           | 3709.                                                                                           | 0.133                                                                      | 582.6                         | 977.9               | 64.66                | 12.82                                          | 22.97                                          | 578                               |
| 51                         | 665.31                           | 3808.                                                                                           | 0.129                                                                      | 596.4                         | 1000.8              | 65.12                | 12.84                                          | 22.90                                          | 584                               |
| 52                         | 680.32                           | 3905.                                                                                           | 0.126                                                                      | 610.1                         | 1023.7              | 65.56                | 12.87                                          | 22.83                                          | 590                               |
| 53                         | 695.26                           | 4002.                                                                                           | 0.123                                                                      | 623.8                         | 1046.5              | 65.99                | 12.89                                          | 22.78                                          | 596                               |
| 54                         | 710.14                           | 4098.                                                                                           | 0.121                                                                      | 637.5                         | 1069.3              | 66.42                | 12.92                                          | 22.74                                          | 602                               |
| 55                         | 724.97                           | 4194.                                                                                           | 0.118                                                                      | 651.2                         | 1092.0              | 66.84                | 12.96                                          | 22.70                                          | 608                               |
| 56                         | 739.74                           | 4289.                                                                                           | 0.116                                                                      | 665.0                         | 1114.7              | 67.25                | 13.00                                          | 22.67                                          | 613                               |
| 57                         | 754.47                           | 4383.                                                                                           | 0.113                                                                      | 678.7                         | 1137.4              | 67.65                | 13.04                                          | 22.66                                          | 619                               |
| 58                         | 769.15                           | 4477.                                                                                           | 0.111                                                                      | 692.4                         | 1160.0              | 68.04                | 13.09                                          | 22.65                                          | 624                               |
| 59                         | 783.79                           | 4571.                                                                                           | 0.109                                                                      | 706.2                         | 1182.7              | 68.43                | 13.15                                          | 22.65                                          | 629                               |
| 60                         | 798.39                           | 4664.                                                                                           | 0.107                                                                      | 719.9                         | 1205.3              | 68.81                | 13.20                                          | 22.66                                          | 634                               |
| 61                         | 812.96                           | 4756.                                                                                           | 0.105                                                                      | 733.8                         | 1228.0              | 69.18                | 13.27                                          | 22.68                                          | 639                               |
| 62                         | 827.49                           | 4848.                                                                                           | 0.103                                                                      | 747.6                         | 1250.7              | 69.55                | 13.33                                          | 22.70                                          | 644                               |
| 63                         | 841.99                           | 4940.                                                                                           | 0.101                                                                      | 761.5                         | 1273.4              | 69.92                | 13.41                                          | 22.74                                          | 649                               |
| 64                         | 856.46                           | 5031.                                                                                           | 0.099                                                                      | 775.5                         | 1296.2              | 70.27                | 13.49                                          | 22.78                                          | 654                               |
| 65                         | 870.89                           | 5122.                                                                                           | 0.097                                                                      | 789.5                         | 1319.0              | 70.63                | 13.57                                          | 22.82                                          | 658                               |
| 66                         | 885.31                           | 5213.                                                                                           | 0.096                                                                      | 803.6                         | 1341.8              | 70.98                | 13.66                                          | 22.88                                          | 663                               |
| 67                         | 899.69                           | 5303.                                                                                           | 0.094                                                                      | 817.8                         | 1364.7              | 71.32                | 13.75                                          | 22.94                                          | 667                               |
| 68                         | 914.05                           | 5394.                                                                                           | 0.093                                                                      | 832.0                         | 1387.7              | 71.66                | 13.85                                          | 23.00                                          | 671                               |
| 69                         | 928.39                           | 5483.                                                                                           | 0.091                                                                      | 846.3                         | 1410.7              | 72.00                | 13.95                                          | 23.08                                          | 675                               |
| 70                         | 942.70                           | 5573.                                                                                           | 0.090                                                                      | 860.7                         | 1433.9              | 72.33                | 14.06                                          | 23.16                                          | 679                               |
| 71                         | 957.00                           | 5662.                                                                                           | 0.088                                                                      | 875.3                         | 1457.1              | 72.66                | 14.17                                          | 23.24                                          | 683                               |
| 72                         | 971.27                           | 5752.                                                                                           | 0.087                                                                      | 889.9                         | 1480.4              | 72.99                | 14.28                                          | 23.34                                          | 687                               |
| 73                         | 985.53                           | 5840.                                                                                           | 0.086                                                                      | 904.6                         | 1503.7              | 73.31                | 14.41                                          | 23.43                                          | 691                               |
| 74                         | 999.77                           | 5929.                                                                                           | 0.084                                                                      | 919.4                         | 1527.2              | 73.63                | 14.53                                          | 23.54                                          | 695                               |
| 75                         | 1014.0                           | 6018.                                                                                           | 0.083                                                                      | 934.4                         | 1550.8              | 73.94                | 14.66                                          | 23.64                                          | 698                               |
| 76                         | 1028.2                           | 6106.                                                                                           | 0.082                                                                      | 949.4                         | 1574.5              | 74.26                | 14.79                                          | 23.76                                          | 702                               |
| 77                         | 1042.4                           | 6194.                                                                                           | 0.081                                                                      | 964.6                         | 1598.3              | 74.57                | 14.93                                          | 23.87                                          | 706                               |
| 78                         | 1056.6                           | 6282.                                                                                           | 0.080                                                                      | 979.9                         | 1622.3              | 74.88                | 15.07                                          | 24.00                                          | 709                               |
| 79                         | 1070.7                           | 6370.                                                                                           | 0.079                                                                      | 995.4                         | 1646.3              | 75.19                | 15.22                                          | 24.12                                          | 712                               |
| 80                         | 1084.9                           | 6457.                                                                                           | 0.078                                                                      | 1011.0                        | 1670.5              | 75.49                | 15.36                                          | 24.25                                          | 716                               |
| 81                         | 1099.0                           | 6545.                                                                                           | 0.077                                                                      | 1026.7                        | 1694.8              | 75.79                | 15.51                                          | 24.39                                          | 719                               |
| 82                         | 1113.1                           | 6632.                                                                                           | 0.076                                                                      | 1042.6                        | 1719.3              | 76.09                | 15.67                                          | 24.53                                          | 722                               |
| 83                         | 1127.2                           | 6719.                                                                                           | 0.075                                                                      | 1058.6                        | 1743.9              | 76.39                | 15.82                                          | 24.67                                          | 726                               |
| 84                         | 1141.3                           | 6806.                                                                                           | 0.074                                                                      | 1074.8                        | 1768.6              | 76.69                | 15.98                                          | 24.81                                          | 729                               |
| 85                         | 1155.4                           | 6893.                                                                                           | 0.073                                                                      | 1091.1                        | 1793.5              | 76.98                | 16.15                                          | 24.96                                          | 732                               |
| 86                         | 1169.5                           | 6980.                                                                                           | 0.072                                                                      | 1107.6                        | 1818.6              | 77.27                | 16.31                                          | 25.11                                          | 735                               |
| 87                         | 1183.5                           | 7067.                                                                                           | 0.071                                                                      | 1124.2                        | 1843.7              | 77.56                | 16.47                                          | 25.26                                          | 738                               |
| 88                         | 1197.6                           | 7153.                                                                                           | 0.070                                                                      | 1141.0                        | 1869.1              | 77.85                | 16.64                                          | 25.42                                          | 741                               |
| 89                         | 1211.6                           | 7240.                                                                                           | 0.069                                                                      | 1158.0                        | 1894.6              | 78.14                | 16.81                                          | 25.58                                          | 744                               |
| 90                         | 1225.7                           | 7326.                                                                                           | 0.068                                                                      | 1175.1                        | 1920.2              | 78.43                | 16.98                                          | 25.74                                          | 747                               |
| 91                         | 1239.7                           | 7412.                                                                                           | 0.068                                                                      | 1192.4                        | 1946.1              | 78.71                | 17.15                                          | 25.90                                          | 750                               |
| 92                         | 1253.7                           | 7498.                                                                                           | 0.067                                                                      | 1209.8                        | 1972.0              | 79.00                | 17.33                                          | 26.06                                          | 753                               |
| 93                         | 1267.7                           | 7584.                                                                                           | 0.066                                                                      | 1227.5                        | 1998.2              | 79.28                | 17.50                                          | 26.22                                          | 756                               |
| 94                         | 1281.7                           | 7670.                                                                                           | 0.065                                                                      | 1245.3                        | 2024.5              | 79.56                | 17.67                                          | 26.39                                          | 759                               |
| 95                         | 1295.7                           | 7756.                                                                                           | 0.065                                                                      | 1263.2                        | 2051.0              | 79.84                | 17.85                                          | 26.55                                          | 762                               |
| 96                         | 1309.7                           | 7842.                                                                                           | 0.064                                                                      | 1281.4                        | 2077.6              | 80.12                | 18.02                                          | 26.72                                          | 764                               |
| 97                         | 1323.7                           | 7927.                                                                                           | 0.063                                                                      | 1299.7                        | 2104.4              | 80.40                | 18.20                                          | 26.88                                          | 767                               |
| 98                         | 1337.7                           | 8013.                                                                                           | 0.063                                                                      | 1318.1                        | 2131.4              | 80.68                | 18.37                                          | 27.05                                          | 770                               |
| 99                         | 1351.6                           | 8098.                                                                                           | 0.062                                                                      | 1336.8                        | 2158.5              | 80.95                | 18.55                                          | 27.22                                          | 773                               |
| 100                        | 1365.6                           | 8184.                                                                                           | 0.061                                                                      | 1355.6                        | 2185.8              | 81.23                | 18.72                                          | 27.38                                          | 776                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 7.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM/GMOLE | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_p$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| • 14.037                   | 26.04              | 24015.                                                                              | 9.429                                                         | -622.4                        | -603.9              | 10.04                | 9.59                                  | 13.16                                 | 1287                              |
| 15                         | 26.31              | 22673.                                                                              | 9.300                                                         | -609.5                        | -590.9              | 10.93                | 9.91                                  | 13.92                                 | 1265                              |
| 16                         | 26.60              | 21239.                                                                              | 9.097                                                         | -595.4                        | -576.6              | 11.86                | 10.24                                 | 14.71                                 | 1238                              |
| 17                         | 26.92              | 19720.                                                                              | 8.921                                                         | -580.4                        | -561.3              | 12.78                | 10.58                                 | 15.62                                 | 1210                              |
| 18                         | 27.26              | 18332.                                                                              | 8.764                                                         | -564.5                        | -545.2              | 13.70                | 10.91                                 | 16.59                                 | 1184                              |
| 19                         | 27.63              | 17014.                                                                              | 8.604                                                         | -547.7                        | -528.1              | 14.63                | 11.20                                 | 17.60                                 | 1159                              |
| 20                         | 28.04              | 15737.                                                                              | 8.429                                                         | -529.9                        | -510.0              | 15.56                | 11.47                                 | 18.66                                 | 1134                              |
| 21                         | 28.48              | 14406.                                                                              | 8.243                                                         | -510.9                        | -490.7              | 16.49                | 11.70                                 | 19.84                                 | 1108                              |
| 22                         | 28.97              | 13104.                                                                              | 8.025                                                         | -490.8                        | -470.3              | 17.45                | 11.91                                 | 21.10                                 | 1080                              |
| 23                         | 29.51              | 11718.                                                                              | 7.782                                                         | -469.4                        | -448.4              | 18.42                | 12.08                                 | 22.57                                 | 1049                              |
| 24                         | 30.13              | 10370.                                                                              | 7.494                                                         | -446.5                        | -425.1              | 19.41                | 12.23                                 | 24.19                                 | 1015                              |
| 25                         | 30.84              | 9001.                                                                               | 7.165                                                         | -421.8                        | -399.9              | 20.44                | 12.36                                 | 26.09                                 | 977                               |
| 26                         | 31.66              | 7639.                                                                               | 6.790                                                         | -395.2                        | -372.7              | 21.50                | 12.47                                 | 28.40                                 | 935                               |
| 27                         | 32.65              | 6251.                                                                               | 6.359                                                         | -365.9                        | -342.7              | 22.64                | 12.58                                 | 31.45                                 | 886                               |
| 28                         | 33.88              | 4814.                                                                               | 5.858                                                         | -333.1                        | -309.0              | 23.86                | 12.72                                 | 35.94                                 | 827                               |
| 29                         | 35.54              | 3383.                                                                               | 5.269                                                         | -294.8                        | -269.6              | 25.24                | 12.88                                 | 43.35                                 | 756                               |
| • 29.097                   | 35.74              | 3211.                                                                               | 5.203                                                         | -290.7                        | -265.3              | 25.39                | 12.90                                 | 44.67                                 | 747                               |
| • 29.097                   | 222.51             | 809.0                                                                               | 0.453                                                         | 222.4                         | 380.2               | 47.59                | 14.71                                 | 51.79                                 | 378                               |
| 30                         | 245.59             | 1042.                                                                               | 0.400                                                         | 248.5                         | 422.7               | 49.03                | 14.24                                 | 42.34                                 | 395                               |
| 31                         | 267.27             | 1254.                                                                               | 0.360                                                         | 272.5                         | 462.1               | 50.32                | 13.92                                 | 37.04                                 | 410                               |
| 32                         | 286.87             | 1440.                                                                               | 0.330                                                         | 294.0                         | 497.4               | 51.44                | 13.70                                 | 33.84                                 | 423                               |
| 33                         | 305.14             | 1608.                                                                               | 0.306                                                         | 313.8                         | 530.2               | 52.45                | 13.53                                 | 31.65                                 | 435                               |
| 34                         | 322.42             | 1763.                                                                               | 0.287                                                         | 332.3                         | 561.0               | 53.37                | 13.35                                 | 30.03                                 | 446                               |
| 35                         | 338.99             | 1909.                                                                               | 0.270                                                         | 350.0                         | 590.4               | 54.22                | 13.22                                 | 28.82                                 | 457                               |
| 36                         | 355.01             | 2048.                                                                               | 0.256                                                         | 366.9                         | 618.7               | 55.02                | 13.12                                 | 27.87                                 | 468                               |
| 37                         | 370.57             | 2181.                                                                               | 0.244                                                         | 383.4                         | 646.2               | 55.77                | 13.04                                 | 27.11                                 | 477                               |
| 38                         | 385.77             | 2310.                                                                               | 0.233                                                         | 399.4                         | 673.0               | 56.49                | 12.99                                 | 26.49                                 | 487                               |
| 39                         | 400.66             | 2434.                                                                               | 0.224                                                         | 415.1                         | 699.2               | 57.17                | 12.94                                 | 25.98                                 | 496                               |
| 40                         | 415.28             | 2555.                                                                               | 0.215                                                         | 430.4                         | 725.0               | 57.82                | 12.91                                 | 25.54                                 | 504                               |
| 41                         | 429.68             | 2673.                                                                               | 0.207                                                         | 445.6                         | 750.3               | 58.45                | 12.88                                 | 25.17                                 | 512                               |
| 42                         | 443.88             | 2788.                                                                               | 0.200                                                         | 460.5                         | 775.3               | 59.05                | 12.86                                 | 24.85                                 | 520                               |
| 43                         | 457.91             | 2901.                                                                               | 0.193                                                         | 475.3                         | 800.1               | 59.63                | 12.84                                 | 24.57                                 | 528                               |
| 44                         | 471.78             | 3012.                                                                               | 0.187                                                         | 489.9                         | 824.5               | 60.19                | 12.83                                 | 24.32                                 | 536                               |
| 45                         | 485.51             | 3121.                                                                               | 0.181                                                         | 504.3                         | 848.7               | 60.74                | 12.83                                 | 24.11                                 | 543                               |
| 46                         | 499.12             | 3229.                                                                               | 0.176                                                         | 518.7                         | 872.7               | 61.26                | 12.83                                 | 23.92                                 | 550                               |
| 47                         | 512.62             | 3335.                                                                               | 0.171                                                         | 533.0                         | 896.6               | 61.78                | 12.83                                 | 23.75                                 | 557                               |
| 48                         | 526.01             | 3440.                                                                               | 0.166                                                         | 547.1                         | 920.2               | 62.28                | 12.83                                 | 23.60                                 | 564                               |
| 49                         | 539.31             | 3543.                                                                               | 0.161                                                         | 561.2                         | 943.8               | 62.76                | 12.84                                 | 23.47                                 | 570                               |
| 50                         | 552.53             | 3645.                                                                               | 0.157                                                         | 575.3                         | 967.2               | 63.23                | 12.86                                 | 23.36                                 | 577                               |
| 51                         | 565.67             | 3747.                                                                               | 0.153                                                         | 589.3                         | 990.5               | 63.70                | 12.87                                 | 23.26                                 | 583                               |
| 52                         | 578.74             | 3847.                                                                               | 0.150                                                         | 603.2                         | 1013.7              | 64.15                | 12.89                                 | 23.17                                 | 589                               |
| 53                         | 591.74             | 3947.                                                                               | 0.146                                                         | 617.1                         | 1036.8              | 64.59                | 12.92                                 | 23.10                                 | 596                               |
| 54                         | 604.68             | 4045.                                                                               | 0.143                                                         | 631.0                         | 1059.9              | 65.02                | 12.95                                 | 23.04                                 | 601                               |
| 55                         | 617.56             | 4143.                                                                               | 0.140                                                         | 644.9                         | 1082.9              | 65.44                | 12.98                                 | 22.99                                 | 607                               |
| 56                         | 630.39             | 4240.                                                                               | 0.137                                                         | 658.8                         | 1105.9              | 65.86                | 13.02                                 | 22.95                                 | 613                               |
| 57                         | 643.17             | 4337.                                                                               | 0.134                                                         | 672.7                         | 1128.9              | 66.26                | 13.07                                 | 22.92                                 | 618                               |
| 58                         | 655.90             | 4433.                                                                               | 0.131                                                         | 686.6                         | 1151.8              | 66.66                | 13.11                                 | 22.90                                 | 624                               |
| 59                         | 668.60             | 4528.                                                                               | 0.128                                                         | 700.5                         | 1174.7              | 67.05                | 13.17                                 | 22.89                                 | 629                               |
| 60                         | 681.25             | 4623.                                                                               | 0.126                                                         | 714.4                         | 1197.6              | 67.44                | 13.22                                 | 22.89                                 | 634                               |
| 61                         | 693.86             | 4717.                                                                               | 0.123                                                         | 728.3                         | 1220.4              | 67.81                | 13.29                                 | 22.89                                 | 639                               |
| 62                         | 706.44             | 4811.                                                                               | 0.121                                                         | 742.3                         | 1243.4              | 68.19                | 13.35                                 | 22.91                                 | 644                               |
| 63                         | 718.99             | 4904.                                                                               | 0.119                                                         | 756.3                         | 1266.3              | 68.55                | 13.43                                 | 22.93                                 | 649                               |
| 64                         | 731.51             | 4997.                                                                               | 0.117                                                         | 770.4                         | 1289.2              | 68.91                | 13.50                                 | 22.96                                 | 654                               |
| 65                         | 743.99             | 5090.                                                                               | 0.115                                                         | 784.5                         | 1312.2              | 69.27                | 13.58                                 | 23.00                                 | 658                               |
| 66                         | 756.45             | 5182.                                                                               | 0.113                                                         | 798.7                         | 1335.2              | 69.62                | 13.67                                 | 23.05                                 | 663                               |
| 67                         | 768.88             | 5274.                                                                               | 0.111                                                         | 813.0                         | 1358.3              | 69.97                | 13.76                                 | 23.10                                 | 667                               |
| 68                         | 781.29             | 5365.                                                                               | 0.109                                                         | 827.3                         | 1381.5              | 70.31                | 13.86                                 | 23.17                                 | 671                               |
| 69                         | 793.68             | 5456.                                                                               | 0.107                                                         | 841.7                         | 1404.7              | 70.65                | 13.96                                 | 23.23                                 | 675                               |
| 70                         | 806.04             | 5547.                                                                               | 0.105                                                         | 856.2                         | 1427.9              | 70.99                | 14.07                                 | 23.31                                 | 680                               |
| 71                         | 818.38             | 5637.                                                                               | 0.104                                                         | 870.8                         | 1451.3              | 71.32                | 14.18                                 | 23.39                                 | 684                               |
| 72                         | 830.70             | 5728.                                                                               | 0.102                                                         | 885.5                         | 1474.7              | 71.64                | 14.30                                 | 23.47                                 | 688                               |
| 73                         | 843.00             | 5818.                                                                               | 0.101                                                         | 900.3                         | 1498.2              | 71.97                | 14.42                                 | 23.57                                 | 691                               |
| 74                         | 855.29             | 5908.                                                                               | 0.099                                                         | 915.2                         | 1521.8              | 72.29                | 14.54                                 | 23.66                                 | 695                               |
| 75                         | 867.55             | 5997.                                                                               | 0.098                                                         | 930.2                         | 1545.6              | 72.61                | 14.67                                 | 23.77                                 | 699                               |
| 76                         | 879.80             | 6086.                                                                               | 0.096                                                         | 945.4                         | 1569.4              | 72.92                | 14.80                                 | 23.88                                 | 702                               |
| 77                         | 892.04             | 6175.                                                                               | 0.095                                                         | 960.6                         | 1593.3              | 73.24                | 14.94                                 | 23.99                                 | 706                               |
| 78                         | 904.26             | 6264.                                                                               | 0.094                                                         | 976.0                         | 1617.4              | 73.55                | 15.08                                 | 24.11                                 | 709                               |
| 79                         | 916.46             | 6353.                                                                               | 0.092                                                         | 991.5                         | 1641.5              | 73.86                | 15.22                                 | 24.23                                 | 713                               |
| 80                         | 928.65             | 6442.                                                                               | 0.091                                                         | 1007.2                        | 1665.8              | 74.16                | 15.37                                 | 24.36                                 | 716                               |
| 81                         | 940.83             | 6530.                                                                               | 0.090                                                         | 1023.0                        | 1690.3              | 74.46                | 15.52                                 | 24.49                                 | 720                               |
| 82                         | 952.99             | 6618.                                                                               | 0.089                                                         | 1038.9                        | 1714.8              | 74.77                | 15.68                                 | 24.63                                 | 723                               |
| 83                         | 965.15             | 6706.                                                                               | 0.087                                                         | 1055.0                        | 1739.5              | 75.07                | 15.83                                 | 24.77                                 | 726                               |
| 84                         | 977.29             | 6794.                                                                               | 0.086                                                         | 1071.2                        | 1764.4              | 75.36                | 15.99                                 | 24.91                                 | 729                               |
| 85                         | 989.42             | 6882.                                                                               | 0.085                                                         | 1087.6                        | 1789.3              | 75.66                | 16.15                                 | 25.05                                 | 732                               |
| 86                         | 1001.5             | 6969.                                                                               | 0.084                                                         | 1104.1                        | 1814.5              | 75.95                | 16.32                                 | 25.20                                 | 736                               |
| 87                         | 1013.6             | 7056.                                                                               | 0.083                                                         | 1120.8                        | 1839.7              | 76.24                | 16.48                                 | 25.35                                 | 739                               |
| 88                         | 1025.7             | 7144.                                                                               | 0.082                                                         | 1137.6                        | 1865.2              | 76.54                | 16.65                                 | 25.50                                 | 742                               |
| 89                         | 1037.8             | 7231.                                                                               | 0.081                                                         | 1154.6                        | 1890.8              | 76.82                | 16.82                                 | 25.66                                 | 745                               |
| 90                         | 1049.9             | 7318.                                                                               | 0.080                                                         | 1171.8                        | 1916.5              | 77.11                | 16.99                                 | 25.82                                 | 748                               |
| 91                         | 1062.0             | 7405.                                                                               | 0.079                                                         | 1189.1                        | 1942.4              | 77.40                | 17.16                                 | 25.98                                 | 751                               |
| 92                         | 1074.1             | 7491.                                                                               | 0.078                                                         | 1206.6                        | 1968.4              | 77.68                | 17.33                                 | 26.14                                 | 753                               |
| 93                         | 1086.1             | 7578.                                                                               | 0.077                                                         | 1224.3                        | 1994.7              | 77.97                | 17.51                                 | 26.30                                 | 756                               |
| 94                         | 1098.2             | 7665.                                                                               | 0.077                                                         | 1242.2                        | 2021.0              | 78.25                | 17.68                                 | 26.46                                 | 759                               |
| 95                         | 1110.2             | 7751.                                                                               | 0.076                                                         | 1260.2                        | 2047.6              | 78.53                | 17.85                                 | 26.62                                 | 762                               |
| 96                         | 1122.2             | 7837.                                                                               | 0.075                                                         | 1278.3                        | 2074.3              | 78.81                | 18.03                                 | 26.79                                 | 765                               |
| 97                         | 1134.3             | 7924.                                                                               | 0.074                                                         | 1296.7                        | 2101.2              | 79.09                | 18.20                                 | 26.95                                 | 768                               |
| 98                         | 1146.3             | 8010.                                                                               | 0.073                                                         | 1315.2                        | 2128.2              | 79.36                | 18.38                                 | 27.12                                 | 771                               |
| 99                         | 1158.3             | 8096.                                                                               | 0.072                                                         | 1333.9                        | 2155.4              | 79.64                | 18.55                                 | 27.28                                 | 774                               |
| 100                        | 1170.3             | 8182.                                                                               | 0.072                                                         | 1352.7                        | 2182.8              | 79.92                | 18.72                                 | 27.44                                 | 776                               |

• TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

8.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> • HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> • HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 14.071                   | 26.02                            | 24146.                                                                                             | 9.433                                                                      | -622.3                        | -601.2              | 10.04                | 9.61                                           | 13.16                                          | 1290                              |
| 15                         | 26.28                            | 22859.                                                                                             | 9.311                                                                      | -609.9                        | -588.6              | 10.90                | 9.91                                           | 13.89                                          | 1269                              |
| 16                         | 26.57                            | 21422.                                                                                             | 9.120                                                                      | -595.9                        | -574.3              | 11.83                | 10.24                                          | 14.69                                          | 1242                              |
| 17                         | 26.88                            | 19921.                                                                                             | 8.945                                                                      | -581.0                        | -559.2              | 12.75                | 10.58                                          | 15.58                                          | 1214                              |
| 18                         | 27.22                            | 18540.                                                                                             | 8.789                                                                      | -565.2                        | -543.1              | 13.67                | 10.90                                          | 16.53                                          | 1189                              |
| 19                         | 27.59                            | 17222.                                                                                             | 8.630                                                                      | -548.4                        | -526.0              | 14.59                | 11.20                                          | 17.54                                          | 1164                              |
| 20                         | 27.99                            | 15936.                                                                                             | 8.457                                                                      | -530.7                        | -508.0              | 15.51                | 11.46                                          | 18.59                                          | 1140                              |
| 21                         | 28.42                            | 14622.                                                                                             | 8.272                                                                      | -511.9                        | -488.8              | 16.45                | 11.70                                          | 19.74                                          | 1114                              |
| 22                         | 28.90                            | 13320.                                                                                             | 8.059                                                                      | -491.9                        | -468.5              | 17.39                | 11.90                                          | 20.98                                          | 1086                              |
| 23                         | 29.44                            | 11954.                                                                                             | 7.820                                                                      | -470.7                        | -446.8              | 18.36                | 12.08                                          | 22.41                                          | 1056                              |
| 24                         | 30.04                            | 10611.                                                                                             | 7.537                                                                      | -448.0                        | -423.6              | 19.34                | 12.23                                          | 23.98                                          | 1023                              |
| 25                         | 30.73                            | 9258.                                                                                              | 7.215                                                                      | -423.7                        | -398.7              | 20.36                | 12.35                                          | 25.80                                          | 986                               |
| 26                         | 31.53                            | 7903.                                                                                              | 6.850                                                                      | -397.4                        | -371.8              | 21.42                | 12.47                                          | 28.01                                          | 945                               |
| 27                         | 32.48                            | 6532.                                                                                              | 6.431                                                                      | -368.7                        | -342.3              | 22.53                | 12.58                                          | 30.85                                          | 897                               |
| 28                         | 33.66                            | 5124.                                                                                              | 5.948                                                                      | -336.7                        | -309.4              | 23.72                | 12.70                                          | 34.89                                          | 841                               |
| 29                         | 35.19                            | 3730.                                                                                              | 5.392                                                                      | -300.1                        | -271.6              | 25.05                | 12.85                                          | 41.22                                          | 775                               |
| * 29.910                   | 37.20                            | 2387.                                                                                              | 4.770                                                                      | -259.5                        | -229.4              | 26.48                | 13.05                                          | 53.02                                          | 698                               |
| * 29.910                   | 188.66                           | 687.4                                                                                              | 0.549                                                                      | 209.8                         | 362.7               | 46.29                | 15.07                                          | 62.87                                          | 378                               |
| 30                         | 191.84                           | 715.6                                                                                              | 0.537                                                                      | 213.8                         | 369.3               | 46.51                | 14.99                                          | 60.13                                          | 380                               |
| 31                         | 215.94                           | 997.8                                                                                              | 0.461                                                                      | 245.9                         | 421.0               | 48.21                | 14.41                                          | 45.65                                          | 399                               |
| 32                         | 235.98                           | 1223.                                                                                              | 0.413                                                                      | 271.8                         | 463.1               | 49.54                | 14.05                                          | 39.19                                          | 414                               |
| 33                         | 253.90                           | 1418.                                                                                              | 0.377                                                                      | 294.6                         | 500.4               | 50.69                | 13.82                                          | 35.38                                          | 427                               |
| 34                         | 270.44                           | 1593.                                                                                              | 0.349                                                                      | 315.2                         | 534.4               | 51.71                | 13.56                                          | 32.82                                          | 440                               |
| 35                         | 286.04                           | 1754.                                                                                              | 0.326                                                                      | 334.4                         | 566.3               | 52.63                | 13.38                                          | 31.00                                          | 452                               |
| 36                         | 300.95                           | 1906.                                                                                              | 0.308                                                                      | 352.6                         | 596.5               | 53.48                | 13.24                                          | 29.65                                          | 463                               |
| 37                         | 315.32                           | 2057.                                                                                              | 0.291                                                                      | 370.1                         | 625.7               | 54.28                | 13.15                                          | 28.60                                          | 473                               |
| 38                         | 329.26                           | 2187.                                                                                              | 0.277                                                                      | 386.9                         | 653.8               | 55.03                | 13.07                                          | 27.76                                          | 483                               |
| 39                         | 342.85                           | 2319.                                                                                              | 0.265                                                                      | 403.3                         | 681.2               | 55.74                | 13.01                                          | 27.08                                          | 492                               |
| 40                         | 356.14                           | 2447.                                                                                              | 0.254                                                                      | 419.3                         | 708.0               | 56.42                | 12.97                                          | 26.51                                          | 501                               |
| 41                         | 369.18                           | 2572.                                                                                              | 0.244                                                                      | 435.0                         | 734.3               | 57.07                | 12.94                                          | 26.03                                          | 510                               |
| 42                         | 382.00                           | 2693.                                                                                              | 0.235                                                                      | 450.4                         | 760.1               | 57.69                | 12.91                                          | 25.62                                          | 518                               |
| 43                         | 394.63                           | 2811.                                                                                              | 0.226                                                                      | 465.7                         | 785.5               | 58.29                | 12.89                                          | 25.27                                          | 526                               |
| 44                         | 407.09                           | 2927.                                                                                              | 0.219                                                                      | 480.7                         | 810.6               | 58.87                | 12.88                                          | 24.96                                          | 534                               |
| 45                         | 419.41                           | 3040.                                                                                              | 0.212                                                                      | 495.5                         | 835.5               | 59.43                | 12.87                                          | 24.69                                          | 541                               |
| 46                         | 431.59                           | 3157.                                                                                              | 0.205                                                                      | 510.2                         | 860.0               | 59.97                | 12.86                                          | 24.45                                          | 549                               |
| 47                         | 443.66                           | 3267.                                                                                              | 0.199                                                                      | 524.8                         | 884.4               | 60.49                | 12.86                                          | 24.25                                          | 556                               |
| 48                         | 455.62                           | 3379.                                                                                              | 0.193                                                                      | 539.2                         | 908.5               | 61.00                | 12.87                                          | 24.06                                          | 563                               |
| 49                         | 467.48                           | 3477.                                                                                              | 0.188                                                                      | 553.6                         | 932.5               | 61.49                | 12.88                                          | 23.90                                          | 570                               |
| 50                         | 479.25                           | 3587.                                                                                              | 0.183                                                                      | 567.9                         | 956.4               | 61.98                | 12.89                                          | 23.76                                          | 576                               |
| 51                         | 490.95                           | 3687.                                                                                              | 0.178                                                                      | 582.1                         | 980.1               | 62.44                | 12.90                                          | 23.64                                          | 583                               |
| 52                         | 502.56                           | 3797.                                                                                              | 0.174                                                                      | 596.3                         | 1003.6              | 62.90                | 12.92                                          | 23.53                                          | 589                               |
| 53                         | 514.11                           | 3857.                                                                                              | 0.170                                                                      | 610.4                         | 1027.1              | 63.35                | 12.95                                          | 23.44                                          | 595                               |
| 54                         | 525.60                           | 3993.                                                                                              | 0.166                                                                      | 624.5                         | 1050.5              | 63.79                | 12.98                                          | 23.36                                          | 601                               |
| 55                         | 537.03                           | 4093.                                                                                              | 0.162                                                                      | 638.5                         | 1073.8              | 64.22                | 13.01                                          | 23.29                                          | 607                               |
| 56                         | 548.40                           | 4197.                                                                                              | 0.158                                                                      | 652.6                         | 1097.1              | 64.63                | 13.05                                          | 23.23                                          | 613                               |
| 57                         | 559.72                           | 4291.                                                                                              | 0.155                                                                      | 666.6                         | 1120.3              | 65.05                | 13.09                                          | 23.19                                          | 618                               |
| 58                         | 570.99                           | 4389.                                                                                              | 0.151                                                                      | 680.7                         | 1143.5              | 65.45                | 13.14                                          | 23.15                                          | 624                               |
| 59                         | 582.22                           | 4486.                                                                                              | 0.148                                                                      | 694.7                         | 1166.7              | 65.84                | 13.19                                          | 23.13                                          | 629                               |
| 60                         | 593.42                           | 4587.                                                                                              | 0.145                                                                      | 708.8                         | 1189.8              | 66.23                | 13.24                                          | 23.12                                          | 634                               |
| 61                         | 604.57                           | 4679.                                                                                              | 0.143                                                                      | 722.8                         | 1212.9              | 66.61                | 13.30                                          | 23.11                                          | 639                               |
| 62                         | 615.69                           | 4774.                                                                                              | 0.140                                                                      | 736.9                         | 1236.0              | 66.99                | 13.37                                          | 23.12                                          | 644                               |
| 63                         | 626.77                           | 4869.                                                                                              | 0.137                                                                      | 751.1                         | 1259.1              | 67.36                | 13.44                                          | 23.13                                          | 649                               |
| 64                         | 637.82                           | 4964.                                                                                              | 0.135                                                                      | 765.3                         | 1282.3              | 67.73                | 13.52                                          | 23.16                                          | 654                               |
| 65                         | 648.84                           | 5058.                                                                                              | 0.132                                                                      | 779.5                         | 1305.5              | 68.08                | 13.60                                          | 23.19                                          | 658                               |
| 66                         | 659.84                           | 5151.                                                                                              | 0.130                                                                      | 793.8                         | 1328.7              | 68.44                | 13.69                                          | 23.23                                          | 663                               |
| 67                         | 670.81                           | 5244.                                                                                              | 0.128                                                                      | 808.2                         | 1351.9              | 68.79                | 13.78                                          | 23.27                                          | 667                               |
| 68                         | 681.75                           | 5337.                                                                                              | 0.126                                                                      | 822.6                         | 1375.2              | 69.13                | 13.88                                          | 23.33                                          | 672                               |
| 69                         | 692.67                           | 5429.                                                                                              | 0.123                                                                      | 837.1                         | 1398.6              | 69.47                | 13.98                                          | 23.39                                          | 676                               |
| 70                         | 703.57                           | 5522.                                                                                              | 0.121                                                                      | 851.7                         | 1422.0              | 69.81                | 14.08                                          | 23.46                                          | 680                               |
| 71                         | 714.44                           | 5617.                                                                                              | 0.119                                                                      | 866.4                         | 1445.5              | 70.15                | 14.19                                          | 23.53                                          | 684                               |
| 72                         | 725.30                           | 5705.                                                                                              | 0.118                                                                      | 881.1                         | 1469.1              | 70.47                | 14.31                                          | 23.61                                          | 688                               |
| 73                         | 736.13                           | 5796.                                                                                              | 0.116                                                                      | 896.0                         | 1492.7              | 70.80                | 14.43                                          | 23.70                                          | 692                               |
| 74                         | 746.95                           | 5887.                                                                                              | 0.114                                                                      | 911.0                         | 1516.5              | 71.12                | 14.55                                          | 23.79                                          | 696                               |
| 75                         | 757.75                           | 5977.                                                                                              | 0.112                                                                      | 926.1                         | 1540.3              | 71.44                | 14.68                                          | 23.89                                          | 699                               |
| 76                         | 768.53                           | 6067.                                                                                              | 0.111                                                                      | 941.3                         | 1564.3              | 71.76                | 14.81                                          | 24.00                                          | 703                               |
| 77                         | 779.30                           | 6158.                                                                                              | 0.109                                                                      | 956.6                         | 1588.3              | 72.08                | 14.95                                          | 24.11                                          | 706                               |
| 78                         | 790.06                           | 6247.                                                                                              | 0.108                                                                      | 972.1                         | 1612.5              | 72.39                | 15.09                                          | 24.22                                          | 710                               |
| 79                         | 800.79                           | 6337.                                                                                              | 0.106                                                                      | 987.6                         | 1636.8              | 72.70                | 15.23                                          | 24.34                                          | 713                               |
| 80                         | 811.52                           | 6426.                                                                                              | 0.105                                                                      | 1003.4                        | 1661.2              | 73.00                | 15.38                                          | 24.47                                          | 717                               |
| 81                         | 822.23                           | 6516.                                                                                              | 0.103                                                                      | 1019.2                        | 1685.7              | 73.31                | 15.53                                          | 24.59                                          | 720                               |
| 82                         | 832.93                           | 6605.                                                                                              | 0.102                                                                      | 1035.2                        | 1710.4              | 73.61                | 15.68                                          | 24.73                                          | 723                               |
| 83                         | 843.62                           | 6693.                                                                                              | 0.100                                                                      | 1051.3                        | 1735.2              | 73.91                | 15.84                                          | 24.86                                          | 727                               |
| 84                         | 854.29                           | 6782.                                                                                              | 0.099                                                                      | 1067.6                        | 1760.1              | 74.21                | 16.00                                          | 25.00                                          | 730                               |
| 85                         | 864.95                           | 6870.                                                                                              | 0.098                                                                      | 1084.0                        | 1785.2              | 74.51                | 16.16                                          | 25.14                                          | 733                               |
| 86                         | 875.61                           | 6959.                                                                                              | 0.097                                                                      | 1100.6                        | 1810.4              | 74.80                | 16.32                                          | 25.29                                          | 736                               |
| 87                         | 886.25                           | 7047.                                                                                              | 0.095                                                                      | 1117.4                        | 1835.8              | 75.10                | 16.49                                          | 25.44                                          | 739                               |
| 88                         | 896.88                           | 7135.                                                                                              | 0.094                                                                      | 1134.3                        | 1861.3              | 75.39                | 16.66                                          | 25.59                                          | 742                               |
| 89                         | 907.51                           | 7223.                                                                                              | 0.093                                                                      | 1151.3                        | 1886.9              | 75.68                | 16.83                                          | 25.74                                          | 745                               |
| 90                         | 918.12                           | 7310.                                                                                              | 0.092                                                                      | 1168.5                        | 1912.8              | 75.97                | 17.00                                          | 25.90                                          | 748                               |
| 91                         | 928.73                           | 7398.                                                                                              | 0.091                                                                      | 1185.9                        | 1938.7              | 76.25                | 17.17                                          | 26.05                                          | 751                               |
| 92                         | 939.32                           | 7485.                                                                                              | 0.090                                                                      | 1203.5                        | 1964.9              | 76.54                | 17.34                                          | 26.21                                          | 754                               |
| 93                         | 949.91                           | 7577.                                                                                              | 0.089                                                                      | 1221.2                        | 1991.2              | 76.82                | 17.51                                          | 26.37                                          | 757                               |
| 94                         | 960.49                           | 7669.                                                                                              | 0.088                                                                      | 1239.0                        | 2017.6              | 77.11                | 17.69                                          | 26.53                                          | 760                               |
| 95                         | 971.07                           | 7767.                                                                                              | 0.087                                                                      | 1257.1                        | 2044.2              | 77.39                | 17.86                                          | 26.69                                          | 763                               |
| 96                         | 981.63                           | 7834.                                                                                              | 0.086                                                                      | 1275.3                        | 2071.0              | 77.67                | 18.03                                          | 26.86                                          | 766                               |
| 97                         | 992.19                           | 7920.                                                                                              | 0.085                                                                      | 1293.7                        | 2097.9              | 77.95                | 18.21                                          | 27.02                                          | 769                               |
| 98                         | 1002.7                           | 8007.                                                                                              | 0.084                                                                      | 1312.2                        | 2125.0              | 78.22                | 18.38                                          | 27.18                                          | 771                               |
| 99                         | 1013.3                           | 8094.                                                                                              | 0.083                                                                      | 1330.9                        | 2152.3              | 78.50                | 18.56                                          | 27.34                                          | 774                               |
| 100                        | 1023.8                           | 8180.                                                                                              | 0.082                                                                      | 1349.8                        | 2179.7              | 78.78                | 18.73                                          | 27.51                                          | 777                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMOODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

9.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 14.104                   | 26.00                            | 24277.                                                                                             | 9.438                                                                      | -622.2                        | -598.5              | 10.04                | 9.62                                           | 13.16                                          | 1292                              |
| 15                         | 26.25                            | 23044.                                                                                             | 9.323                                                                      | -610.3                        | -586.4              | 10.88                | 9.91                                           | 13.86                                          | 1273                              |
| 16                         | 26.53                            | 21604.                                                                                             | 9.142                                                                      | -596.3                        | -572.1              | 11.80                | 10.24                                          | 14.66                                          | 1247                              |
| 17                         | 26.85                            | 20120.                                                                                             | 8.969                                                                      | -581.5                        | -557.0              | 12.71                | 10.58                                          | 15.54                                          | 1219                              |
| 18                         | 27.18                            | 18747.                                                                                             | 8.814                                                                      | -565.8                        | -541.0              | 13.63                | 10.90                                          | 16.48                                          | 1194                              |
| 19                         | 27.55                            | 17427.                                                                                             | 8.657                                                                      | -549.1                        | -524.0              | 14.55                | 11.19                                          | 17.47                                          | 1169                              |
| 20                         | 27.94                            | 16134.                                                                                             | 8.485                                                                      | -531.5                        | -506.0              | 15.47                | 11.46                                          | 18.52                                          | 1145                              |
| 21                         | 28.37                            | 14836.                                                                                             | 8.301                                                                      | -512.8                        | -486.9              | 16.40                | 11.69                                          | 19.65                                          | 1119                              |
| 22                         | 28.84                            | 13534.                                                                                             | 8.091                                                                      | -493.0                        | -466.7              | 17.34                | 11.90                                          | 20.87                                          | 1092                              |
| 23                         | 29.37                            | 12189.                                                                                             | 7.856                                                                      | -471.9                        | -445.1              | 18.30                | 12.07                                          | 22.25                                          | 1063                              |
| 24                         | 29.96                            | 10849.                                                                                             | 7.579                                                                      | -449.4                        | -422.1              | 19.28                | 12.22                                          | 23.78                                          | 1030                              |
| 25                         | 30.63                            | 9506.                                                                                              | 7.264                                                                      | -425.4                        | -397.5              | 20.29                | 12.35                                          | 25.54                                          | 994                               |
| 26                         | 31.41                            | 8163.                                                                                              | 6.908                                                                      | -399.5                        | -370.9              | 21.33                | 12.46                                          | 27.65                                          | 954                               |
| 27                         | 32.32                            | 6807.                                                                                              | 6.500                                                                      | -371.3                        | -341.8              | 22.43                | 12.57                                          | 30.31                                          | 908                               |
| 28                         | 33.44                            | 5426.                                                                                              | 6.033                                                                      | -340.2                        | -309.7              | 23.59                | 12.69                                          | 33.97                                          | 854                               |
| 29                         | 34.87                            | 4064.                                                                                              | 5.504                                                                      | -304.9                        | -273.1              | 24.88                | 12.83                                          | 39.47                                          | 793                               |
| 30                         | 36.89                            | 2647.                                                                                              | 4.865                                                                      | -262.6                        | -229.0              | 26.37                | 13.02                                          | 49.99                                          | 715                               |
| * 30.651                   | 38.88                            | 1687.                                                                                              | 4.337                                                                      | -227.8                        | -192.3              | 27.58                | 13.22                                          | 65.56                                          | 648                               |
| * 30.651                   | 161.07                           | 543.4                                                                                              | 0.662                                                                      | 193.9                         | 340.8               | 44.98                | 15.51                                          | 80.41                                          | 376                               |
| 31                         | 171.69                           | 683.4                                                                                              | 0.609                                                                      | 210.6                         | 367.1               | 45.84                | 15.15                                          | 65.33                                          | 385                               |
| 32                         | 194.27                           | 978.9                                                                                              | 0.519                                                                      | 245.2                         | 422.4               | 47.59                | 14.53                                          | 48.17                                          | 404                               |
| 33                         | 212.79                           | 1213.                                                                                              | 0.462                                                                      | 272.7                         | 466.7               | 48.96                | 14.17                                          | 40.80                                          | 419                               |
| 34                         | 229.18                           | 1413.                                                                                              | 0.421                                                                      | 296.2                         | 505.2               | 50.11                | 13.80                                          | 36.53                                          | 434                               |
| 35                         | 244.28                           | 1593.                                                                                              | 0.390                                                                      | 317.5                         | 540.3               | 51.12                | 13.55                                          | 33.76                                          | 447                               |
| 36                         | 258.49                           | 1760.                                                                                              | 0.365                                                                      | 337.3                         | 573.0               | 52.04                | 13.38                                          | 31.80                                          | 458                               |
| 37                         | 272.04                           | 1915.                                                                                              | 0.343                                                                      | 356.0                         | 604.0               | 52.90                | 13.25                                          | 30.35                                          | 469                               |
| 38                         | 285.08                           | 2063.                                                                                              | 0.325                                                                      | 373.8                         | 633.8               | 53.69                | 13.16                                          | 29.22                                          | 480                               |
| 39                         | 297.71                           | 2204.                                                                                              | 0.310                                                                      | 391.1                         | 662.5               | 54.44                | 13.09                                          | 28.32                                          | 489                               |
| 40                         | 310.00                           | 2339.                                                                                              | 0.296                                                                      | 407.8                         | 690.5               | 55.14                | 13.04                                          | 27.58                                          | 499                               |
| 41                         | 322.01                           | 2470.                                                                                              | 0.283                                                                      | 424.1                         | 717.8               | 55.82                | 12.99                                          | 26.97                                          | 508                               |
| 42                         | 333.78                           | 2597.                                                                                              | 0.272                                                                      | 440.1                         | 744.5               | 56.46                | 12.96                                          | 26.46                                          | 516                               |
| 43                         | 345.35                           | 2721.                                                                                              | 0.262                                                                      | 455.8                         | 770.7               | 57.08                | 12.94                                          | 26.02                                          | 524                               |
| 44                         | 356.74                           | 2842.                                                                                              | 0.252                                                                      | 471.2                         | 796.5               | 57.67                | 12.92                                          | 25.64                                          | 532                               |
| 45                         | 367.96                           | 2960.                                                                                              | 0.244                                                                      | 486.5                         | 822.0               | 58.24                | 12.91                                          | 25.31                                          | 540                               |
| 46                         | 379.05                           | 3076.                                                                                              | 0.236                                                                      | 501.5                         | 847.2               | 58.80                | 12.90                                          | 25.02                                          | 548                               |
| 47                         | 390.01                           | 3189.                                                                                              | 0.229                                                                      | 516.4                         | 872.1               | 59.33                | 12.90                                          | 24.77                                          | 555                               |
| 48                         | 400.86                           | 3301.                                                                                              | 0.222                                                                      | 531.2                         | 896.7               | 59.85                | 12.90                                          | 24.55                                          | 562                               |
| 49                         | 411.61                           | 3411.                                                                                              | 0.215                                                                      | 545.8                         | 921.2               | 60.36                | 12.91                                          | 24.35                                          | 569                               |
| 50                         | 422.26                           | 3520.                                                                                              | 0.209                                                                      | 560.4                         | 945.4               | 60.85                | 12.92                                          | 24.18                                          | 575                               |
| 51                         | 432.83                           | 3627.                                                                                              | 0.204                                                                      | 574.8                         | 969.5               | 61.32                | 12.93                                          | 24.03                                          | 582                               |
| 52                         | 443.33                           | 3733.                                                                                              | 0.199                                                                      | 589.2                         | 993.5               | 61.79                | 12.95                                          | 23.89                                          | 588                               |
| 53                         | 453.75                           | 3838.                                                                                              | 0.194                                                                      | 603.6                         | 1017.3              | 62.24                | 12.98                                          | 23.78                                          | 595                               |
| 54                         | 464.11                           | 3941.                                                                                              | 0.189                                                                      | 617.8                         | 1041.1              | 62.69                | 13.00                                          | 23.68                                          | 601                               |
| 55                         | 474.41                           | 4044.                                                                                              | 0.185                                                                      | 632.1                         | 1064.7              | 63.12                | 13.04                                          | 23.59                                          | 607                               |
| 56                         | 484.64                           | 4145.                                                                                              | 0.180                                                                      | 646.3                         | 1088.3              | 63.54                | 13.07                                          | 23.52                                          | 612                               |
| 57                         | 494.83                           | 4246.                                                                                              | 0.176                                                                      | 660.5                         | 1111.8              | 63.96                | 13.11                                          | 23.46                                          | 618                               |
| 58                         | 504.97                           | 4346.                                                                                              | 0.172                                                                      | 674.7                         | 1135.2              | 64.37                | 13.16                                          | 23.41                                          | 623                               |
| 59                         | 515.07                           | 4445.                                                                                              | 0.169                                                                      | 688.9                         | 1158.6              | 64.77                | 13.21                                          | 23.38                                          | 629                               |
| 60                         | 525.12                           | 4543.                                                                                              | 0.165                                                                      | 703.1                         | 1182.0              | 65.16                | 13.26                                          | 23.35                                          | 634                               |
| 61                         | 535.14                           | 4641.                                                                                              | 0.162                                                                      | 717.3                         | 1205.3              | 65.55                | 13.32                                          | 23.34                                          | 639                               |
| 62                         | 545.12                           | 4738.                                                                                              | 0.159                                                                      | 731.5                         | 1228.7              | 65.93                | 13.39                                          | 23.33                                          | 644                               |
| 63                         | 555.07                           | 4835.                                                                                              | 0.156                                                                      | 745.8                         | 1252.0              | 66.30                | 13.46                                          | 23.34                                          | 649                               |
| 64                         | 564.98                           | 4931.                                                                                              | 0.153                                                                      | 760.1                         | 1275.3              | 66.67                | 13.54                                          | 23.35                                          | 654                               |
| 65                         | 574.86                           | 5026.                                                                                              | 0.150                                                                      | 774.5                         | 1298.7              | 67.03                | 13.62                                          | 23.37                                          | 659                               |
| 66                         | 584.72                           | 5121.                                                                                              | 0.147                                                                      | 788.9                         | 1322.1              | 67.39                | 13.70                                          | 23.40                                          | 663                               |
| 67                         | 594.55                           | 5216.                                                                                              | 0.145                                                                      | 803.3                         | 1345.5              | 67.74                | 13.79                                          | 23.44                                          | 668                               |
| 68                         | 604.35                           | 5310.                                                                                              | 0.142                                                                      | 817.9                         | 1369.0              | 68.09                | 13.89                                          | 23.49                                          | 672                               |
| 69                         | 614.13                           | 5404.                                                                                              | 0.140                                                                      | 832.5                         | 1392.5              | 68.43                | 13.99                                          | 23.55                                          | 676                               |
| 70                         | 623.89                           | 5497.                                                                                              | 0.138                                                                      | 847.1                         | 1416.1              | 68.77                | 14.10                                          | 23.61                                          | 680                               |
| 71                         | 633.62                           | 5590.                                                                                              | 0.135                                                                      | 861.9                         | 1439.7              | 69.10                | 14.21                                          | 23.68                                          | 684                               |
| 72                         | 643.34                           | 5682.                                                                                              | 0.133                                                                      | 876.8                         | 1463.4              | 69.44                | 14.32                                          | 23.75                                          | 688                               |
| 73                         | 653.04                           | 5774.                                                                                              | 0.131                                                                      | 891.7                         | 1487.2              | 69.76                | 14.44                                          | 23.84                                          | 692                               |
| 74                         | 662.71                           | 5866.                                                                                              | 0.129                                                                      | 906.8                         | 1511.1              | 70.09                | 14.56                                          | 23.93                                          | 696                               |
| 75                         | 672.37                           | 5958.                                                                                              | 0.127                                                                      | 921.9                         | 1535.1              | 70.41                | 14.69                                          | 24.02                                          | 700                               |
| 76                         | 682.02                           | 6049.                                                                                              | 0.125                                                                      | 937.2                         | 1559.2              | 70.73                | 14.82                                          | 24.12                                          | 703                               |
| 77                         | 691.64                           | 6140.                                                                                              | 0.123                                                                      | 952.6                         | 1583.3              | 71.05                | 14.96                                          | 24.23                                          | 707                               |
| 78                         | 701.26                           | 6231.                                                                                              | 0.122                                                                      | 968.1                         | 1607.6              | 71.36                | 15.10                                          | 24.34                                          | 710                               |
| 79                         | 710.85                           | 6322.                                                                                              | 0.120                                                                      | 983.8                         | 1632.0              | 71.67                | 15.24                                          | 24.45                                          | 714                               |
| 80                         | 720.44                           | 6412.                                                                                              | 0.118                                                                      | 999.5                         | 1656.5              | 71.98                | 15.39                                          | 24.57                                          | 717                               |
| 81                         | 730.01                           | 6502.                                                                                              | 0.117                                                                      | 1015.5                        | 1681.2              | 72.28                | 15.54                                          | 24.70                                          | 721                               |
| 82                         | 739.57                           | 6592.                                                                                              | 0.115                                                                      | 1031.5                        | 1705.9              | 72.59                | 15.69                                          | 24.83                                          | 724                               |
| 83                         | 749.11                           | 6681.                                                                                              | 0.114                                                                      | 1047.7                        | 1730.8              | 72.89                | 15.85                                          | 24.96                                          | 727                               |
| 84                         | 758.65                           | 6771.                                                                                              | 0.112                                                                      | 1064.0                        | 1755.9              | 73.19                | 16.01                                          | 25.10                                          | 730                               |
| 85                         | 768.17                           | 6860.                                                                                              | 0.111                                                                      | 1080.5                        | 1781.0              | 73.49                | 16.17                                          | 25.24                                          | 734                               |
| 86                         | 777.68                           | 6949.                                                                                              | 0.109                                                                      | 1097.1                        | 1806.3              | 73.78                | 16.33                                          | 25.38                                          | 737                               |
| 87                         | 787.18                           | 7038.                                                                                              | 0.108                                                                      | 1113.9                        | 1831.8              | 74.08                | 16.50                                          | 25.53                                          | 740                               |
| 88                         | 796.68                           | 7126.                                                                                              | 0.107                                                                      | 1130.9                        | 1857.4              | 74.37                | 16.66                                          | 25.67                                          | 743                               |
| 89                         | 806.16                           | 7215.                                                                                              | 0.105                                                                      | 1148.0                        | 1883.1              | 74.66                | 16.83                                          | 25.82                                          | 746                               |
| 90                         | 815.63                           | 7303.                                                                                              | 0.104                                                                      | 1165.2                        | 1909.0              | 74.95                | 17.00                                          | 25.98                                          | 749                               |
| 91                         | 825.10                           | 7391.                                                                                              | 0.103                                                                      | 1182.7                        | 1935.1              | 75.24                | 17.17                                          | 26.13                                          | 752                               |
| 92                         | 834.55                           | 7479.                                                                                              | 0.102                                                                      | 1200.3                        | 1961.3              | 75.53                | 17.34                                          | 26.29                                          | 755                               |
| 93                         | 844.00                           | 7567.                                                                                              | 0.100                                                                      | 1218.0                        | 1987.7              | 75.81                | 17.52                                          | 26.45                                          | 758                               |
| 94                         | 853.44                           | 7655.                                                                                              | 0.099                                                                      | 1235.9                        | 2014.2              | 76.09                | 17.69                                          | 26.60                                          | 761                               |
| 95                         | 862.87                           | 7743.                                                                                              | 0.098                                                                      | 1254.0                        | 2040.9              | 76.38                | 17.87                                          | 26.76                                          | 764                               |
| 96                         | 872.30                           | 7831.                                                                                              | 0.097                                                                      | 1272.3                        | 2067.7              | 76.66                | 18.04                                          | 26.92                                          | 766                               |
| 97                         | 881.72                           | 7919.                                                                                              | 0.096                                                                      | 1290.7                        | 2094.7              | 76.94                | 18.21                                          | 27.09                                          | 769                               |
| 98                         | 891.13                           | 8007.                                                                                              | 0.095                                                                      | 1309.3                        | 2121.9              | 77.22                | 18.39                                          | 27.25                                          | 772                               |
| 99                         | 900.54                           | 8095.                                                                                              | 0.094                                                                      | 1328.0                        | 2149.2              | 77.49                | 18.56                                          | 27.41                                          | 775                               |
| 100                        | 909.93                           | 8179.                                                                                              | 0.093                                                                      | 1346.9                        | 2176.7              | 77.77                | 18.73                                          | 27.57                                          | 778                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISO8ARS-CONTINUED

## 10.0 ATMOSPHERE ISO8AR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM/GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY,<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 14.137                     | 25.98              | 24408.                                                                                              | 9.442                                                                      | -622.1                         | -595.8              | 10.05                | 9.63                                           | 13.16                                          | 1295                              |
| 15                         | 26.22              | 23229.                                                                                              | 9.334                                                                      | -610.7                         | -584.2              | 10.85                | 9.91                                           | 13.83                                          | 1276                              |
| 16                         | 26.50              | 21785.                                                                                              | 9.163                                                                      | -596.8                         | -569.9              | 11.77                | 10.24                                          | 14.63                                          | 1251                              |
| 17                         | 26.81              | 20318.                                                                                              | 8.993                                                                      | -582.0                         | -554.8              | 12.68                | 10.57                                          | 15.50                                          | 1224                              |
| 18                         | 27.14              | 18952.                                                                                              | 8.838                                                                      | -566.4                         | -538.8              | 13.60                | 10.89                                          | 16.43                                          | 1199                              |
| 19                         | 27.50              | 17631.                                                                                              | 8.683                                                                      | -549.8                         | -521.9              | 14.51                | 11.19                                          | 17.41                                          | 1174                              |
| 20                         | 27.89              | 16332.                                                                                              | 8.513                                                                      | -532.2                         | -504.0              | 15.43                | 11.45                                          | 18.45                                          | 1150                              |
| 21                         | 28.32              | 15048.                                                                                              | 8.330                                                                      | -513.7                         | -485.0              | 16.36                | 11.69                                          | 19.55                                          | 1125                              |
| 22                         | 28.78              | 13747.                                                                                              | 8.124                                                                      | -494.0                         | -464.9              | 17.29                | 11.89                                          | 20.76                                          | 1098                              |
| 23                         | 29.30              | 12418.                                                                                              | 7.891                                                                      | -473.1                         | -443.4              | 18.25                | 12.07                                          | 22.10                                          | 1069                              |
| 24                         | 29.88              | 11085.                                                                                              | 7.620                                                                      | -450.9                         | -420.6              | 19.22                | 12.22                                          | 23.59                                          | 1037                              |
| 25                         | 30.53              | 9752.                                                                                               | 7.311                                                                      | -427.1                         | -396.2              | 20.21                | 12.35                                          | 25.29                                          | 1002                              |
| 26                         | 31.29              | 8418.                                                                                               | 6.965                                                                      | -401.6                         | -369.8              | 21.25                | 12.46                                          | 27.32                                          | 963                               |
| 27                         | 32.17              | 7082.                                                                                               | 6.567                                                                      | -373.9                         | -341.3              | 22.32                | 12.57                                          | 29.81                                          | 919                               |
| 28                         | 33.24              | 5724.                                                                                               | 6.117                                                                      | -343.5                         | -309.8              | 23.47                | 12.68                                          | 33.17                                          | 868                               |
| 29                         | 34.59              | 4384.                                                                                               | 5.607                                                                      | -309.3                         | -274.2              | 24.72                | 12.81                                          | 38.02                                          | 809                               |
| 30                         | 36.41              | 3016.                                                                                               | 5.010                                                                      | -269.3                         | -232.4              | 26.13                | 12.97                                          | 46.51                                          | 737                               |
| 31                         | 39.31              | 1613.                                                                                               | 4.243                                                                      | -217.8                         | -177.9              | 27.92                | 13.26                                          | 67.43                                          | 642                               |
| 31.335                     | 40.93              | 1109.                                                                                               | 3.894                                                                      | -194.1                         | -152.6              | 28.73                | 13.45                                          | 86.20                                          | 598                               |
| 31.335                     | 137.49             | 405.2                                                                                               | 0.796                                                                      | 173.6                          | 312.9               | 43.59                | 16.05                                          | 109.86                                         | 373                               |
| 32                         | 157.42             | 686.8                                                                                               | 0.669                                                                      | 210.4                          | 369.9               | 45.40                | 15.24                                          | 67.64                                          | 391                               |
| 33                         | 178.23             | 985.4                                                                                               | 0.569                                                                      | 246.7                          | 427.3               | 47.16                | 14.63                                          | 49.55                                          | 410                               |
| 34                         | 195.19             | 1221.                                                                                               | 0.508                                                                      | 274.8                          | 472.6               | 48.52                | 14.10                                          | 41.78                                          | 426                               |
| 35                         | 210.23             | 1425.                                                                                               | 0.463                                                                      | 298.9                          | 512.0               | 49.66                | 13.76                                          | 37.36                                          | 441                               |
| 36                         | 224.08             | 1608.                                                                                               | 0.429                                                                      | 320.7                          | 547.8               | 50.67                | 13.53                                          | 34.47                                          | 454                               |
| 37                         | 237.10             | 1778.                                                                                               | 0.401                                                                      | 341.0                          | 581.2               | 51.58                | 13.37                                          | 32.43                                          | 466                               |
| 38                         | 249.50             | 1936.                                                                                               | 0.378                                                                      | 360.0                          | 612.8               | 52.43                | 13.25                                          | 30.91                                          | 476                               |
| 39                         | 261.42             | 2087.                                                                                               | 0.358                                                                      | 378.2                          | 643.1               | 53.21                | 13.17                                          | 29.73                                          | 487                               |
| 40                         | 272.96             | 2230.                                                                                               | 0.340                                                                      | 395.8                          | 672.4               | 53.95                | 13.10                                          | 28.79                                          | 496                               |
| 41                         | 284.18             | 2368.                                                                                               | 0.325                                                                      | 412.8                          | 700.8               | 54.65                | 13.05                                          | 28.02                                          | 505                               |
| 42                         | 295.14             | 2502.                                                                                               | 0.311                                                                      | 429.4                          | 728.5               | 55.32                | 13.01                                          | 27.37                                          | 514                               |
| 43                         | 305.87             | 2631.                                                                                               | 0.299                                                                      | 445.6                          | 755.6               | 55.96                | 12.99                                          | 26.83                                          | 523                               |
| 44                         | 316.41             | 2757.                                                                                               | 0.288                                                                      | 461.5                          | 782.1               | 56.57                | 12.96                                          | 26.37                                          | 531                               |
| 45                         | 326.78             | 2880.                                                                                               | 0.278                                                                      | 477.2                          | 808.3               | 57.16                | 12.95                                          | 25.97                                          | 539                               |
| 46                         | 337.00             | 3000.                                                                                               | 0.268                                                                      | 492.6                          | 834.1               | 57.73                | 12.94                                          | 25.62                                          | 546                               |
| 47                         | 347.08             | 3118.                                                                                               | 0.259                                                                      | 507.9                          | 859.6               | 58.27                | 12.94                                          | 25.32                                          | 554                               |
| 48                         | 357.05             | 3233.                                                                                               | 0.251                                                                      | 523.0                          | 884.8               | 58.80                | 12.94                                          | 25.05                                          | 561                               |
| 49                         | 366.91             | 3347.                                                                                               | 0.244                                                                      | 537.9                          | 909.7               | 59.32                | 12.94                                          | 24.82                                          | 568                               |
| 50                         | 376.68             | 3458.                                                                                               | 0.237                                                                      | 552.7                          | 934.4               | 59.82                | 12.95                                          | 24.61                                          | 575                               |
| 51                         | 386.35             | 3569.                                                                                               | 0.230                                                                      | 567.5                          | 958.9               | 60.30                | 12.96                                          | 24.43                                          | 581                               |
| 52                         | 395.95             | 3677.                                                                                               | 0.224                                                                      | 582.1                          | 983.3               | 60.78                | 12.98                                          | 24.27                                          | 588                               |
| 53                         | 405.47             | 3785.                                                                                               | 0.218                                                                      | 596.6                          | 1007.5              | 61.24                | 13.00                                          | 24.13                                          | 594                               |
| 54                         | 414.93             | 3891.                                                                                               | 0.213                                                                      | 611.1                          | 1031.6              | 61.69                | 13.03                                          | 24.01                                          | 600                               |
| 55                         | 424.32             | 3996.                                                                                               | 0.208                                                                      | 625.6                          | 1055.5              | 62.13                | 13.06                                          | 23.91                                          | 606                               |
| 56                         | 433.66             | 4099.                                                                                               | 0.203                                                                      | 640.0                          | 1079.4              | 62.56                | 13.10                                          | 23.81                                          | 612                               |
| 57                         | 442.94             | 4202.                                                                                               | 0.198                                                                      | 654.4                          | 1103.2              | 62.98                | 13.13                                          | 23.74                                          | 618                               |
| 58                         | 452.17             | 4304.                                                                                               | 0.194                                                                      | 668.7                          | 1126.9              | 63.39                | 13.18                                          | 23.67                                          | 623                               |
| 59                         | 461.36             | 4405.                                                                                               | 0.190                                                                      | 683.1                          | 1150.6              | 63.79                | 13.23                                          | 23.63                                          | 629                               |
| 60                         | 470.51             | 4505.                                                                                               | 0.186                                                                      | 697.4                          | 1174.2              | 64.19                | 13.28                                          | 23.59                                          | 634                               |
| 61                         | 479.62             | 4605.                                                                                               | 0.182                                                                      | 711.8                          | 1197.7              | 64.58                | 13.34                                          | 23.56                                          | 639                               |
| 62                         | 488.69             | 4703.                                                                                               | 0.178                                                                      | 726.1                          | 1221.3              | 64.96                | 13.41                                          | 23.55                                          | 644                               |
| 63                         | 497.73             | 4801.                                                                                               | 0.175                                                                      | 740.5                          | 1244.8              | 65.34                | 13.48                                          | 23.54                                          | 649                               |
| 64                         | 506.73             | 4899.                                                                                               | 0.171                                                                      | 754.9                          | 1268.4              | 65.71                | 13.55                                          | 23.55                                          | 654                               |
| 65                         | 515.70             | 4996.                                                                                               | 0.168                                                                      | 769.4                          | 1291.9              | 66.08                | 13.63                                          | 23.56                                          | 659                               |
| 66                         | 524.65             | 5097.                                                                                               | 0.165                                                                      | 783.9                          | 1315.5              | 66.44                | 13.72                                          | 23.58                                          | 663                               |
| 67                         | 533.56             | 5188.                                                                                               | 0.162                                                                      | 798.5                          | 1339.1              | 66.79                | 13.81                                          | 23.62                                          | 668                               |
| 68                         | 542.46             | 5287.                                                                                               | 0.159                                                                      | 813.1                          | 1362.8              | 67.14                | 13.90                                          | 23.66                                          | 672                               |
| 69                         | 551.32             | 5378.                                                                                               | 0.157                                                                      | 827.8                          | 1386.4              | 67.49                | 14.00                                          | 23.71                                          | 676                               |
| 70                         | 560.17             | 5477.                                                                                               | 0.154                                                                      | 842.6                          | 1410.2              | 67.83                | 14.11                                          | 23.76                                          | 681                               |
| 71                         | 568.99             | 5567.                                                                                               | 0.152                                                                      | 857.4                          | 1434.0              | 68.17                | 14.22                                          | 23.83                                          | 685                               |
| 72                         | 577.80             | 5661.                                                                                               | 0.149                                                                      | 872.4                          | 1457.8              | 68.50                | 14.33                                          | 23.90                                          | 689                               |
| 73                         | 586.58             | 5754.                                                                                               | 0.147                                                                      | 887.4                          | 1481.8              | 68.83                | 14.45                                          | 23.97                                          | 693                               |
| 74                         | 595.35             | 5847.                                                                                               | 0.144                                                                      | 902.5                          | 1505.8              | 69.16                | 14.57                                          | 24.06                                          | 696                               |
| 75                         | 604.09             | 5939.                                                                                               | 0.142                                                                      | 917.8                          | 1529.9              | 69.48                | 14.70                                          | 24.15                                          | 700                               |
| 76                         | 612.82             | 6037.                                                                                               | 0.140                                                                      | 933.1                          | 1554.1              | 69.80                | 14.83                                          | 24.24                                          | 704                               |
| 77                         | 621.54             | 6124.                                                                                               | 0.138                                                                      | 948.6                          | 1578.4              | 70.12                | 14.97                                          | 24.34                                          | 707                               |
| 78                         | 630.24             | 6217.                                                                                               | 0.136                                                                      | 964.2                          | 1602.8              | 70.43                | 15.11                                          | 24.45                                          | 711                               |
| 79                         | 638.92             | 6307.                                                                                               | 0.134                                                                      | 979.9                          | 1627.3              | 70.75                | 15.25                                          | 24.56                                          | 714                               |
| 80                         | 647.59             | 6398.                                                                                               | 0.132                                                                      | 995.7                          | 1651.9              | 71.06                | 15.40                                          | 24.68                                          | 718                               |
| 81                         | 656.25             | 6489.                                                                                               | 0.130                                                                      | 1011.7                         | 1676.6              | 71.36                | 15.55                                          | 24.80                                          | 721                               |
| 82                         | 664.90             | 6579.                                                                                               | 0.129                                                                      | 1027.8                         | 1701.5              | 71.67                | 15.70                                          | 24.93                                          | 725                               |
| 83                         | 673.53             | 6670.                                                                                               | 0.127                                                                      | 1044.1                         | 1726.5              | 71.97                | 15.86                                          | 25.06                                          | 728                               |
| 84                         | 682.15             | 6761.                                                                                               | 0.125                                                                      | 1060.4                         | 1751.6              | 72.27                | 16.01                                          | 25.19                                          | 731                               |
| 85                         | 690.76             | 6851.                                                                                               | 0.124                                                                      | 1077.0                         | 1776.9              | 72.57                | 16.18                                          | 25.33                                          | 734                               |
| 86                         | 699.36             | 6941.                                                                                               | 0.122                                                                      | 1093.7                         | 1802.3              | 72.87                | 16.34                                          | 25.47                                          | 737                               |
| 87                         | 707.95             | 7029.                                                                                               | 0.120                                                                      | 1110.5                         | 1827.8              | 73.16                | 16.50                                          | 25.61                                          | 740                               |
| 88                         | 716.53             | 7118.                                                                                               | 0.119                                                                      | 1127.5                         | 1853.5              | 73.46                | 16.67                                          | 25.76                                          | 744                               |
| 89                         | 725.10             | 7208.                                                                                               | 0.117                                                                      | 1144.7                         | 1879.4              | 73.75                | 16.84                                          | 25.91                                          | 747                               |
| 90                         | 733.66             | 7297.                                                                                               | 0.116                                                                      | 1162.0                         | 1905.3              | 74.04                | 17.01                                          | 26.06                                          | 750                               |
| 91                         | 742.21             | 7385.                                                                                               | 0.115                                                                      | 1179.4                         | 1931.5              | 74.33                | 17.18                                          | 26.21                                          | 753                               |
| 92                         | 750.75             | 7474.                                                                                               | 0.113                                                                      | 1197.1                         | 1957.8              | 74.62                | 17.35                                          | 26.36                                          | 756                               |
| 93                         | 759.29             | 7563.                                                                                               | 0.112                                                                      | 1214.9                         | 1984.2              | 74.90                | 17.52                                          | 26.52                                          | 758                               |
| 94                         | 767.82             | 7651.                                                                                               | 0.111                                                                      | 1232.8                         | 2010.8              | 75.19                | 17.70                                          | 26.68                                          | 761                               |
| 95                         | 776.34             | 7739.                                                                                               | 0.109                                                                      | 1250.9                         | 2037.6              | 75.47                | 17.87                                          | 26.83                                          | 764                               |
| 96                         | 784.85             | 7827.                                                                                               | 0.108                                                                      | 1269.2                         | 2064.5              | 75.75                | 18.04                                          | 26.99                                          | 767                               |
| 97                         | 793.35             | 7915.                                                                                               | 0.107                                                                      | 1287.7                         | 2091.6              | 76.03                | 18.22                                          | 27.15                                          | 770                               |
| 98                         | 801.85             | 8003.                                                                                               | 0.106                                                                      | 1306.3                         | 2118.8              | 76.31                | 18.39                                          | 27.31                                          | 773                               |
| 99                         | 810.35             | 8091.                                                                                               | 0.105                                                                      | 1325.1                         | 2146.2              | 76.59                | 18.57                                          | 27.47                                          | 776                               |
| 100                        | 818.83             | 8178.                                                                                               | 0.103                                                                      | 1344.1                         | 2173.7              | 76.87                | 18.74                                          | 27.63                                          | 779                               |

• TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 12.5 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 14.220                   | 25.94                            | 24716.                                                                                              | 9.447                                                                      | -621.9                        | -589.0              | 10.06                | 9.66                                           | 13.16                                          | 1301                              |
| 15                         | 26.14                            | 23688.                                                                                              | 9.361                                                                      | -611.7                        | -578.6              | 10.78                | 9.91                                           | 13.75                                          | 1285                              |
| 16                         | 26.42                            | 22235.                                                                                              | 9.217                                                                      | -597.9                        | -564.4              | 11.69                | 10.24                                          | 14.56                                          | 1261                              |
| 17                         | 26.73                            | 20806.                                                                                              | 9.052                                                                      | -583.2                        | -549.4              | 12.60                | 10.57                                          | 15.41                                          | 1235                              |
| 18                         | 27.05                            | 19455.                                                                                              | 8.899                                                                      | -567.8                        | -533.5              | 13.51                | 10.88                                          | 16.31                                          | 1211                              |
| 19                         | 27.40                            | 18135.                                                                                              | 8.746                                                                      | -551.4                        | -516.7              | 14.42                | 11.18                                          | 17.27                                          | 1187                              |
| 20                         | 27.78                            | 16819.                                                                                              | 8.581                                                                      | -534.1                        | -499.0              | 15.33                | 11.44                                          | 18.28                                          | 1162                              |
| 21                         | 28.19                            | 15570.                                                                                              | 8.400                                                                      | -515.9                        | -480.2              | 16.25                | 11.67                                          | 19.33                                          | 1138                              |
| 22                         | 28.63                            | 14277.                                                                                              | 8.202                                                                      | -496.5                        | -460.3              | 17.17                | 11.88                                          | 20.50                                          | 1112                              |
| 23                         | 29.13                            | 12980.                                                                                              | 7.975                                                                      | -476.0                        | -439.1              | 18.11                | 12.06                                          | 21.75                                          | 1085                              |
| 24                         | 29.68                            | 11663.                                                                                              | 7.718                                                                      | -454.3                        | -416.7              | 19.07                | 12.21                                          | 23.15                                          | 1054                              |
| 25                         | 30.30                            | 10354.                                                                                              | 7.425                                                                      | -431.2                        | -392.8              | 20.04                | 12.34                                          | 24.72                                          | 1021                              |
| 26                         | 31.01                            | 9044.                                                                                               | 7.095                                                                      | -406.4                        | -367.1              | 21.05                | 12.45                                          | 26.55                                          | 984                               |
| 27                         | 31.83                            | 7737.                                                                                               | 6.724                                                                      | -379.8                        | -339.5              | 22.09                | 12.55                                          | 28.75                                          | 944                               |
| 28                         | 32.79                            | 6429.                                                                                               | 6.312                                                                      | -350.9                        | -309.3              | 23.19                | 12.66                                          | 31.56                                          | 898                               |
| 29                         | 33.97                            | 5144.                                                                                               | 5.845                                                                      | -319.0                        | -276.0              | 24.36                | 12.77                                          | 35.29                                          | 845                               |
| 30                         | 35.47                            | 3864.                                                                                               | 5.319                                                                      | -283.0                        | -238.1              | 25.64                | 12.90                                          | 40.93                                          | 785                               |
| 31                         | 37.56                            | 2596.                                                                                               | 4.700                                                                      | -240.4                        | -192.8              | 27.13                | 13.08                                          | 50.80                                          | 712                               |
| 32                         | 41.02                            | 1317.                                                                                               | 3.902                                                                      | -184.2                        | -132.2              | 29.05                | 13.42                                          | 76.51                                          | 614                               |
| * 32.836                   | 52.53                            | 66.57                                                                                               | 2.332                                                                      | -72.9                         | -6.4                | 32.92                | 16.54                                          | 766.30                                         | 394                               |
| * 32.836                   | 81.91                            | 39.36                                                                                               | 1.479                                                                      | 67.2                          | 171.0               | 38.32                | 18.90                                          | 1259.25                                        | 363                               |
| 33                         | 97.38                            | 201.1                                                                                               | 1.195                                                                      | 119.6                         | 243.0               | 40.51                | 17.52                                          | 242.84                                         | 374                               |
| 34                         | 127.57                           | 661.6                                                                                               | 0.849                                                                      | 200.2                         | 361.8               | 44.07                | 15.35                                          | 76.37                                          | 407                               |
| 35                         | 145.57                           | 959.8                                                                                               | 0.714                                                                      | 241.2                         | 425.6               | 45.92                | 14.48                                          | 54.42                                          | 426                               |
| 36                         | 160.07                           | 1206.                                                                                               | 0.634                                                                      | 272.1                         | 474.9               | 47.30                | 14.01                                          | 45.16                                          | 442                               |
| 37                         | 172.82                           | 1420.                                                                                               | 0.577                                                                      | 298.3                         | 517.2               | 48.47                | 13.71                                          | 39.98                                          | 456                               |
| 38                         | 184.49                           | 1617.                                                                                               | 0.533                                                                      | 321.7                         | 555.4               | 49.48                | 13.51                                          | 36.62                                          | 469                               |
| 39                         | 195.42                           | 1790.                                                                                               | 0.498                                                                      | 343.3                         | 590.8               | 50.40                | 13.37                                          | 34.26                                          | 480                               |
| 40                         | 205.78                           | 1954.                                                                                               | 0.468                                                                      | 363.5                         | 624.1               | 51.25                | 13.27                                          | 32.50                                          | 491                               |
| 41                         | 215.72                           | 2114.                                                                                               | 0.443                                                                      | 382.7                         | 655.9               | 52.03                | 13.20                                          | 31.14                                          | 501                               |
| 42                         | 225.31                           | 2264.                                                                                               | 0.421                                                                      | 401.2                         | 686.5               | 52.77                | 13.14                                          | 30.06                                          | 510                               |
| 43                         | 234.62                           | 2409.                                                                                               | 0.402                                                                      | 419.0                         | 716.1               | 53.47                | 13.10                                          | 29.17                                          | 519                               |
| 44                         | 243.69                           | 2548.                                                                                               | 0.385                                                                      | 436.3                         | 744.9               | 54.13                | 13.07                                          | 28.43                                          | 528                               |
| 45                         | 252.55                           | 2683.                                                                                               | 0.369                                                                      | 453.2                         | 773.0               | 54.76                | 13.05                                          | 27.81                                          | 536                               |
| 46                         | 261.24                           | 2814.                                                                                               | 0.355                                                                      | 469.7                         | 800.6               | 55.37                | 13.03                                          | 27.28                                          | 544                               |
| 47                         | 269.78                           | 2942.                                                                                               | 0.342                                                                      | 485.9                         | 827.6               | 55.95                | 13.02                                          | 26.82                                          | 552                               |
| 48                         | 278.19                           | 3067.                                                                                               | 0.331                                                                      | 501.9                         | 854.2               | 56.51                | 13.02                                          | 26.43                                          | 559                               |
| 49                         | 286.47                           | 3189.                                                                                               | 0.320                                                                      | 517.7                         | 880.5               | 57.05                | 13.02                                          | 26.08                                          | 567                               |
| 50                         | 294.65                           | 3309.                                                                                               | 0.310                                                                      | 533.2                         | 906.4               | 57.57                | 13.03                                          | 25.78                                          | 574                               |
| 51                         | 302.73                           | 3426.                                                                                               | 0.300                                                                      | 548.6                         | 932.1               | 58.08                | 13.04                                          | 25.51                                          | 581                               |
| 52                         | 310.72                           | 3542.                                                                                               | 0.292                                                                      | 563.9                         | 957.5               | 58.57                | 13.05                                          | 25.27                                          | 587                               |
| 53                         | 318.63                           | 3656.                                                                                               | 0.284                                                                      | 579.1                         | 982.6               | 59.05                | 13.07                                          | 25.07                                          | 594                               |
| 54                         | 326.47                           | 3768.                                                                                               | 0.276                                                                      | 594.1                         | 1007.6              | 59.52                | 13.09                                          | 24.89                                          | 600                               |
| 55                         | 334.25                           | 3879.                                                                                               | 0.269                                                                      | 609.1                         | 1032.4              | 59.97                | 13.12                                          | 24.73                                          | 606                               |
| 56                         | 341.96                           | 3988.                                                                                               | 0.262                                                                      | 624.0                         | 1057.1              | 60.42                | 13.16                                          | 24.58                                          | 612                               |
| 57                         | 349.61                           | 4096.                                                                                               | 0.256                                                                      | 638.8                         | 1081.7              | 60.85                | 13.19                                          | 24.46                                          | 618                               |
| 58                         | 357.22                           | 4203.                                                                                               | 0.250                                                                      | 653.6                         | 1106.1              | 61.28                | 13.23                                          | 24.36                                          | 624                               |
| 59                         | 364.78                           | 4308.                                                                                               | 0.244                                                                      | 668.4                         | 1130.4              | 61.69                | 13.28                                          | 24.27                                          | 629                               |
| 60                         | 372.29                           | 4413.                                                                                               | 0.239                                                                      | 683.1                         | 1154.6              | 62.10                | 13.33                                          | 24.20                                          | 635                               |
| 61                         | 379.76                           | 4517.                                                                                               | 0.233                                                                      | 697.8                         | 1178.8              | 62.50                | 13.39                                          | 24.14                                          | 640                               |
| 62                         | 387.20                           | 4620.                                                                                               | 0.229                                                                      | 712.5                         | 1202.9              | 62.89                | 13.45                                          | 24.10                                          | 645                               |
| 63                         | 394.60                           | 4727.                                                                                               | 0.224                                                                      | 727.2                         | 1227.0              | 63.28                | 13.52                                          | 24.07                                          | 650                               |
| 64                         | 401.96                           | 4831.                                                                                               | 0.219                                                                      | 741.9                         | 1251.0              | 63.66                | 13.59                                          | 24.05                                          | 655                               |
| 65                         | 409.30                           | 4927.                                                                                               | 0.215                                                                      | 756.7                         | 1275.1              | 64.03                | 13.67                                          | 24.04                                          | 660                               |
| 66                         | 416.60                           | 5027.                                                                                               | 0.211                                                                      | 771.5                         | 1299.1              | 64.40                | 13.76                                          | 24.04                                          | 664                               |
| 67                         | 423.88                           | 5127.                                                                                               | 0.207                                                                      | 786.3                         | 1323.2              | 64.76                | 13.84                                          | 24.05                                          | 669                               |
| 68                         | 431.13                           | 5221.                                                                                               | 0.203                                                                      | 801.2                         | 1347.2              | 65.12                | 13.94                                          | 24.08                                          | 673                               |
| 69                         | 438.35                           | 5319.                                                                                               | 0.200                                                                      | 816.1                         | 1371.3              | 65.47                | 14.04                                          | 24.11                                          | 678                               |
| 70                         | 445.56                           | 5416.                                                                                               | 0.196                                                                      | 831.1                         | 1395.5              | 65.81                | 14.14                                          | 24.15                                          | 682                               |
| 71                         | 452.74                           | 5513.                                                                                               | 0.193                                                                      | 846.2                         | 1419.6              | 66.16                | 14.25                                          | 24.20                                          | 686                               |
| 72                         | 459.90                           | 5610.                                                                                               | 0.190                                                                      | 861.4                         | 1443.9              | 66.50                | 14.36                                          | 24.25                                          | 690                               |
| 73                         | 467.04                           | 5706.                                                                                               | 0.187                                                                      | 876.6                         | 1468.2              | 66.83                | 14.48                                          | 24.32                                          | 694                               |
| 74                         | 474.16                           | 5801.                                                                                               | 0.184                                                                      | 892.0                         | 1492.5              | 67.16                | 14.60                                          | 24.39                                          | 698                               |
| 75                         | 481.26                           | 5896.                                                                                               | 0.181                                                                      | 907.4                         | 1516.9              | 67.49                | 14.73                                          | 24.47                                          | 702                               |
| 76                         | 488.35                           | 5991.                                                                                               | 0.178                                                                      | 922.9                         | 1541.4              | 67.82                | 14.86                                          | 24.55                                          | 705                               |
| 77                         | 495.42                           | 6085.                                                                                               | 0.175                                                                      | 938.6                         | 1566.0              | 68.14                | 14.99                                          | 24.64                                          | 709                               |
| 78                         | 502.48                           | 6179.                                                                                               | 0.172                                                                      | 954.3                         | 1590.7              | 68.46                | 15.13                                          | 24.74                                          | 713                               |
| 79                         | 509.52                           | 6272.                                                                                               | 0.170                                                                      | 970.2                         | 1615.5              | 68.77                | 15.27                                          | 24.84                                          | 716                               |
| 80                         | 516.54                           | 6366.                                                                                               | 0.167                                                                      | 986.2                         | 1640.4              | 69.08                | 15.42                                          | 24.95                                          | 719                               |
| 81                         | 523.56                           | 6459.                                                                                               | 0.165                                                                      | 1002.3                        | 1665.4              | 69.40                | 15.57                                          | 25.06                                          | 723                               |
| 82                         | 530.56                           | 6551.                                                                                               | 0.163                                                                      | 1018.6                        | 1690.6              | 69.70                | 15.72                                          | 25.18                                          | 726                               |
| 83                         | 537.55                           | 6644.                                                                                               | 0.161                                                                      | 1035.0                        | 1715.8              | 70.01                | 15.88                                          | 25.30                                          | 730                               |
| 84                         | 544.53                           | 6736.                                                                                               | 0.158                                                                      | 1051.5                        | 1741.2              | 70.31                | 16.03                                          | 25.43                                          | 733                               |
| 85                         | 551.49                           | 6827.                                                                                               | 0.156                                                                      | 1068.2                        | 1766.7              | 70.62                | 16.19                                          | 25.56                                          | 736                               |
| 86                         | 558.45                           | 6919.                                                                                               | 0.154                                                                      | 1085.0                        | 1792.3              | 70.91                | 16.36                                          | 25.69                                          | 739                               |
| 87                         | 565.39                           | 7010.                                                                                               | 0.152                                                                      | 1102.0                        | 1818.1              | 71.21                | 16.52                                          | 25.83                                          | 742                               |
| 88                         | 572.33                           | 7101.                                                                                               | 0.150                                                                      | 1119.1                        | 1844.0              | 71.51                | 16.69                                          | 25.97                                          | 745                               |
| 89                         | 579.25                           | 7192.                                                                                               | 0.148                                                                      | 1136.3                        | 1870.0              | 71.80                | 16.85                                          | 26.11                                          | 748                               |
| 90                         | 586.17                           | 7283.                                                                                               | 0.146                                                                      | 1153.8                        | 1896.2              | 72.10                | 17.02                                          | 26.26                                          | 751                               |
| 91                         | 593.08                           | 7373.                                                                                               | 0.145                                                                      | 1171.3                        | 1922.5              | 72.39                | 17.19                                          | 26.40                                          | 754                               |
| 92                         | 599.97                           | 7463.                                                                                               | 0.143                                                                      | 1189.1                        | 1949.0              | 72.68                | 17.37                                          | 26.55                                          | 757                               |
| 93                         | 606.87                           | 7553.                                                                                               | 0.141                                                                      | 1207.0                        | 1975.6              | 72.96                | 17.54                                          | 26.70                                          | 760                               |
| 94                         | 613.75                           | 7643.                                                                                               | 0.140                                                                      | 1225.1                        | 2002.4              | 73.25                | 17.71                                          | 26.86                                          | 763                               |
| 95                         | 620.62                           | 7733.                                                                                               | 0.138                                                                      | 1243.3                        | 2029.3              | 73.54                | 17.88                                          | 27.01                                          | 766                               |
| 96                         | 627.49                           | 7822.                                                                                               | 0.136                                                                      | 1261.7                        | 2056.4              | 73.82                | 18.06                                          | 27.16                                          | 769                               |
| 97                         | 634.35                           | 7911.                                                                                               | 0.135                                                                      | 1280.2                        | 2083.7              | 74.10                | 18.23                                          | 27.32                                          | 772                               |
| 98                         | 641.21                           | 8000.                                                                                               | 0.133                                                                      | 1298.9                        | 2111.1              | 74.38                | 18.41                                          | 27.47                                          | 775                               |
| 99                         | 648.06                           | 8089.                                                                                               | 0.132                                                                      | 1317.8                        | 2138.6              | 74.66                | 18.58                                          | 27.63                                          | 778                               |
| 100                        | 654.90                           | 8178.                                                                                               | 0.130                                                                      | 1336.9                        | 2166.3              | 74.94                | 18.75                                          | 27.79                                          | 780                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISO8ARS-CONTINUED

15.0 ATMOSPHERE ISO8AR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial p$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>p</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 14.302                   | 25.89                            | 25048.                                                                                           | 9.452                                                                      | -621.7                        | -582.3              | 10.07                | 9.69                                           | 13.16                                          | 1307                              |
| 15                         | 26.07                            | 24143.                                                                                           | 9.387                                                                      | -612.6                        | -573.0              | 10.71                | 9.91                                           | 13.68                                          | 1294                              |
| 16                         | 26.35                            | 22681.                                                                                           | 9.270                                                                      | -598.9                        | -558.9              | 11.62                | 10.24                                          | 14.50                                          | 1271                              |
| 17                         | 26.64                            | 21292.                                                                                           | 9.108                                                                      | -584.5                        | -544.0              | 12.52                | 10.56                                          | 15.32                                          | 1246                              |
| 18                         | 26.96                            | 19952.                                                                                           | 8.955                                                                      | -569.2                        | -528.2              | 13.43                | 10.87                                          | 16.20                                          | 1222                              |
| 19                         | 27.30                            | 18632.                                                                                           | 8.806                                                                      | -553.0                        | -511.5              | 14.33                | 11.16                                          | 17.13                                          | 1199                              |
| 20                         | 27.66                            | 17311.                                                                                           | 8.645                                                                      | -535.9                        | -493.9              | 15.23                | 11.43                                          | 18.12                                          | 1175                              |
| 21                         | 28.06                            | 16083.                                                                                           | 8.468                                                                      | -517.9                        | -475.3              | 16.14                | 11.66                                          | 19.13                                          | 1152                              |
| 22                         | 28.49                            | 14788.                                                                                           | 8.276                                                                      | -498.9                        | -455.6              | 17.06                | 11.87                                          | 20.25                                          | 1126                              |
| 23                         | 28.97                            | 13531.                                                                                           | 8.056                                                                      | -478.8                        | -434.8              | 17.98                | 12.05                                          | 21.43                                          | 1100                              |
| 24                         | 29.50                            | 12225.                                                                                           | 7.811                                                                      | -457.5                        | -412.7              | 18.92                | 12.20                                          | 22.76                                          | 1071                              |
| 25                         | 30.09                            | 10936.                                                                                           | 7.530                                                                      | -434.9                        | -389.2              | 19.88                | 12.33                                          | 24.22                                          | 1039                              |
| 26                         | 30.75                            | 9648.                                                                                            | 7.215                                                                      | -410.9                        | -364.1              | 20.86                | 12.45                                          | 25.89                                          | 1004                              |
| 27                         | 31.51                            | 8369.                                                                                            | 6.867                                                                      | -385.1                        | -337.2              | 21.88                | 12.55                                          | 27.86                                          | 966                               |
| 28                         | 32.40                            | 7099.                                                                                            | 6.479                                                                      | -357.4                        | -308.2              | 22.93                | 12.65                                          | 30.26                                          | 924                               |
| 29                         | 33.45                            | 5854.                                                                                            | 6.047                                                                      | -327.3                        | -276.5              | 24.05                | 12.75                                          | 33.28                                          | 876                               |
| 30                         | 34.75                            | 4629.                                                                                            | 5.571                                                                      | -294.0                        | -241.2              | 25.24                | 12.85                                          | 37.46                                          | 823                               |
| 31                         | 36.42                            | 3439.                                                                                            | 5.033                                                                      | -256.2                        | -200.8              | 26.56                | 12.99                                          | 43.69                                          | 762                               |
| 32                         | 38.79                            | 2277.                                                                                            | 4.405                                                                      | -211.2                        | -152.2              | 28.11                | 13.19                                          | 54.84                                          | 689                               |
| 33                         | 42.80                            | 1135.                                                                                            | 3.601                                                                      | -151.2                        | -86.1               | 30.14                | 13.57                                          | 83.57                                          | 593                               |
| 34                         | 56.62                            | 199.1                                                                                            | 2.212                                                                      | -27.6                         | 58.5                | 34.44                | 16.68                                          | 300.97                                         | 415                               |
| 35                         | 94.56                            | 451.3                                                                                            | 1.208                                                                      | 145.0                         | 288.8               | 41.14                | 15.66                                          | 118.28                                         | 414                               |
| 36                         | 113.63                           | 781.7                                                                                            | 0.962                                                                      | 204.9                         | 377.6               | 43.65                | 14.72                                          | 70.47                                          | 434                               |
| 37                         | 127.84                           | 1057.                                                                                            | 0.830                                                                      | 244.7                         | 439.0               | 45.33                | 14.21                                          | 54.36                                          | 450                               |
| 38                         | 139.74                           | 1289.                                                                                            | 0.741                                                                      | 276.0                         | 488.4               | 46.65                | 13.83                                          | 46.07                                          | 463                               |
| 39                         | 150.47                           | 1491.                                                                                            | 0.675                                                                      | 303.0                         | 531.7               | 47.77                | 13.60                                          | 40.97                                          | 475                               |
| 40                         | 160.36                           | 1687.                                                                                            | 0.625                                                                      | 327.2                         | 570.9               | 48.77                | 13.45                                          | 37.65                                          | 487                               |
| 41                         | 169.63                           | 1862.                                                                                            | 0.584                                                                      | 349.5                         | 607.3               | 49.66                | 13.34                                          | 35.26                                          | 497                               |
| 42                         | 178.45                           | 2031.                                                                                            | 0.550                                                                      | 370.4                         | 641.6               | 50.49                | 13.27                                          | 33.45                                          | 507                               |
| 43                         | 186.91                           | 2192.                                                                                            | 0.521                                                                      | 390.2                         | 674.3               | 51.26                | 13.21                                          | 32.04                                          | 517                               |
| 44                         | 195.07                           | 2345.                                                                                            | 0.495                                                                      | 409.3                         | 705.8               | 51.98                | 13.17                                          | 30.91                                          | 526                               |
| 45                         | 202.99                           | 2493.                                                                                            | 0.473                                                                      | 427.7                         | 736.2               | 52.67                | 13.14                                          | 29.97                                          | 535                               |
| 46                         | 210.70                           | 2635.                                                                                            | 0.452                                                                      | 445.5                         | 765.8               | 53.32                | 13.12                                          | 29.19                                          | 543                               |
| 47                         | 218.24                           | 2773.                                                                                            | 0.434                                                                      | 462.9                         | 794.6               | 53.94                | 13.11                                          | 28.53                                          | 551                               |
| 48                         | 225.63                           | 2907.                                                                                            | 0.418                                                                      | 479.9                         | 822.9               | 54.53                | 13.10                                          | 27.96                                          | 559                               |
| 49                         | 232.88                           | 3038.                                                                                            | 0.403                                                                      | 496.6                         | 850.6               | 55.10                | 13.10                                          | 27.48                                          | 566                               |
| 50                         | 240.01                           | 3166.                                                                                            | 0.389                                                                      | 513.1                         | 877.8               | 55.66                | 13.10                                          | 27.05                                          | 573                               |
| 51                         | 247.04                           | 3291.                                                                                            | 0.376                                                                      | 529.2                         | 904.7               | 56.19                | 13.11                                          | 26.68                                          | 580                               |
| 52                         | 253.98                           | 3414.                                                                                            | 0.365                                                                      | 545.2                         | 931.2               | 56.70                | 13.12                                          | 26.35                                          | 587                               |
| 53                         | 260.82                           | 3534.                                                                                            | 0.354                                                                      | 561.0                         | 957.4               | 57.20                | 13.14                                          | 26.07                                          | 594                               |
| 54                         | 267.60                           | 3653.                                                                                            | 0.344                                                                      | 576.7                         | 983.4               | 57.69                | 13.16                                          | 25.82                                          | 600                               |
| 55                         | 274.30                           | 3769.                                                                                            | 0.334                                                                      | 592.2                         | 1009.1              | 58.16                | 13.19                                          | 25.60                                          | 606                               |
| 56                         | 280.92                           | 3883.                                                                                            | 0.325                                                                      | 607.7                         | 1034.7              | 58.62                | 13.21                                          | 25.39                                          | 612                               |
| 57                         | 287.50                           | 3996.                                                                                            | 0.317                                                                      | 623.0                         | 1060.0              | 59.07                | 13.25                                          | 25.22                                          | 618                               |
| 58                         | 294.02                           | 4108.                                                                                            | 0.309                                                                      | 638.3                         | 1085.1              | 59.50                | 13.29                                          | 25.07                                          | 624                               |
| 59                         | 300.49                           | 4219.                                                                                            | 0.301                                                                      | 653.4                         | 1110.1              | 59.93                | 13.33                                          | 24.94                                          | 630                               |
| 60                         | 306.92                           | 4327.                                                                                            | 0.294                                                                      | 668.6                         | 1135.0              | 60.35                | 13.38                                          | 24.83                                          | 635                               |
| 61                         | 313.30                           | 4435.                                                                                            | 0.288                                                                      | 683.6                         | 1159.8              | 60.76                | 13.44                                          | 24.74                                          | 641                               |
| 62                         | 319.64                           | 4547.                                                                                            | 0.281                                                                      | 698.7                         | 1184.5              | 61.16                | 13.50                                          | 24.67                                          | 646                               |
| 63                         | 325.95                           | 4648.                                                                                            | 0.275                                                                      | 713.8                         | 1209.2              | 61.56                | 13.56                                          | 24.61                                          | 651                               |
| 64                         | 332.22                           | 4752.                                                                                            | 0.269                                                                      | 728.8                         | 1233.7              | 61.94                | 13.63                                          | 24.56                                          | 656                               |
| 65                         | 338.46                           | 4856.                                                                                            | 0.264                                                                      | 743.9                         | 1258.3              | 62.32                | 13.71                                          | 24.53                                          | 661                               |
| 66                         | 344.67                           | 4960.                                                                                            | 0.259                                                                      | 759.0                         | 1282.8              | 62.70                | 13.79                                          | 24.51                                          | 666                               |
| 67                         | 350.86                           | 5067.                                                                                            | 0.254                                                                      | 774.1                         | 1307.3              | 63.07                | 13.88                                          | 24.50                                          | 670                               |
| 68                         | 357.01                           | 5163.                                                                                            | 0.249                                                                      | 789.2                         | 1331.8              | 63.43                | 13.97                                          | 24.50                                          | 675                               |
| 69                         | 363.14                           | 5264.                                                                                            | 0.244                                                                      | 804.4                         | 1356.3              | 63.79                | 14.07                                          | 24.52                                          | 679                               |
| 70                         | 369.25                           | 5365.                                                                                            | 0.240                                                                      | 819.7                         | 1380.9              | 64.14                | 14.17                                          | 24.54                                          | 683                               |
| 71                         | 375.33                           | 5464.                                                                                            | 0.236                                                                      | 835.0                         | 1405.4              | 64.49                | 14.28                                          | 24.57                                          | 687                               |
| 72                         | 381.40                           | 5563.                                                                                            | 0.232                                                                      | 850.3                         | 1430.0              | 64.83                | 14.39                                          | 24.61                                          | 692                               |
| 73                         | 387.44                           | 5667.                                                                                            | 0.228                                                                      | 865.8                         | 1454.7              | 65.17                | 14.51                                          | 24.67                                          | 696                               |
| 74                         | 393.46                           | 5769.                                                                                            | 0.224                                                                      | 881.3                         | 1479.4              | 65.51                | 14.63                                          | 24.72                                          | 699                               |
| 75                         | 399.47                           | 5875.                                                                                            | 0.220                                                                      | 897.0                         | 1504.1              | 65.84                | 14.75                                          | 24.79                                          | 703                               |
| 76                         | 405.46                           | 5954.                                                                                            | 0.217                                                                      | 912.7                         | 1528.9              | 66.17                | 14.88                                          | 24.86                                          | 707                               |
| 77                         | 411.43                           | 6051.                                                                                            | 0.213                                                                      | 928.5                         | 1553.8              | 66.50                | 15.02                                          | 24.94                                          | 711                               |
| 78                         | 417.39                           | 6147.                                                                                            | 0.210                                                                      | 944.4                         | 1578.8              | 66.82                | 15.16                                          | 25.03                                          | 714                               |
| 79                         | 423.34                           | 6247.                                                                                            | 0.207                                                                      | 960.5                         | 1603.9              | 67.14                | 15.30                                          | 25.12                                          | 718                               |
| 80                         | 429.27                           | 6338.                                                                                            | 0.204                                                                      | 976.6                         | 1629.1              | 67.45                | 15.44                                          | 25.22                                          | 721                               |
| 81                         | 435.18                           | 6433.                                                                                            | 0.201                                                                      | 992.9                         | 1654.3              | 67.77                | 15.59                                          | 25.33                                          | 725                               |
| 82                         | 441.09                           | 6527.                                                                                            | 0.198                                                                      | 1009.3                        | 1679.7              | 68.08                | 15.74                                          | 25.43                                          | 728                               |
| 83                         | 446.98                           | 6621.                                                                                            | 0.195                                                                      | 1025.9                        | 1705.2              | 68.39                | 15.90                                          | 25.55                                          | 731                               |
| 84                         | 452.86                           | 6715.                                                                                            | 0.192                                                                      | 1042.5                        | 1730.8              | 68.69                | 16.05                                          | 25.67                                          | 735                               |
| 85                         | 458.72                           | 6809.                                                                                            | 0.190                                                                      | 1059.4                        | 1756.6              | 69.00                | 16.21                                          | 25.79                                          | 738                               |
| 86                         | 464.58                           | 6907.                                                                                            | 0.187                                                                      | 1076.3                        | 1782.4              | 69.30                | 16.37                                          | 25.92                                          | 741                               |
| 87                         | 470.43                           | 6995.                                                                                            | 0.185                                                                      | 1093.4                        | 1808.4              | 69.60                | 16.54                                          | 26.05                                          | 744                               |
| 88                         | 476.27                           | 7088.                                                                                            | 0.182                                                                      | 1110.6                        | 1834.5              | 69.90                | 16.70                                          | 26.18                                          | 747                               |
| 89                         | 482.10                           | 7180.                                                                                            | 0.180                                                                      | 1128.0                        | 1860.8              | 70.20                | 16.87                                          | 26.32                                          | 750                               |
| 90                         | 487.91                           | 7277.                                                                                            | 0.178                                                                      | 1145.6                        | 1887.2              | 70.49                | 17.04                                          | 26.46                                          | 753                               |
| 91                         | 493.72                           | 7364.                                                                                            | 0.175                                                                      | 1163.3                        | 1913.7              | 70.79                | 17.21                                          | 26.60                                          | 756                               |
| 92                         | 499.53                           | 7456.                                                                                            | 0.173                                                                      | 1181.1                        | 1940.4              | 71.08                | 17.38                                          | 26.74                                          | 759                               |
| 93                         | 505.32                           | 7547.                                                                                            | 0.171                                                                      | 1199.1                        | 1967.2              | 71.37                | 17.55                                          | 26.89                                          | 762                               |
| 94                         | 511.11                           | 7638.                                                                                            | 0.169                                                                      | 1217.3                        | 1994.1              | 71.65                | 17.72                                          | 27.04                                          | 765                               |
| 95                         | 516.88                           | 7729.                                                                                            | 0.167                                                                      | 1235.6                        | 2021.2              | 71.94                | 17.90                                          | 27.18                                          | 768                               |
| 96                         | 522.66                           | 7820.                                                                                            | 0.165                                                                      | 1254.1                        | 2048.5              | 72.23                | 18.07                                          | 27.33                                          | 771                               |
| 97                         | 528.42                           | 7911.                                                                                            | 0.163                                                                      | 1272.8                        | 2075.9              | 72.51                | 18.24                                          | 27.47                                          | 774                               |
| 98                         | 534.18                           | 8001.                                                                                            | 0.161                                                                      | 1291.6                        | 2103.5              | 72.79                | 18.42                                          | 27.64                                          | 777                               |
| 99                         | 539.93                           | 8091.                                                                                            | 0.160                                                                      | 1310.6                        | 2131.2              | 73.08                | 18.59                                          | 27.79                                          | 780                               |
| 100                        | 545.67                           | 8181.                                                                                            | 0.158                                                                      | 1329.7                        | 2159.0              | 73.36                | 18.76                                          | 27.94                                          | 783                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAMHYROGEN, ISOBARS-CONTINUED

20.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ·ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 14.465                   | 25.80                            | 2571 <sup>5</sup> .                                                                                 | 9.465                                                                       | -621.2                        | -568.9              | 10.10                | 9.75                                           | 13.15                                          | 1320                              |
| 15                         | 25.93                            | 2504.1                                                                                              | 9.433                                                                       | -614.3                        | -561.8              | 10.58                | 9.91                                           | 13.55                                          | 1311                              |
| 16                         | 26.20                            | 2355.9                                                                                              | 9.339                                                                       | -600.9                        | -547.8              | 11.48                | 10.23                                          | 14.35                                          | 1289                              |
| 17                         | 26.48                            | 2222.9                                                                                              | 9.206                                                                       | -586.7                        | -533.1              | 12.37                | 10.55                                          | 15.15                                          | 1267                              |
| 18                         | 26.78                            | 2090.7                                                                                              | 9.063                                                                       | -571.8                        | -517.5              | 13.26                | 10.86                                          | 15.99                                          | 1244                              |
| 19                         | 27.10                            | 1959.7                                                                                              | 8.920                                                                       | -556.0                        | -501.1              | 14.15                | 11.14                                          | 16.89                                          | 1222                              |
| 20                         | 27.45                            | 1827.9                                                                                              | 8.768                                                                       | -539.3                        | -483.7              | 15.04                | 11.41                                          | 17.83                                          | 1198                              |
| 21                         | 27.82                            | 1707.9                                                                                              | 8.600                                                                       | -521.8                        | -465.4              | 15.94                | 11.64                                          | 18.77                                          | 1177                              |
| 22                         | 28.23                            | 1580.0                                                                                              | 8.415                                                                       | -503.3                        | -446.1              | 16.83                | 11.85                                          | 19.81                                          | 1152                              |
| 23                         | 28.67                            | 1458.4                                                                                              | 8.211                                                                       | -483.9                        | -425.8              | 17.74                | 12.03                                          | 20.89                                          | 1128                              |
| 24                         | 29.16                            | 1331.0                                                                                              | 7.981                                                                       | -463.4                        | -404.3              | 18.65                | 12.19                                          | 22.08                                          | 1101                              |
| 25                         | 29.70                            | 1205.3                                                                                              | 7.723                                                                       | -441.7                        | -381.6              | 19.58                | 12.32                                          | 23.38                                          | 1072                              |
| 26                         | 30.30                            | 1080.3                                                                                              | 7.436                                                                       | -418.9                        | -357.5              | 20.52                | 12.44                                          | 24.82                                          | 1041                              |
| 27                         | 30.97                            | 956.7                                                                                               | 7.119                                                                       | -394.6                        | -331.8              | 21.49                | 12.54                                          | 26.44                                          | 1007                              |
| 28                         | 31.73                            | 835.8                                                                                               | 6.773                                                                       | -368.8                        | -304.5              | 22.49                | 12.64                                          | 28.32                                          | 970                               |
| 29                         | 32.61                            | 717.0                                                                                               | 6.396                                                                       | -341.2                        | -275.1              | 23.52                | 12.72                                          | 30.55                                          | 930                               |
| 30                         | 33.64                            | 602.2                                                                                               | 5.984                                                                       | -311.4                        | -243.2              | 24.60                | 12.81                                          | 33.26                                          | 887                               |
| 31                         | 34.89                            | 490.7                                                                                               | 5.538                                                                       | -279.0                        | -208.3              | 25.74                | 12.90                                          | 36.79                                          | 839                               |
| 32                         | 36.44                            | 383.6                                                                                               | 5.048                                                                       | -243.0                        | -169.1              | 26.99                | 13.01                                          | 41.61                                          | 785                               |
| 33                         | 38.47                            | 283.5                                                                                               | 4.509                                                                       | -202.1                        | -124.2              | 28.37                | 13.16                                          | 48.63                                          | 726                               |
| 34                         | 41.34                            | 189.9                                                                                               | 3.900                                                                       | -153.8                        | -70.0               | 29.98                | 13.37                                          | 60.50                                          | 657                               |
| 35                         | 45.92                            | 112.8                                                                                               | 3.199                                                                       | -93.0                         | 0.0                 | 32.01                | 13.74                                          | 81.57                                          | 580                               |
| 36                         | 54.20                            | 641.7                                                                                               | 2.448                                                                       | -12.7                         | 97.1                | 34.75                | 14.53                                          | 114.58                                         | 504                               |
| 37                         | 67.60                            | 578.2                                                                                               | 1.812                                                                       | 78.4                          | 215.4               | 37.99                | 14.71                                          | 112.04                                         | 470                               |
| 38                         | 81.11                            | 757.9                                                                                               | 1.442                                                                       | 148.2                         | 312.5               | 40.58                | 14.84                                          | 84.14                                          | 468                               |
| 39                         | 92.64                            | 984.2                                                                                               | 1.220                                                                       | 198.8                         | 386.5               | 42.51                | 14.27                                          | 65.59                                          | 477                               |
| 40                         | 102.60                           | 1207.                                                                                               | 1.073                                                                       | 238.3                         | 446.2               | 44.02                | 13.97                                          | 54.68                                          | 487                               |
| 41                         | 111.48                           | 1417.                                                                                               | 0.966                                                                       | 271.3                         | 497.2               | 45.28                | 13.74                                          | 47.77                                          | 498                               |
| 42                         | 119.62                           | 1615.                                                                                               | 0.885                                                                       | 300.0                         | 542.5               | 46.37                | 13.57                                          | 43.09                                          | 508                               |
| 43                         | 127.20                           | 1803.                                                                                               | 0.820                                                                       | 326.0                         | 583.7               | 47.34                | 13.45                                          | 39.72                                          | 517                               |
| 44                         | 134.19                           | 1976.                                                                                               | 0.767                                                                       | 349.6                         | 621.5               | 48.21                | 13.36                                          | 37.27                                          | 526                               |
| 45                         | 141.03                           | 2146.                                                                                               | 0.723                                                                       | 372.0                         | 657.8               | 49.02                | 13.31                                          | 35.38                                          | 536                               |
| 46                         | 147.60                           | 2310.                                                                                               | 0.684                                                                       | 393.3                         | 692.4               | 49.78                | 13.28                                          | 33.86                                          | 544                               |
| 47                         | 153.95                           | 2467.                                                                                               | 0.650                                                                       | 413.7                         | 725.6               | 50.50                | 13.26                                          | 32.60                                          | 552                               |
| 48                         | 160.11                           | 2619.                                                                                               | 0.620                                                                       | 433.3                         | 757.7               | 51.17                | 13.24                                          | 31.56                                          | 560                               |
| 49                         | 166.10                           | 2766.                                                                                               | 0.594                                                                       | 452.2                         | 788.8               | 51.82                | 13.24                                          | 30.69                                          | 568                               |
| 50                         | 171.96                           | 2909.                                                                                               | 0.570                                                                       | 470.7                         | 819.1               | 52.43                | 13.24                                          | 29.95                                          | 575                               |
| 51                         | 177.69                           | 3048.                                                                                               | 0.548                                                                       | 488.7                         | 848.8               | 53.01                | 13.24                                          | 29.31                                          | 582                               |
| 52                         | 183.31                           | 3184.                                                                                               | 0.528                                                                       | 506.3                         | 877.8               | 53.58                | 13.25                                          | 28.75                                          | 589                               |
| 53                         | 188.84                           | 3316.                                                                                               | 0.510                                                                       | 523.6                         | 906.3               | 54.12                | 13.27                                          | 28.27                                          | 596                               |
| 54                         | 194.28                           | 3446.                                                                                               | 0.493                                                                       | 540.6                         | 934.3               | 54.64                | 13.28                                          | 27.85                                          | 603                               |
| 55                         | 199.64                           | 3573.                                                                                               | 0.477                                                                       | 557.4                         | 962.0               | 55.15                | 13.31                                          | 27.47                                          | 609                               |
| 56                         | 204.91                           | 3697.                                                                                               | 0.463                                                                       | 574.3                         | 989.5               | 55.65                | 13.33                                          | 27.12                                          | 615                               |
| 57                         | 210.14                           | 3819.                                                                                               | 0.449                                                                       | 590.6                         | 1016.5              | 56.13                | 13.36                                          | 26.83                                          | 621                               |
| 58                         | 215.30                           | 3940.                                                                                               | 0.437                                                                       | 606.9                         | 1043.2              | 56.59                | 13.39                                          | 26.58                                          | 627                               |
| 59                         | 220.41                           | 4059.                                                                                               | 0.425                                                                       | 623.0                         | 1069.7              | 57.04                | 13.43                                          | 26.36                                          | 633                               |
| 60                         | 225.48                           | 4176.                                                                                               | 0.414                                                                       | 639.0                         | 1095.9              | 57.48                | 13.48                                          | 26.16                                          | 638                               |
| 61                         | 230.50                           | 4291.                                                                                               | 0.404                                                                       | 654.9                         | 1122.0              | 57.92                | 13.53                                          | 26.00                                          | 644                               |
| 62                         | 235.47                           | 4405.                                                                                               | 0.394                                                                       | 670.7                         | 1147.9              | 58.34                | 13.59                                          | 25.85                                          | 649                               |
| 63                         | 240.41                           | 4518.                                                                                               | 0.385                                                                       | 686.5                         | 1173.7              | 58.75                | 13.65                                          | 25.73                                          | 654                               |
| 64                         | 245.31                           | 4630.                                                                                               | 0.376                                                                       | 702.3                         | 1199.4              | 59.15                | 13.71                                          | 25.62                                          | 659                               |
| 65                         | 250.18                           | 4740.                                                                                               | 0.368                                                                       | 718.0                         | 1225.0              | 59.55                | 13.79                                          | 25.54                                          | 664                               |
| 66                         | 255.02                           | 4849.                                                                                               | 0.360                                                                       | 733.7                         | 1250.5              | 59.94                | 13.87                                          | 25.47                                          | 669                               |
| 67                         | 259.83                           | 4958.                                                                                               | 0.352                                                                       | 749.4                         | 1275.9              | 60.32                | 13.95                                          | 25.42                                          | 674                               |
| 68                         | 264.61                           | 5065.                                                                                               | 0.345                                                                       | 765.1                         | 1301.3              | 60.70                | 14.04                                          | 25.38                                          | 678                               |
| 69                         | 269.37                           | 5171.                                                                                               | 0.338                                                                       | 780.8                         | 1326.7              | 61.07                | 14.13                                          | 25.35                                          | 683                               |
| 70                         | 274.10                           | 5277.                                                                                               | 0.332                                                                       | 796.5                         | 1352.0              | 61.43                | 14.23                                          | 25.34                                          | 687                               |
| 71                         | 278.81                           | 5387.                                                                                               | 0.325                                                                       | 812.3                         | 1377.4              | 61.79                | 14.34                                          | 25.34                                          | 691                               |
| 72                         | 283.50                           | 5486.                                                                                               | 0.319                                                                       | 828.2                         | 1402.7              | 62.15                | 14.45                                          | 25.35                                          | 695                               |
| 73                         | 288.17                           | 5589.                                                                                               | 0.314                                                                       | 844.1                         | 1428.1              | 62.50                | 14.56                                          | 25.37                                          | 699                               |
| 74                         | 292.82                           | 5691.                                                                                               | 0.308                                                                       | 860.0                         | 1453.4              | 62.84                | 14.68                                          | 25.40                                          | 703                               |
| 75                         | 297.45                           | 5792.                                                                                               | 0.303                                                                       | 876.1                         | 1478.9              | 63.18                | 14.81                                          | 25.44                                          | 707                               |
| 76                         | 302.07                           | 5894.                                                                                               | 0.298                                                                       | 892.2                         | 1504.3              | 63.52                | 14.93                                          | 25.49                                          | 711                               |
| 77                         | 306.66                           | 5995.                                                                                               | 0.293                                                                       | 908.4                         | 1529.8              | 63.85                | 15.07                                          | 25.55                                          | 715                               |
| 78                         | 311.25                           | 6095.                                                                                               | 0.288                                                                       | 924.7                         | 1555.4              | 64.18                | 15.20                                          | 25.61                                          | 718                               |
| 79                         | 315.81                           | 6195.                                                                                               | 0.283                                                                       | 941.1                         | 1581.1              | 64.51                | 15.34                                          | 25.68                                          | 722                               |
| 80                         | 320.37                           | 6294.                                                                                               | 0.279                                                                       | 957.6                         | 1606.8              | 64.83                | 15.49                                          | 25.76                                          | 725                               |
| 81                         | 324.91                           | 6397.                                                                                               | 0.275                                                                       | 974.2                         | 1632.6              | 65.16                | 15.63                                          | 25.85                                          | 729                               |
| 82                         | 329.44                           | 6491.                                                                                               | 0.270                                                                       | 990.9                         | 1658.5              | 65.47                | 15.78                                          | 25.94                                          | 732                               |
| 83                         | 333.95                           | 6585.                                                                                               | 0.266                                                                       | 1007.7                        | 1684.5              | 65.79                | 15.93                                          | 26.04                                          | 736                               |
| 84                         | 338.46                           | 6685.                                                                                               | 0.263                                                                       | 1024.7                        | 1710.6              | 66.10                | 16.09                                          | 26.14                                          | 739                               |
| 85                         | 342.95                           | 6787.                                                                                               | 0.259                                                                       | 1041.8                        | 1736.8              | 66.41                | 16.25                                          | 26.25                                          | 742                               |
| 86                         | 347.43                           | 6879.                                                                                               | 0.255                                                                       | 1059.0                        | 1763.1              | 66.72                | 16.41                                          | 26.36                                          | 745                               |
| 87                         | 351.90                           | 6975.                                                                                               | 0.252                                                                       | 1076.4                        | 1789.5              | 67.02                | 16.57                                          | 26.48                                          | 748                               |
| 88                         | 356.37                           | 7071.                                                                                               | 0.248                                                                       | 1093.9                        | 1816.0              | 67.33                | 16.74                                          | 26.60                                          | 752                               |
| 89                         | 360.82                           | 7166.                                                                                               | 0.245                                                                       | 1111.5                        | 1842.7              | 67.63                | 16.90                                          | 26.72                                          | 755                               |
| 90                         | 365.26                           | 7261.                                                                                               | 0.242                                                                       | 1129.3                        | 1869.5              | 67.93                | 17.07                                          | 26.85                                          | 758                               |
| 91                         | 369.70                           | 7356.                                                                                               | 0.238                                                                       | 1147.2                        | 1896.4              | 68.23                | 17.24                                          | 26.98                                          | 761                               |
| 92                         | 374.13                           | 7450.                                                                                               | 0.235                                                                       | 1165.3                        | 1923.5              | 68.52                | 17.41                                          | 27.12                                          | 764                               |
| 93                         | 378.55                           | 7544.                                                                                               | 0.232                                                                       | 1183.5                        | 1950.6              | 68.81                | 17.58                                          | 27.25                                          | 767                               |
| 94                         | 382.96                           | 7638.                                                                                               | 0.230                                                                       | 1201.9                        | 1978.0              | 69.11                | 17.75                                          | 27.39                                          | 770                               |
| 95                         | 387.36                           | 7731.                                                                                               | 0.227                                                                       | 1220.4                        | 2005.4              | 69.40                | 17.92                                          | 27.53                                          | 773                               |
| 96                         | 391.76                           | 7825.                                                                                               | 0.224                                                                       | 1239.1                        | 2033.0              | 69.69                | 18.10                                          | 27.67                                          | 775                               |
| 97                         | 396.15                           | 7918.                                                                                               | 0.221                                                                       | 1258.0                        | 2060.8              | 69.97                | 18.27                                          | 27.81                                          | 778                               |
| 98                         | 400.53                           | 8011.                                                                                               | 0.219                                                                       | 1277.0                        | 2088.6              | 70.26                | 18.44                                          | 27.96                                          | 781                               |
| 99                         | 404.91                           | 8103.                                                                                               | 0.216                                                                       | 1296.1                        | 2116.7              | 70.54                | 18.61                                          | 28.10                                          | 784                               |
| 100                        | 409.28                           | 8195.                                                                                               | 0.214                                                                       | 1315.4                        | 2144.8              | 70.83                | 18.79                                          | 28.24                                          | 787                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 25.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial P$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 14.626                     | 25.71                            | 26386.                                                                                          | 9.482                                                                      | -620.6                        | -555.5              | 10.12                | 9.80                                           | 13.14                                          | 1333                              |
| 15                         | 25.80                            | 25929.                                                                                          | 9.465                                                                      | -615.9                        | -550.5              | 10.45                | 9.91                                           | 13.41                                          | 1328                              |
| 16                         | 26.05                            | 24428.                                                                                          | 9.397                                                                      | -602.7                        | -536.7              | 11.34                | 10.23                                          | 14.21                                          | 1306                              |
| 17                         | 26.32                            | 23137.                                                                                          | 9.300                                                                      | -588.8                        | -522.2              | 12.23                | 10.54                                          | 15.00                                          | 1286                              |
| 18                         | 26.61                            | 21830.                                                                                          | 9.163                                                                      | -574.2                        | -506.7              | 13.11                | 10.84                                          | 15.81                                          | 1265                              |
| 19                         | 26.92                            | 20533.                                                                                          | 9.025                                                                      | -558.7                        | -490.5              | 13.99                | 11.13                                          | 16.66                                          | 1243                              |
| 20                         | 27.25                            | 19224.                                                                                          | 8.881                                                                      | -542.4                        | -473.4              | 14.87                | 11.39                                          | 17.56                                          | 1221                              |
| 21                         | 27.61                            | 18046.                                                                                          | 8.722                                                                      | -525.3                        | -455.4              | 15.74                | 11.62                                          | 18.46                                          | 1200                              |
| 22                         | 27.99                            | 16781.                                                                                          | 8.546                                                                      | -507.4                        | -436.5              | 16.62                | 11.83                                          | 19.43                                          | 1177                              |
| 23                         | 28.40                            | 15597.                                                                                          | 8.353                                                                      | -488.5                        | -416.5              | 17.51                | 12.02                                          | 20.43                                          | 1154                              |
| 24                         | 28.86                            | 14349.                                                                                          | 8.136                                                                      | -468.7                        | -395.6              | 18.40                | 12.18                                          | 21.52                                          | 1129                              |
| 25                         | 29.35                            | 13121.                                                                                          | 7.898                                                                      | -447.8                        | -373.5              | 19.31                | 12.31                                          | 22.69                                          | 1102                              |
| 26                         | 29.90                            | 11900.                                                                                          | 7.632                                                                      | -425.9                        | -350.1              | 20.22                | 12.43                                          | 23.96                                          | 1074                              |
| 27                         | 30.50                            | 10699.                                                                                          | 7.340                                                                      | -402.8                        | -325.5              | 21.15                | 12.54                                          | 25.36                                          | 1043                              |
| 28                         | 31.18                            | 9532.                                                                                           | 7.025                                                                      | -378.4                        | -299.4              | 22.10                | 12.63                                          | 26.91                                          | 1010                              |
| 29                         | 31.94                            | 8385.                                                                                           | 6.682                                                                      | -352.5                        | -271.6              | 23.07                | 12.72                                          | 28.68                                          | 975                               |
| 30                         | 32.81                            | 7283.                                                                                           | 6.317                                                                      | -325.1                        | -241.9              | 24.08                | 12.79                                          | 30.72                                          | 938                               |
| 31                         | 33.82                            | 6210.                                                                                           | 5.924                                                                      | -295.7                        | -210.1              | 25.12                | 12.87                                          | 33.17                                          | 897                               |
| 32                         | 35.01                            | 5186.                                                                                           | 5.505                                                                      | -264.1                        | -175.4              | 26.22                | 12.95                                          | 36.18                                          | 853                               |
| 33                         | 36.45                            | 4225.                                                                                           | 5.058                                                                      | -229.7                        | -137.4              | 27.40                | 13.04                                          | 39.95                                          | 807                               |
| 34                         | 38.25                            | 3321.                                                                                           | 4.582                                                                      | -191.8                        | -94.9               | 28.66                | 13.15                                          | 45.01                                          | 756                               |
| 35                         | 40.57                            | 2521.                                                                                           | 4.074                                                                      | -149.5                        | -46.7               | 30.06                | 13.29                                          | 51.72                                          | 702                               |
| 36                         | 43.69                            | 1851.                                                                                           | 3.537                                                                      | -101.3                        | 9.3                 | 31.64                | 13.49                                          | 60.57                                          | 646                               |
| 37                         | 48.02                            | 1352.                                                                                           | 3.007                                                                      | -46.6                         | 75.1                | 33.44                | 13.77                                          | 71.58                                          | 594                               |
| 38                         | 54.04                            | 1061.                                                                                           | 2.485                                                                      | 14.3                          | 151.2               | 35.47                | 14.06                                          | 79.50                                          | 549                               |
| 39                         | 61.52                            | 983.3                                                                                           | 2.067                                                                      | 75.5                          | 231.4               | 37.55                | 14.24                                          | 79.24                                          | 525                               |
| 40                         | 69.62                            | 1052.                                                                                           | 1.753                                                                      | 130.9                         | 307.3               | 39.47                | 14.20                                          | 71.55                                          | 516                               |
| 41                         | 77.52                            | 1195.                                                                                           | 1.523                                                                      | 178.0                         | 374.3               | 41.13                | 14.05                                          | 62.53                                          | 517                               |
| 42                         | 84.94                            | 1364.                                                                                           | 1.353                                                                      | 217.9                         | 433.1               | 42.55                | 13.89                                          | 55.11                                          | 522                               |
| 43                         | 91.87                            | 1542.                                                                                           | 1.223                                                                      | 252.5                         | 485.2               | 43.77                | 13.74                                          | 49.44                                          | 528                               |
| 44                         | 98.36                            | 1720.                                                                                           | 1.121                                                                      | 283.3                         | 532.4               | 44.86                | 13.63                                          | 45.14                                          | 535                               |
| 45                         | 104.49                           | 1896.                                                                                           | 1.038                                                                      | 311.1                         | 575.8               | 45.83                | 13.54                                          | 41.84                                          | 543                               |
| 46                         | 110.33                           | 2066.                                                                                           | 0.969                                                                      | 336.8                         | 616.3               | 46.72                | 13.47                                          | 39.27                                          | 550                               |
| 47                         | 115.92                           | 2232.                                                                                           | 0.911                                                                      | 360.9                         | 654.5               | 47.55                | 13.42                                          | 37.22                                          | 558                               |
| 48                         | 121.31                           | 2393.                                                                                           | 0.861                                                                      | 383.6                         | 690.8               | 48.31                | 13.39                                          | 35.56                                          | 565                               |
| 49                         | 126.52                           | 2550.                                                                                           | 0.817                                                                      | 405.2                         | 725.7               | 49.03                | 13.37                                          | 34.19                                          | 572                               |
| 50                         | 131.57                           | 2702.                                                                                           | 0.779                                                                      | 426.0                         | 759.3               | 49.71                | 13.36                                          | 33.05                                          | 580                               |
| 51                         | 136.51                           | 2853.                                                                                           | 0.746                                                                      | 446.1                         | 791.9               | 50.35                | 13.36                                          | 32.13                                          | 587                               |
| 52                         | 141.33                           | 2999.                                                                                           | 0.716                                                                      | 465.6                         | 823.6               | 50.97                | 13.37                                          | 31.38                                          | 595                               |
| 53                         | 146.06                           | 3141.                                                                                           | 0.688                                                                      | 484.7                         | 854.7               | 51.56                | 13.39                                          | 30.68                                          | 601                               |
| 54                         | 150.69                           | 3280.                                                                                           | 0.663                                                                      | 503.3                         | 885.0               | 52.13                | 13.40                                          | 30.05                                          | 608                               |
| 55                         | 155.24                           | 3416.                                                                                           | 0.639                                                                      | 521.6                         | 914.8               | 52.68                | 13.43                                          | 29.50                                          | 614                               |
| 56                         | 159.69                           | 3547.                                                                                           | 0.617                                                                      | 539.8                         | 944.4               | 53.21                | 13.45                                          | 28.97                                          | 620                               |
| 57                         | 164.10                           | 3677.                                                                                           | 0.597                                                                      | 557.4                         | 973.1               | 53.72                | 13.47                                          | 28.54                                          | 626                               |
| 58                         | 168.44                           | 3805.                                                                                           | 0.579                                                                      | 574.8                         | 1001.5              | 54.21                | 13.50                                          | 28.17                                          | 632                               |
| 59                         | 172.73                           | 3931.                                                                                           | 0.562                                                                      | 591.9                         | 1029.5              | 54.69                | 13.53                                          | 27.84                                          | 638                               |
| 60                         | 176.96                           | 4055.                                                                                           | 0.546                                                                      | 608.9                         | 1057.2              | 55.15                | 13.57                                          | 27.55                                          | 643                               |
| 61                         | 181.16                           | 4177.                                                                                           | 0.531                                                                      | 625.7                         | 1084.6              | 55.61                | 13.62                                          | 27.30                                          | 649                               |
| 62                         | 185.30                           | 4297.                                                                                           | 0.517                                                                      | 642.4                         | 1111.8              | 56.05                | 13.67                                          | 27.07                                          | 654                               |
| 63                         | 189.41                           | 4416.                                                                                           | 0.504                                                                      | 658.9                         | 1138.8              | 56.48                | 13.73                                          | 26.88                                          | 659                               |
| 64                         | 193.49                           | 4534.                                                                                           | 0.491                                                                      | 675.4                         | 1165.6              | 56.90                | 13.79                                          | 26.71                                          | 664                               |
| 65                         | 197.53                           | 4649.                                                                                           | 0.479                                                                      | 691.8                         | 1192.2              | 57.32                | 13.86                                          | 26.57                                          | 669                               |
| 66                         | 201.53                           | 4764.                                                                                           | 0.468                                                                      | 708.2                         | 1218.7              | 57.72                | 13.94                                          | 26.45                                          | 674                               |
| 67                         | 205.51                           | 4877.                                                                                           | 0.458                                                                      | 724.5                         | 1245.1              | 58.12                | 14.02                                          | 26.34                                          | 679                               |
| 68                         | 209.47                           | 4990.                                                                                           | 0.448                                                                      | 740.8                         | 1271.4              | 58.51                | 14.11                                          | 26.26                                          | 683                               |
| 69                         | 213.39                           | 5101.                                                                                           | 0.438                                                                      | 757.1                         | 1297.6              | 58.89                | 14.20                                          | 26.19                                          | 688                               |
| 70                         | 217.29                           | 5211.                                                                                           | 0.429                                                                      | 773.4                         | 1323.8              | 59.27                | 14.30                                          | 26.14                                          | 692                               |
| 71                         | 221.17                           | 5320.                                                                                           | 0.421                                                                      | 789.7                         | 1349.9              | 59.64                | 14.40                                          | 26.10                                          | 696                               |
| 72                         | 225.03                           | 5428.                                                                                           | 0.412                                                                      | 806.0                         | 1376.0              | 60.00                | 14.51                                          | 26.08                                          | 700                               |
| 73                         | 228.87                           | 5536.                                                                                           | 0.405                                                                      | 822.3                         | 1402.1              | 60.36                | 14.62                                          | 26.07                                          | 704                               |
| 74                         | 232.69                           | 5642.                                                                                           | 0.397                                                                      | 838.7                         | 1428.2              | 60.72                | 14.74                                          | 26.07                                          | 708                               |
| 75                         | 236.49                           | 5748.                                                                                           | 0.390                                                                      | 855.2                         | 1454.2              | 61.07                | 14.86                                          | 26.09                                          | 712                               |
| 76                         | 240.27                           | 5853.                                                                                           | 0.383                                                                      | 871.7                         | 1480.3              | 61.41                | 14.98                                          | 26.11                                          | 716                               |
| 77                         | 244.04                           | 5958.                                                                                           | 0.376                                                                      | 888.3                         | 1506.5              | 61.75                | 15.11                                          | 26.15                                          | 720                               |
| 78                         | 247.79                           | 6061.                                                                                           | 0.370                                                                      | 905.0                         | 1532.6              | 62.09                | 15.25                                          | 26.19                                          | 723                               |
| 79                         | 251.53                           | 6164.                                                                                           | 0.363                                                                      | 921.7                         | 1558.8              | 62.43                | 15.39                                          | 26.24                                          | 727                               |
| 80                         | 255.25                           | 6267.                                                                                           | 0.358                                                                      | 938.5                         | 1585.1              | 62.76                | 15.53                                          | 26.30                                          | 730                               |
| 81                         | 258.96                           | 6369.                                                                                           | 0.352                                                                      | 955.5                         | 1611.5              | 63.08                | 15.67                                          | 26.37                                          | 734                               |
| 82                         | 262.66                           | 6470.                                                                                           | 0.346                                                                      | 972.5                         | 1637.9              | 63.41                | 15.82                                          | 26.44                                          | 737                               |
| 83                         | 266.35                           | 6571.                                                                                           | 0.341                                                                      | 989.7                         | 1664.3              | 63.73                | 15.97                                          | 26.52                                          | 741                               |
| 84                         | 270.02                           | 6671.                                                                                           | 0.336                                                                      | 1006.9                        | 1690.9              | 64.05                | 16.13                                          | 26.61                                          | 744                               |
| 85                         | 273.68                           | 6771.                                                                                           | 0.331                                                                      | 1024.3                        | 1717.6              | 64.36                | 16.28                                          | 26.70                                          | 747                               |
| 86                         | 277.34                           | 6870.                                                                                           | 0.326                                                                      | 1041.8                        | 1744.3              | 64.68                | 16.44                                          | 26.80                                          | 750                               |
| 87                         | 280.98                           | 6969.                                                                                           | 0.321                                                                      | 1059.4                        | 1771.2              | 64.99                | 16.60                                          | 26.91                                          | 753                               |
| 88                         | 284.61                           | 7068.                                                                                           | 0.317                                                                      | 1077.2                        | 1798.1              | 65.29                | 16.77                                          | 27.01                                          | 756                               |
| 89                         | 288.24                           | 7166.                                                                                           | 0.312                                                                      | 1095.1                        | 1825.2              | 65.60                | 16.93                                          | 27.13                                          | 760                               |
| 90                         | 291.86                           | 7263.                                                                                           | 0.308                                                                      | 1113.1                        | 1852.4              | 65.90                | 17.10                                          | 27.24                                          | 763                               |
| 91                         | 295.46                           | 7361.                                                                                           | 0.304                                                                      | 1131.2                        | 1879.7              | 66.21                | 17.27                                          | 27.36                                          | 766                               |
| 92                         | 299.06                           | 7457.                                                                                           | 0.300                                                                      | 1149.6                        | 1907.1              | 66.50                | 17.44                                          | 27.48                                          | 769                               |
| 93                         | 302.65                           | 7554.                                                                                           | 0.296                                                                      | 1168.0                        | 1934.7              | 66.80                | 17.61                                          | 27.61                                          | 772                               |
| 94                         | 306.24                           | 7650.                                                                                           | 0.292                                                                      | 1186.6                        | 1962.3              | 67.10                | 17.78                                          | 27.74                                          | 775                               |
| 95                         | 309.81                           | 7746.                                                                                           | 0.288                                                                      | 1205.3                        | 1990.1              | 67.39                | 17.95                                          | 27.87                                          | 777                               |
| 96                         | 313.38                           | 7842.                                                                                           | 0.285                                                                      | 1224.2                        | 2018.1              | 67.69                | 18.12                                          | 28.00                                          | 780                               |
| 97                         | 316.95                           | 7937.                                                                                           | 0.281                                                                      | 1243.3                        | 2046.1              | 67.98                | 18.29                                          | 28.13                                          | 783                               |
| 98                         | 320.50                           | 8032.                                                                                           | 0.278                                                                      | 1262.5                        | 2074.3              | 68.27                | 18.47                                          | 28.27                                          | 786                               |
| 99                         | 324.05                           | 8126.                                                                                           | 0.275                                                                      | 1281.8                        | 2102.7              | 68.55                | 18.64                                          | 28.40                                          | 789                               |
| 100                        | 327.60                           | 8221.                                                                                           | 0.271                                                                      | 1301.3                        | 2131.1              | 68.84                | 18.81                                          | 28.54                                          | 792                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

30.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 14.785                     | 25.63                            | 27055.                                                                                              | 9.500                                                                       | -620.1                        | -542.2              | 10.14                | 9.84                                           | 13.13                                          | 1347                              |
| 15                         | 25.68                            | 26806.                                                                                              | 9.495                                                                       | -617.4                        | -539.3              | 10.33                | 9.91                                           | 13.28                                          | 1344                              |
| 16                         | 25.92                            | 25276.                                                                                              | 9.448                                                                       | -604.4                        | -525.6              | 11.22                | 10.23                                          | 14.07                                          | 1322                              |
| 17                         | 26.18                            | 24017.                                                                                              | 9.366                                                                       | -590.8                        | -511.2              | 12.09                | 10.54                                          | 14.85                                          | 1304                              |
| 18                         | 26.45                            | 22721.                                                                                              | 9.252                                                                       | -576.4                        | -496.0              | 12.96                | 10.83                                          | 15.64                                          | 1284                              |
| 19                         | 26.75                            | 21444.                                                                                              | 9.124                                                                       | -561.2                        | -479.9              | 13.83                | 11.11                                          | 16.46                                          | 1263                              |
| 20                         | 27.06                            | 20156.                                                                                              | 8.988                                                                       | -545.3                        | -463.0              | 14.70                | 11.37                                          | 17.32                                          | 1242                              |
| 21                         | 27.40                            | 18981.                                                                                              | 8.837                                                                       | -528.6                        | -445.3              | 15.56                | 11.61                                          | 18.18                                          | 1222                              |
| 22                         | 27.76                            | 17736.                                                                                              | 8.669                                                                       | -511.0                        | -426.6              | 16.43                | 11.82                                          | 19.10                                          | 1200                              |
| 23                         | 28.15                            | 16572.                                                                                              | 8.485                                                                       | -492.7                        | -407.1              | 17.30                | 12.00                                          | 20.03                                          | 1179                              |
| 24                         | 28.58                            | 15348.                                                                                              | 8.281                                                                       | -473.4                        | -386.6              | 18.17                | 12.17                                          | 21.04                                          | 1155                              |
| 25                         | 29.04                            | 14141.                                                                                              | 8.056                                                                       | -453.3                        | -365.0              | 19.05                | 12.31                                          | 22.11                                          | 1130                              |
| 26                         | 29.54                            | 12949.                                                                                              | 7.809                                                                       | -432.1                        | -342.3              | 19.94                | 12.43                                          | 23.25                                          | 1104                              |
| 27                         | 30.09                            | 11776.                                                                                              | 7.538                                                                       | -409.9                        | -318.5              | 20.84                | 12.54                                          | 24.49                                          | 1075                              |
| 28                         | 30.70                            | 10641.                                                                                              | 7.244                                                                       | -386.6                        | -293.3              | 21.76                | 12.63                                          | 25.82                                          | 1046                              |
| 29                         | 31.38                            | 9525.                                                                                               | 6.931                                                                       | -362.2                        | -266.8              | 22.69                | 12.72                                          | 27.31                                          | 1014                              |
| 30                         | 32.14                            | 8458.                                                                                               | 6.596                                                                       | -336.4                        | -238.7              | 23.64                | 12.79                                          | 28.94                                          | 981                               |
| 31                         | 33.00                            | 7401.                                                                                               | 6.242                                                                       | -309.1                        | -208.8              | 24.62                | 12.86                                          | 30.85                                          | 945                               |
| 32                         | 33.98                            | 6411.                                                                                               | 5.868                                                                       | -280.2                        | -176.9              | 25.63                | 12.93                                          | 33.04                                          | 907                               |
| 33                         | 35.13                            | 5470.                                                                                               | 5.475                                                                       | -249.4                        | -142.6              | 26.69                | 13.00                                          | 35.61                                          | 868                               |
| 34                         | 36.47                            | 4592.                                                                                               | 5.064                                                                       | -216.4                        | -105.5              | 27.79                | 13.07                                          | 38.67                                          | 826                               |
| 35                         | 38.09                            | 3785.                                                                                               | 4.636                                                                       | -180.8                        | -65.0               | 28.97                | 13.16                                          | 42.38                                          | 783                               |
| 36                         | 40.06                            | 3075.                                                                                               | 4.194                                                                       | -142.3                        | -20.5               | 30.22                | 13.26                                          | 46.75                                          | 738                               |
| 37                         | 42.52                            | 2474.                                                                                               | 3.745                                                                       | -100.5                        | 28.8                | 31.57                | 13.39                                          | 51.82                                          | 694                               |
| 38                         | 45.60                            | 1998.                                                                                               | 3.303                                                                       | -55.2                         | 83.4                | 33.03                | 13.54                                          | 57.24                                          | 652                               |
| 39                         | 49.43                            | 1668.                                                                                               | 2.884                                                                       | -7.2                          | 143.1               | 34.58                | 13.70                                          | 61.86                                          | 615                               |
| 40                         | 54.03                            | 1479.                                                                                               | 2.510                                                                       | 42.1                          | 206.4               | 36.18                | 13.83                                          | 64.27                                          | 588                               |
| 41                         | 59.26                            | 1418.                                                                                               | 2.194                                                                       | 90.4                          | 270.6               | 37.77                | 13.91                                          | 63.45                                          | 570                               |
| 42                         | 64.83                            | 1449.                                                                                               | 1.936                                                                       | 135.7                         | 332.7               | 39.27                | 13.88                                          | 60.12                                          | 562                               |
| 43                         | 70.45                            | 1539.                                                                                               | 1.728                                                                       | 176.7                         | 390.9               | 40.63                | 13.83                                          | 55.79                                          | 559                               |
| 44                         | 75.98                            | 1662.                                                                                               | 1.562                                                                       | 213.7                         | 444.6               | 41.87                | 13.75                                          | 51.55                                          | 560                               |
| 45                         | 81.31                            | 1804.                                                                                               | 1.428                                                                       | 247.1                         | 494.3               | 42.99                | 13.68                                          | 47.76                                          | 563                               |
| 46                         | 86.45                            | 1954.                                                                                               | 1.318                                                                       | 277.6                         | 540.4               | 44.00                | 13.61                                          | 44.57                                          | 567                               |
| 47                         | 91.39                            | 2109.                                                                                               | 1.226                                                                       | 305.7                         | 583.5               | 44.93                | 13.56                                          | 41.90                                          | 572                               |
| 48                         | 96.16                            | 2265.                                                                                               | 1.148                                                                       | 332.0                         | 624.3               | 45.79                | 13.52                                          | 39.70                                          | 578                               |
| 49                         | 100.77                           | 2419.                                                                                               | 1.081                                                                       | 356.7                         | 663.0               | 46.58                | 13.49                                          | 37.86                                          | 584                               |
| 50                         | 105.24                           | 2572.                                                                                               | 1.023                                                                       | 380.2                         | 700.1               | 47.33                | 13.47                                          | 36.32                                          | 590                               |
| 51                         | 109.59                           | 2722.                                                                                               | 0.972                                                                       | 402.6                         | 735.7               | 48.04                | 13.47                                          | 35.02                                          | 596                               |
| 52                         | 113.82                           | 2870.                                                                                               | 0.927                                                                       | 424.2                         | 770.2               | 48.71                | 13.47                                          | 33.92                                          | 603                               |
| 53                         | 117.96                           | 3015.                                                                                               | 0.887                                                                       | 445.0                         | 803.6               | 49.35                | 13.48                                          | 32.96                                          | 609                               |
| 54                         | 122.01                           | 3157.                                                                                               | 0.850                                                                       | 465.3                         | 836.1               | 49.95                | 13.50                                          | 32.15                                          | 615                               |
| 55                         | 125.98                           | 3297.                                                                                               | 0.817                                                                       | 485.0                         | 867.9               | 50.54                | 13.52                                          | 31.44                                          | 621                               |
| 56                         | 129.88                           | 3434.                                                                                               | 0.787                                                                       | 504.8                         | 899.6               | 51.11                | 13.55                                          | 30.82                                          | 627                               |
| 57                         | 133.79                           | 3576.                                                                                               | 0.759                                                                       | 523.8                         | 930.5               | 51.65                | 13.57                                          | 30.23                                          | 633                               |
| 58                         | 137.57                           | 3709.                                                                                               | 0.734                                                                       | 542.3                         | 960.5               | 52.18                | 13.60                                          | 29.77                                          | 639                               |
| 59                         | 141.29                           | 3840.                                                                                               | 0.711                                                                       | 560.5                         | 990.0               | 52.68                | 13.63                                          | 29.34                                          | 645                               |
| 60                         | 144.97                           | 3969.                                                                                               | 0.689                                                                       | 578.5                         | 1019.2              | 53.17                | 13.66                                          | 28.95                                          | 650                               |
| 61                         | 148.59                           | 4096.                                                                                               | 0.669                                                                       | 596.3                         | 1048.0              | 53.65                | 13.71                                          | 28.61                                          | 655                               |
| 62                         | 152.18                           | 4221.                                                                                               | 0.650                                                                       | 613.8                         | 1076.4              | 54.11                | 13.75                                          | 28.30                                          | 661                               |
| 63                         | 155.72                           | 4344.                                                                                               | 0.632                                                                       | 631.2                         | 1104.6              | 54.56                | 13.81                                          | 28.04                                          | 666                               |
| 64                         | 159.23                           | 4466.                                                                                               | 0.615                                                                       | 648.5                         | 1132.5              | 55.00                | 13.87                                          | 27.80                                          | 671                               |
| 65                         | 162.71                           | 4588.                                                                                               | 0.599                                                                       | 665.6                         | 1160.2              | 55.43                | 13.94                                          | 27.60                                          | 676                               |
| 66                         | 166.15                           | 4705.                                                                                               | 0.585                                                                       | 682.6                         | 1187.7              | 55.85                | 14.01                                          | 27.42                                          | 680                               |
| 67                         | 169.57                           | 4823.                                                                                               | 0.571                                                                       | 699.6                         | 1215.1              | 56.26                | 14.09                                          | 27.27                                          | 685                               |
| 68                         | 172.96                           | 4939.                                                                                               | 0.557                                                                       | 716.5                         | 1242.3              | 56.66                | 14.17                                          | 27.14                                          | 689                               |
| 69                         | 176.32                           | 5054.                                                                                               | 0.545                                                                       | 733.4                         | 1269.3              | 57.06                | 14.26                                          | 27.03                                          | 694                               |
| 70                         | 179.66                           | 5168.                                                                                               | 0.533                                                                       | 750.2                         | 1296.3              | 57.45                | 14.36                                          | 26.94                                          | 698                               |
| 71                         | 182.98                           | 5281.                                                                                               | 0.522                                                                       | 767.0                         | 1323.2              | 57.83                | 14.46                                          | 26.87                                          | 702                               |
| 72                         | 186.28                           | 5393.                                                                                               | 0.511                                                                       | 783.8                         | 1350.1              | 58.20                | 14.56                                          | 26.81                                          | 706                               |
| 73                         | 189.56                           | 5504.                                                                                               | 0.501                                                                       | 800.6                         | 1376.9              | 58.57                | 14.67                                          | 26.77                                          | 710                               |
| 74                         | 192.82                           | 5614.                                                                                               | 0.491                                                                       | 817.5                         | 1403.6              | 58.94                | 14.79                                          | 26.74                                          | 714                               |
| 75                         | 196.06                           | 5723.                                                                                               | 0.481                                                                       | 834.4                         | 1430.3              | 59.30                | 14.91                                          | 26.73                                          | 718                               |
| 76                         | 199.28                           | 5831.                                                                                               | 0.472                                                                       | 851.3                         | 1457.1              | 59.65                | 15.03                                          | 26.73                                          | 722                               |
| 77                         | 202.49                           | 5939.                                                                                               | 0.464                                                                       | 868.3                         | 1483.8              | 60.00                | 15.16                                          | 26.74                                          | 726                               |
| 78                         | 205.68                           | 6046.                                                                                               | 0.455                                                                       | 885.3                         | 1510.6              | 60.35                | 15.29                                          | 26.76                                          | 729                               |
| 79                         | 208.86                           | 6152.                                                                                               | 0.447                                                                       | 902.4                         | 1537.3              | 60.69                | 15.43                                          | 26.79                                          | 733                               |
| 80                         | 212.03                           | 6257.                                                                                               | 0.440                                                                       | 919.6                         | 1564.1              | 61.02                | 15.57                                          | 26.83                                          | 736                               |
| 81                         | 215.18                           | 6362.                                                                                               | 0.432                                                                       | 936.9                         | 1591.0              | 61.36                | 15.71                                          | 26.88                                          | 740                               |
| 82                         | 218.32                           | 6466.                                                                                               | 0.425                                                                       | 954.2                         | 1617.9              | 61.69                | 15.86                                          | 26.93                                          | 743                               |
| 83                         | 221.45                           | 6569.                                                                                               | 0.418                                                                       | 971.7                         | 1644.9              | 62.01                | 16.01                                          | 27.00                                          | 746                               |
| 84                         | 224.57                           | 6672.                                                                                               | 0.412                                                                       | 989.3                         | 1671.9              | 62.34                | 16.16                                          | 27.07                                          | 749                               |
| 85                         | 227.68                           | 6775.                                                                                               | 0.405                                                                       | 1006.9                        | 1699.0              | 62.66                | 16.32                                          | 27.15                                          | 753                               |
| 86                         | 230.77                           | 6877.                                                                                               | 0.399                                                                       | 1024.7                        | 1726.2              | 62.98                | 16.48                                          | 27.23                                          | 756                               |
| 87                         | 233.86                           | 6978.                                                                                               | 0.393                                                                       | 1042.6                        | 1753.5              | 63.29                | 16.64                                          | 27.32                                          | 759                               |
| 88                         | 236.94                           | 7079.                                                                                               | 0.388                                                                       | 1060.6                        | 1780.8              | 63.60                | 16.80                                          | 27.42                                          | 762                               |
| 89                         | 240.01                           | 7179.                                                                                               | 0.382                                                                       | 1078.8                        | 1808.3              | 63.92                | 16.96                                          | 27.52                                          | 765                               |
| 90                         | 243.07                           | 7279.                                                                                               | 0.377                                                                       | 1097.0                        | 1835.9              | 64.22                | 17.13                                          | 27.62                                          | 768                               |
| 91                         | 246.12                           | 7379.                                                                                               | 0.371                                                                       | 1115.4                        | 1863.6              | 64.53                | 17.30                                          | 27.73                                          | 771                               |
| 92                         | 249.16                           | 7478.                                                                                               | 0.366                                                                       | 1134.0                        | 1891.3              | 64.83                | 17.47                                          | 27.84                                          | 774                               |
| 93                         | 252.20                           | 7576.                                                                                               | 0.361                                                                       | 1152.6                        | 1919.2              | 65.13                | 17.63                                          | 27.96                                          | 777                               |
| 94                         | 255.23                           | 7675.                                                                                               | 0.356                                                                       | 1171.4                        | 1947.3              | 65.43                | 17.80                                          | 28.08                                          | 780                               |
| 95                         | 258.25                           | 7773.                                                                                               | 0.352                                                                       | 1190.4                        | 1975.4              | 65.73                | 17.98                                          | 28.20                                          | 783                               |
| 96                         | 261.27                           | 7870.                                                                                               | 0.347                                                                       | 1209.5                        | 2003.7              | 66.03                | 18.15                                          | 28.32                                          | 786                               |
| 97                         | 264.27                           | 7967.                                                                                               | 0.343                                                                       | 1228.7                        | 2032.0              | 66.32                | 18.32                                          | 28.45                                          | 789                               |
| 98                         | 267.28                           | 8064.                                                                                               | 0.339                                                                       | 1248.1                        | 2060.6              | 66.61                | 18.49                                          | 28.57                                          | 791                               |
| 99                         | 270.27                           | 8161.                                                                                               | 0.334                                                                       | 1267.6                        | 2089.2              | 66.90                | 18.66                                          | 28.70                                          | 794                               |
| 100                        | 273.26                           | 8257.                                                                                               | 0.330                                                                       | 1287.3                        | 2118.0              | 67.19                | 18.83                                          | 28.83                                          | 797                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 35.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>OEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> <sup>*</sup> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|-------------------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 14.942                   | 25.54                            | 27739.                                                                                             | 9.510                                                                      | -619.4                        | -528.9              | 10.17                | 9.89                                                        | 13.11                                          | 1360                              |
| 15                         | 25.56                            | 27675.                                                                                             | 9.511                                                                      | -618.7                        | -528.1              | 10.22                | 9.91                                                        | 13.15                                          | 1359                              |
| 16                         | 25.79                            | 26122.                                                                                             | 9.490                                                                      | -606.0                        | -514.5              | 11.09                | 10.22                                                       | 13.94                                          | 1338                              |
| 17                         | 26.04                            | 24876.                                                                                             | 9.428                                                                      | -592.6                        | -500.2              | 11.96                | 10.53                                                       | 14.70                                          | 1321                              |
| 18                         | 26.30                            | 23587.                                                                                             | 9.337                                                                      | -578.4                        | -485.1              | 12.82                | 10.82                                                       | 15.49                                          | 1302                              |
| 19                         | 26.59                            | 22329.                                                                                             | 9.215                                                                      | -563.5                        | -469.3              | 13.68                | 11.10                                                       | 16.28                                          | 1283                              |
| 20                         | 26.89                            | 21062.                                                                                             | 9.085                                                                      | -547.9                        | -452.6              | 14.54                | 11.36                                                       | 17.10                                          | 1262                              |
| 21                         | 27.21                            | 19894.                                                                                             | 8.943                                                                      | -531.6                        | -435.1              | 15.39                | 11.59                                                       | 17.92                                          | 1243                              |
| 22                         | 27.55                            | 18668.                                                                                             | 8.784                                                                      | -514.4                        | -416.7              | 16.24                | 11.80                                                       | 18.80                                          | 1222                              |
| 23                         | 27.92                            | 17513.                                                                                             | 8.608                                                                      | -496.5                        | -397.5              | 17.10                | 11.99                                                       | 19.68                                          | 1202                              |
| 24                         | 28.32                            | 16315.                                                                                             | 8.415                                                                      | -477.8                        | -377.3              | 17.96                | 12.16                                                       | 20.62                                          | 1179                              |
| 25                         | 28.75                            | 15130.                                                                                             | 8.202                                                                      | -458.2                        | -356.2              | 18.82                | 12.30                                                       | 21.61                                          | 1156                              |
| 26                         | 29.22                            | 13959.                                                                                             | 7.970                                                                      | -437.7                        | -334.1              | 19.69                | 12.42                                                       | 22.66                                          | 1131                              |
| 27                         | 29.73                            | 12809.                                                                                             | 7.717                                                                      | -416.3                        | -310.9              | 20.56                | 12.54                                                       | 23.78                                          | 1105                              |
| 28                         | 30.29                            | 11702.                                                                                             | 7.443                                                                      | -393.9                        | -286.5              | 21.45                | 12.64                                                       | 24.96                                          | 1078                              |
| 29                         | 30.90                            | 10609.                                                                                             | 7.150                                                                      | -370.5                        | -261.0              | 22.34                | 12.72                                                       | 26.24                                          | 1049                              |
| 30                         | 31.58                            | 9564.                                                                                              | 6.840                                                                      | -346.0                        | -234.0              | 23.26                | 12.79                                                       | 27.62                                          | 1019                              |
| 31                         | 32.33                            | 8535.                                                                                              | 6.514                                                                      | -320.3                        | -205.7              | 24.19                | 12.86                                                       | 29.18                                          | 987                               |
| 32                         | 33.18                            | 7556.                                                                                              | 6.172                                                                      | -293.3                        | -175.6              | 25.14                | 12.93                                                       | 30.92                                          | 953                               |
| 33                         | 34.13                            | 6625.                                                                                              | 5.816                                                                      | -264.8                        | -143.8              | 26.12                | 12.99                                                       | 32.88                                          | 918                               |
| 34                         | 35.23                            | 5767.                                                                                              | 5.447                                                                      | -234.8                        | -109.9              | 27.13                | 13.04                                                       | 35.04                                          | 882                               |
| 35                         | 36.49                            | 4959.                                                                                              | 5.066                                                                      | -203.0                        | -73.6               | 28.18                | 13.11                                                       | 37.55                                          | 845                               |
| 36                         | 37.96                            | 4230.                                                                                              | 4.677                                                                      | -169.3                        | -34.7               | 29.28                | 13.17                                                       | 40.37                                          | 807                               |
| 37                         | 39.70                            | 3586.                                                                                              | 4.284                                                                      | -133.5                        | 7.2                 | 30.43                | 13.25                                                       | 43.49                                          | 769                               |
| 38                         | 41.75                            | 3035.                                                                                              | 3.891                                                                      | -95.6                         | 52.4                | 31.63                | 13.34                                                       | 46.83                                          | 732                               |
| 39                         | 44.19                            | 2590.                                                                                              | 3.510                                                                      | -55.8                         | 100.9               | 32.89                | 13.42                                                       | 50.13                                          | 697                               |
| 40                         | 47.06                            | 2255.                                                                                              | 3.149                                                                      | -14.3                         | 152.6               | 34.20                | 13.52                                                       | 53.00                                          | 667                               |
| 41                         | 50.38                            | 2026.                                                                                              | 2.818                                                                      | 28.0                          | 206.6               | 35.53                | 13.61                                                       | 54.93                                          | 641                               |
| 42                         | 54.09                            | 1897.                                                                                              | 2.523                                                                      | 70.1                          | 261.9               | 36.87                | 13.67                                                       | 55.48                                          | 622                               |
| 43                         | 58.12                            | 1854.                                                                                              | 2.269                                                                      | 111.0                         | 317.1               | 38.17                | 13.71                                                       | 54.58                                          | 609                               |
| 44                         | 62.34                            | 1872.                                                                                              | 2.051                                                                      | 149.8                         | 370.8               | 39.40                | 13.71                                                       | 52.65                                          | 601                               |
| 45                         | 66.63                            | 1935.                                                                                              | 1.868                                                                      | 186.1                         | 422.4               | 40.56                | 13.68                                                       | 50.18                                          | 597                               |
| 46                         | 70.92                            | 2028.                                                                                              | 1.714                                                                      | 219.9                         | 471.4               | 41.64                | 13.65                                                       | 47.61                                          | 596                               |
| 47                         | 75.13                            | 2143.                                                                                              | 1.585                                                                      | 251.4                         | 517.8               | 42.64                | 13.62                                                       | 45.12                                          | 597                               |
| 48                         | 79.26                            | 2270.                                                                                              | 1.475                                                                      | 280.7                         | 561.8               | 43.56                | 13.59                                                       | 42.86                                          | 600                               |
| 49                         | 83.30                            | 2404.                                                                                              | 1.380                                                                      | 308.2                         | 603.6               | 44.43                | 13.57                                                       | 40.86                                          | 603                               |
| 50                         | 87.23                            | 2543.                                                                                              | 1.299                                                                      | 334.3                         | 643.6               | 45.23                | 13.55                                                       | 39.13                                          | 608                               |
| 51                         | 91.07                            | 2684.                                                                                              | 1.228                                                                      | 359.0                         | 682.0               | 45.99                | 13.54                                                       | 37.62                                          | 612                               |
| 52                         | 94.82                            | 2825.                                                                                              | 1.165                                                                      | 382.6                         | 718.9               | 46.71                | 13.54                                                       | 36.32                                          | 617                               |
| 53                         | 98.49                            | 2966.                                                                                              | 1.110                                                                      | 405.4                         | 754.6               | 47.39                | 13.55                                                       | 35.19                                          | 622                               |
| 54                         | 102.08                           | 3106.                                                                                              | 1.060                                                                      | 427.3                         | 789.3               | 48.04                | 13.57                                                       | 34.20                                          | 627                               |
| 55                         | 105.61                           | 3245.                                                                                              | 1.015                                                                      | 448.6                         | 823.1               | 48.66                | 13.59                                                       | 33.33                                          | 633                               |
| 56                         | 109.06                           | 3387.                                                                                              | 0.975                                                                      | 469.8                         | 856.5               | 49.26                | 13.61                                                       | 32.58                                          | 638                               |
| 57                         | 112.46                           | 3518.                                                                                              | 0.938                                                                      | 489.9                         | 888.8               | 49.83                | 13.63                                                       | 31.90                                          | 643                               |
| 58                         | 115.81                           | 3657.                                                                                              | 0.904                                                                      | 509.7                         | 920.4               | 50.38                | 13.65                                                       | 31.30                                          | 649                               |
| 59                         | 119.11                           | 3784.                                                                                              | 0.873                                                                      | 529.0                         | 951.4               | 50.91                | 13.69                                                       | 30.77                                          | 654                               |
| 60                         | 122.36                           | 3915.                                                                                              | 0.844                                                                      | 548.0                         | 981.9               | 51.43                | 13.73                                                       | 30.30                                          | 659                               |
| 61                         | 125.57                           | 4044.                                                                                              | 0.818                                                                      | 566.7                         | 1012.0              | 51.92                | 13.77                                                       | 29.88                                          | 664                               |
| 62                         | 128.74                           | 4172.                                                                                              | 0.793                                                                      | 585.2                         | 1041.7              | 52.41                | 13.82                                                       | 29.52                                          | 669                               |
| 63                         | 131.87                           | 4299.                                                                                              | 0.770                                                                      | 603.4                         | 1071.1              | 52.88                | 13.88                                                       | 29.19                                          | 674                               |
| 64                         | 135.04                           | 4429.                                                                                              | 0.748                                                                      | 621.6                         | 1100.5              | 53.34                | 13.94                                                       | 28.88                                          | 679                               |
| 65                         | 138.11                           | 4553.                                                                                              | 0.728                                                                      | 639.4                         | 1129.2              | 53.79                | 14.01                                                       | 28.62                                          | 684                               |
| 66                         | 141.14                           | 4674.                                                                                              | 0.708                                                                      | 657.2                         | 1157.7              | 54.22                | 14.08                                                       | 28.38                                          | 688                               |
| 67                         | 144.15                           | 4795.                                                                                              | 0.690                                                                      | 674.8                         | 1186.0              | 54.65                | 14.15                                                       | 28.17                                          | 693                               |
| 68                         | 147.12                           | 4914.                                                                                              | 0.673                                                                      | 692.3                         | 1214.1              | 55.06                | 14.23                                                       | 28.00                                          | 697                               |
| 69                         | 150.08                           | 5032.                                                                                              | 0.657                                                                      | 709.8                         | 1242.0              | 55.47                | 14.32                                                       | 27.85                                          | 701                               |
| 70                         | 153.01                           | 5149.                                                                                              | 0.642                                                                      | 727.1                         | 1269.8              | 55.87                | 14.41                                                       | 27.72                                          | 705                               |
| 71                         | 155.92                           | 5265.                                                                                              | 0.628                                                                      | 744.5                         | 1297.4              | 56.26                | 14.51                                                       | 27.61                                          | 710                               |
| 72                         | 158.81                           | 5380.                                                                                              | 0.614                                                                      | 761.8                         | 1325.0              | 56.65                | 14.61                                                       | 27.52                                          | 714                               |
| 73                         | 161.68                           | 5493.                                                                                              | 0.601                                                                      | 779.1                         | 1352.5              | 57.03                | 14.72                                                       | 27.45                                          | 717                               |
| 74                         | 164.53                           | 5606.                                                                                              | 0.589                                                                      | 796.4                         | 1379.9              | 57.40                | 14.84                                                       | 27.39                                          | 721                               |
| 75                         | 167.37                           | 5718.                                                                                              | 0.577                                                                      | 813.7                         | 1407.3              | 57.77                | 14.95                                                       | 27.35                                          | 725                               |
| 76                         | 170.19                           | 5829.                                                                                              | 0.566                                                                      | 831.1                         | 1434.6              | 58.13                | 15.08                                                       | 27.33                                          | 729                               |
| 77                         | 172.99                           | 5939.                                                                                              | 0.555                                                                      | 848.4                         | 1461.9              | 58.49                | 15.20                                                       | 27.31                                          | 732                               |
| 78                         | 175.78                           | 6048.                                                                                              | 0.545                                                                      | 865.9                         | 1489.2              | 58.84                | 15.33                                                       | 27.31                                          | 736                               |
| 79                         | 178.56                           | 6157.                                                                                              | 0.535                                                                      | 883.3                         | 1516.6              | 59.19                | 15.47                                                       | 27.32                                          | 739                               |
| 80                         | 181.32                           | 6265.                                                                                              | 0.525                                                                      | 900.9                         | 1543.9              | 59.53                | 15.61                                                       | 27.34                                          | 743                               |
| 81                         | 184.07                           | 6372.                                                                                              | 0.516                                                                      | 918.5                         | 1571.2              | 59.87                | 15.75                                                       | 27.37                                          | 746                               |
| 82                         | 186.81                           | 6478.                                                                                              | 0.507                                                                      | 936.2                         | 1598.6              | 60.21                | 15.90                                                       | 27.41                                          | 749                               |
| 83                         | 189.53                           | 6584.                                                                                              | 0.499                                                                      | 953.9                         | 1626.1              | 60.54                | 16.05                                                       | 27.46                                          | 753                               |
| 84                         | 192.25                           | 6689.                                                                                              | 0.491                                                                      | 971.8                         | 1653.6              | 60.87                | 16.20                                                       | 27.52                                          | 756                               |
| 85                         | 194.96                           | 6794.                                                                                              | 0.483                                                                      | 989.7                         | 1681.1              | 61.19                | 16.35                                                       | 27.58                                          | 759                               |
| 86                         | 197.65                           | 6898.                                                                                              | 0.475                                                                      | 1007.8                        | 1708.7              | 61.52                | 16.51                                                       | 27.65                                          | 762                               |
| 87                         | 200.34                           | 7001.                                                                                              | 0.468                                                                      | 1025.9                        | 1736.4              | 61.84                | 16.67                                                       | 27.73                                          | 765                               |
| 88                         | 203.02                           | 7104.                                                                                              | 0.461                                                                      | 1044.2                        | 1764.2              | 62.15                | 16.83                                                       | 27.81                                          | 768                               |
| 89                         | 205.68                           | 7206.                                                                                              | 0.454                                                                      | 1062.6                        | 1792.0              | 62.47                | 16.99                                                       | 27.90                                          | 771                               |
| 90                         | 208.35                           | 7308.                                                                                              | 0.447                                                                      | 1081.1                        | 1820.0              | 62.78                | 17.16                                                       | 27.99                                          | 774                               |
| 91                         | 211.00                           | 7410.                                                                                              | 0.441                                                                      | 1099.8                        | 1848.0              | 63.09                | 17.32                                                       | 28.09                                          | 777                               |
| 92                         | 213.64                           | 7511.                                                                                              | 0.435                                                                      | 1118.5                        | 1876.2              | 63.40                | 17.49                                                       | 28.19                                          | 780                               |
| 93                         | 216.28                           | 7611.                                                                                              | 0.429                                                                      | 1137.4                        | 1904.4              | 63.70                | 17.66                                                       | 28.30                                          | 783                               |
| 94                         | 218.91                           | 7712.                                                                                              | 0.423                                                                      | 1156.4                        | 1932.8              | 64.01                | 17.83                                                       | 28.41                                          | 786                               |
| 95                         | 221.53                           | 7811.                                                                                              | 0.417                                                                      | 1175.6                        | 1961.2              | 64.31                | 18.00                                                       | 28.52                                          | 789                               |
| 96                         | 224.15                           | 7911.                                                                                              | 0.412                                                                      | 1194.9                        | 1989.8              | 64.61                | 18.17                                                       | 28.63                                          | 792                               |
| 97                         | 226.76                           | 8010.                                                                                              | 0.406                                                                      | 1214.3                        | 2018.5              | 64.90                | 18.34                                                       | 28.75                                          | 794                               |
| 98                         | 229.37                           | 8108.                                                                                              | 0.401                                                                      | 1233.9                        | 2047.3              | 65.20                | 18.51                                                       | 28.87                                          | 797                               |
| 99                         | 231.96                           | 8207.                                                                                              | 0.396                                                                      | 1253.6                        | 2076.2              | 65.49                | 18.68                                                       | 28.99                                          | 800                               |
| 100                        | 234.56                           | 8304.                                                                                              | 0.391                                                                      | 1273.5                        | 2105.3              | 65.79                | 18.85                                                       | 29.11                                          | 803                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

40.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 15.097                     | 25.46                            | 28373.                                                                                             | 9.525                                                                      | -618.8                        | -515.6              | 10.19                | 9.93                                           | 13.10                                          | 1372                              |
| 16                         | 25.67                            | 26957.                                                                                             | 9.531                                                                      | -607.4                        | -503.4              | 10.97                | 10.21                                          | 13.81                                          | 1354                              |
| 17                         | 25.91                            | 25709.                                                                                             | 9.484                                                                      | -594.2                        | -489.2              | 11.83                | 10.52                                          | 14.57                                          | 1337                              |
| 18                         | 26.16                            | 24429.                                                                                             | 9.405                                                                      | -580.3                        | -474.3              | 12.69                | 10.82                                          | 15.34                                          | 1319                              |
| 19                         | 26.43                            | 23196.                                                                                             | 9.299                                                                      | -565.7                        | -458.6              | 13.53                | 11.09                                          | 16.11                                          | 1301                              |
| 20                         | 26.72                            | 21955.                                                                                             | 9.177                                                                      | -550.4                        | -442.1              | 14.38                | 11.35                                          | 16.90                                          | 1282                              |
| 21                         | 27.03                            | 20782.                                                                                             | 9.044                                                                      | -534.4                        | -424.8              | 15.22                | 11.58                                          | 17.70                                          | 1264                              |
| 22                         | 27.36                            | 19577.                                                                                             | 8.893                                                                      | -517.6                        | -406.7              | 16.07                | 11.79                                          | 18.53                                          | 1244                              |
| 23                         | 27.71                            | 18429.                                                                                             | 8.725                                                                      | -500.1                        | -387.8              | 16.91                | 11.98                                          | 19.37                                          | 1224                              |
| 24                         | 28.09                            | 17257.                                                                                             | 8.541                                                                      | -481.8                        | -367.9              | 17.75                | 12.15                                          | 20.26                                          | 1203                              |
| 25                         | 28.49                            | 16085.                                                                                             | 8.339                                                                      | -462.7                        | -347.2              | 18.60                | 12.29                                          | 21.18                                          | 1180                              |
| 26                         | 28.93                            | 14934.                                                                                             | 8.119                                                                      | -442.8                        | -325.6              | 19.45                | 12.42                                          | 22.15                                          | 1157                              |
| 27                         | 29.40                            | 13806.                                                                                             | 7.880                                                                      | -422.1                        | -302.9              | 20.30                | 12.54                                          | 23.17                                          | 1133                              |
| 28                         | 29.92                            | 12719.                                                                                             | 7.624                                                                      | -400.5                        | -279.2              | 21.16                | 12.64                                          | 24.24                                          | 1107                              |
| 29                         | 30.48                            | 11646.                                                                                             | 7.348                                                                      | -377.9                        | -254.4              | 22.03                | 12.73                                          | 25.38                                          | 1080                              |
| 30                         | 31.09                            | 10618.                                                                                             | 7.058                                                                      | -354.5                        | -228.5              | 22.91                | 12.80                                          | 26.59                                          | 1053                              |
| 31                         | 31.76                            | 9606.                                                                                              | 6.754                                                                      | -330.0                        | -201.2              | 23.81                | 12.87                                          | 27.92                                          | 1023                              |
| 32                         | 32.51                            | 8641.                                                                                              | 6.436                                                                      | -304.4                        | -172.6              | 24.71                | 12.93                                          | 29.36                                          | 993                               |
| 33                         | 33.34                            | 7721.                                                                                              | 6.109                                                                      | -277.6                        | -142.5              | 25.64                | 12.99                                          | 30.95                                          | 962                               |
| 34                         | 34.27                            | 6877.                                                                                              | 5.769                                                                      | -249.7                        | -110.8              | 26.59                | 13.04                                          | 32.63                                          | 930                               |
| 35                         | 35.32                            | 6066.                                                                                              | 5.420                                                                      | -220.4                        | -77.2               | 27.56                | 13.09                                          | 34.52                                          | 897                               |
| 36                         | 36.51                            | 5325.                                                                                              | 5.066                                                                      | -189.6                        | -41.7               | 28.56                | 13.14                                          | 36.58                                          | 863                               |
| 37                         | 37.87                            | 4657.                                                                                              | 4.709                                                                      | -157.5                        | -4.0                | 29.59                | 13.20                                          | 38.79                                          | 829                               |
| 38                         | 39.42                            | 4065.                                                                                              | 4.352                                                                      | -123.8                        | 36.0                | 30.66                | 13.25                                          | 41.14                                          | 796                               |
| 39                         | 41.20                            | 3557.                                                                                              | 4.002                                                                      | -88.7                         | 78.3                | 31.76                | 13.31                                          | 43.50                                          | 765                               |
| 40                         | 43.25                            | 3147.                                                                                              | 3.662                                                                      | -52.4                         | 122.9               | 32.89                | 13.36                                          | 45.72                                          | 735                               |
| 41                         | 45.57                            | 2811.                                                                                              | 3.341                                                                      | -15.0                         | 169.7               | 34.04                | 13.42                                          | 47.68                                          | 708                               |
| 42                         | 48.18                            | 2567.                                                                                              | 3.043                                                                      | 22.8                          | 218.1               | 35.21                | 13.48                                          | 49.12                                          | 686                               |
| 43                         | 51.06                            | 2407.                                                                                              | 2.772                                                                      | 60.6                          | 267.6               | 36.37                | 13.54                                          | 49.80                                          | 667                               |
| 44                         | 54.17                            | 2318.                                                                                              | 2.530                                                                      | 97.8                          | 317.4               | 37.52                | 13.57                                          | 49.68                                          | 653                               |
| 45                         | 57.45                            | 2287.                                                                                              | 2.316                                                                      | 133.9                         | 366.8               | 38.63                | 13.59                                          | 48.89                                          | 643                               |
| 46                         | 60.85                            | 2301.                                                                                              | 2.129                                                                      | 168.5                         | 415.2               | 39.70                | 13.61                                          | 47.59                                          | 636                               |
| 47                         | 64.30                            | 2357.                                                                                              | 1.967                                                                      | 201.4                         | 462.0               | 40.70                | 13.61                                          | 45.98                                          | 632                               |
| 48                         | 67.76                            | 2429.                                                                                              | 1.827                                                                      | 232.6                         | 507.2               | 41.65                | 13.60                                          | 44.27                                          | 630                               |
| 49                         | 71.20                            | 2525.                                                                                              | 1.705                                                                      | 262.1                         | 550.6               | 42.55                | 13.59                                          | 42.57                                          | 630                               |
| 50                         | 74.61                            | 2637.                                                                                              | 1.599                                                                      | 290.0                         | 592.4               | 43.39                | 13.59                                          | 40.97                                          | 632                               |
| 51                         | 77.96                            | 2750.                                                                                              | 1.506                                                                      | 316.6                         | 632.6               | 44.19                | 13.59                                          | 39.49                                          | 634                               |
| 52                         | 81.26                            | 2874.                                                                                              | 1.425                                                                      | 342.1                         | 671.4               | 44.94                | 13.59                                          | 38.16                                          | 637                               |
| 53                         | 84.51                            | 3001.                                                                                              | 1.352                                                                      | 366.5                         | 709.0               | 45.66                | 13.60                                          | 36.96                                          | 640                               |
| 54                         | 87.70                            | 3131.                                                                                              | 1.288                                                                      | 390.0                         | 745.4               | 46.34                | 13.61                                          | 35.90                                          | 644                               |
| 55                         | 90.83                            | 3262.                                                                                              | 1.229                                                                      | 412.6                         | 780.8               | 46.99                | 13.64                                          | 34.94                                          | 648                               |
| 56                         | 93.92                            | 3393.                                                                                              | 1.177                                                                      | 435.2                         | 815.8               | 47.62                | 13.66                                          | 34.10                                          | 653                               |
| 57                         | 96.95                            | 3524.                                                                                              | 1.130                                                                      | 456.6                         | 849.5               | 48.22                | 13.68                                          | 33.34                                          | 657                               |
| 58                         | 99.94                            | 3655.                                                                                              | 1.086                                                                      | 477.5                         | 882.5               | 48.79                | 13.70                                          | 32.66                                          | 662                               |
| 59                         | 102.89                           | 3785.                                                                                              | 1.047                                                                      | 497.9                         | 914.9               | 49.35                | 13.73                                          | 32.06                                          | 666                               |
| 60                         | 105.80                           | 3915.                                                                                              | 1.010                                                                      | 517.9                         | 946.7               | 49.88                | 13.77                                          | 31.52                                          | 671                               |
| 61                         | 108.67                           | 4043.                                                                                              | 0.977                                                                      | 537.5                         | 978.0               | 50.40                | 13.82                                          | 31.04                                          | 676                               |
| 62                         | 111.51                           | 4171.                                                                                              | 0.945                                                                      | 556.8                         | 1008.8              | 50.90                | 13.87                                          | 30.61                                          | 680                               |
| 63                         | 114.31                           | 4297.                                                                                              | 0.917                                                                      | 575.9                         | 1039.2              | 51.36                | 13.92                                          | 30.23                                          | 685                               |
| 64                         | 117.08                           | 4423.                                                                                              | 0.889                                                                      | 594.7                         | 1069.2              | 51.86                | 13.98                                          | 29.88                                          | 689                               |
| 65                         | 119.83                           | 4547.                                                                                              | 0.864                                                                      | 613.3                         | 1099.0              | 52.32                | 14.05                                          | 29.58                                          | 694                               |
| 66                         | 122.54                           | 4670.                                                                                              | 0.840                                                                      | 631.8                         | 1128.4              | 52.77                | 14.12                                          | 29.31                                          | 698                               |
| 67                         | 125.24                           | 4792.                                                                                              | 0.818                                                                      | 650.0                         | 1157.6              | 53.21                | 14.20                                          | 29.07                                          | 702                               |
| 68                         | 127.90                           | 4913.                                                                                              | 0.797                                                                      | 668.2                         | 1186.6              | 53.64                | 14.28                                          | 28.86                                          | 706                               |
| 69                         | 130.54                           | 5033.                                                                                              | 0.777                                                                      | 686.3                         | 1215.3              | 54.06                | 14.37                                          | 28.68                                          | 710                               |
| 70                         | 133.16                           | 5152.                                                                                              | 0.758                                                                      | 704.2                         | 1243.9              | 54.47                | 14.47                                          | 28.51                                          | 714                               |
| 71                         | 135.82                           | 5272.                                                                                              | 0.740                                                                      | 722.2                         | 1272.6              | 54.87                | 14.56                                          | 28.36                                          | 718                               |
| 72                         | 138.39                           | 5389.                                                                                              | 0.723                                                                      | 740.0                         | 1300.9              | 55.27                | 14.66                                          | 28.23                                          | 722                               |
| 73                         | 140.95                           | 5504.                                                                                              | 0.707                                                                      | 757.8                         | 1329.1              | 55.66                | 14.77                                          | 28.11                                          | 726                               |
| 74                         | 143.49                           | 5619.                                                                                              | 0.691                                                                      | 775.5                         | 1357.1              | 56.04                | 14.88                                          | 28.02                                          | 729                               |
| 75                         | 146.02                           | 5733.                                                                                              | 0.677                                                                      | 793.3                         | 1385.1              | 56.42                | 15.00                                          | 27.95                                          | 733                               |
| 76                         | 148.53                           | 5846.                                                                                              | 0.663                                                                      | 811.0                         | 1413.0              | 56.79                | 15.12                                          | 27.90                                          | 736                               |
| 77                         | 151.02                           | 5958.                                                                                              | 0.650                                                                      | 828.8                         | 1440.9              | 57.15                | 15.25                                          | 27.87                                          | 740                               |
| 78                         | 153.51                           | 6069.                                                                                              | 0.637                                                                      | 846.6                         | 1468.8              | 57.51                | 15.38                                          | 27.84                                          | 743                               |
| 79                         | 155.97                           | 6180.                                                                                              | 0.625                                                                      | 864.4                         | 1496.6              | 57.86                | 15.51                                          | 27.83                                          | 747                               |
| 80                         | 158.43                           | 6289.                                                                                              | 0.614                                                                      | 882.3                         | 1524.4              | 58.21                | 15.65                                          | 27.84                                          | 750                               |
| 81                         | 160.87                           | 6398.                                                                                              | 0.603                                                                      | 900.3                         | 1552.3              | 58.56                | 15.79                                          | 27.85                                          | 753                               |
| 82                         | 163.31                           | 6507.                                                                                              | 0.592                                                                      | 918.3                         | 1580.2              | 58.90                | 15.93                                          | 27.87                                          | 756                               |
| 83                         | 165.73                           | 6614.                                                                                              | 0.582                                                                      | 936.3                         | 1608.0              | 59.24                | 16.08                                          | 27.91                                          | 760                               |
| 84                         | 168.14                           | 6721.                                                                                              | 0.572                                                                      | 954.5                         | 1636.0              | 59.57                | 16.23                                          | 27.95                                          | 763                               |
| 85                         | 170.54                           | 6828.                                                                                              | 0.563                                                                      | 972.7                         | 1663.9              | 59.91                | 16.38                                          | 28.00                                          | 766                               |
| 86                         | 172.93                           | 6933.                                                                                              | 0.553                                                                      | 991.1                         | 1692.0              | 60.23                | 16.54                                          | 28.05                                          | 769                               |
| 87                         | 175.32                           | 7039.                                                                                              | 0.545                                                                      | 1009.5                        | 1720.1              | 60.56                | 16.70                                          | 28.12                                          | 772                               |
| 88                         | 177.69                           | 7147.                                                                                              | 0.536                                                                      | 1028.0                        | 1748.2              | 60.88                | 16.86                                          | 28.19                                          | 775                               |
| 89                         | 180.06                           | 7247.                                                                                              | 0.528                                                                      | 1046.7                        | 1776.4              | 61.20                | 17.02                                          | 28.27                                          | 778                               |
| 90                         | 182.42                           | 7351.                                                                                              | 0.520                                                                      | 1065.4                        | 1804.7              | 61.52                | 17.19                                          | 28.35                                          | 781                               |
| 91                         | 184.77                           | 7454.                                                                                              | 0.512                                                                      | 1084.3                        | 1833.1              | 61.83                | 17.35                                          | 28.44                                          | 784                               |
| 92                         | 187.11                           | 7557.                                                                                              | 0.505                                                                      | 1103.3                        | 1861.6              | 62.14                | 17.52                                          | 28.53                                          | 786                               |
| 93                         | 189.44                           | 7659.                                                                                              | 0.498                                                                      | 1122.4                        | 1890.2              | 62.45                | 17.69                                          | 28.62                                          | 789                               |
| 94                         | 191.77                           | 7761.                                                                                              | 0.491                                                                      | 1141.6                        | 1918.9              | 62.76                | 17.86                                          | 28.72                                          | 792                               |
| 95                         | 194.10                           | 7862.                                                                                              | 0.484                                                                      | 1161.0                        | 1947.7              | 63.06                | 18.02                                          | 28.83                                          | 795                               |
| 96                         | 196.41                           | 7963.                                                                                              | 0.477                                                                      | 1180.5                        | 1976.5              | 63.36                | 18.19                                          | 28.93                                          | 798                               |
| 97                         | 198.72                           | 8063.                                                                                              | 0.471                                                                      | 1200.1                        | 2005.5              | 63.66                | 18.36                                          | 29.04                                          | 801                               |
| 98                         | 201.03                           | 8163.                                                                                              | 0.465                                                                      | 1219.9                        | 2034.6              | 63.96                | 18.53                                          | 29.16                                          | 803                               |
| 99                         | 203.32                           | 8263.                                                                                              | 0.459                                                                      | 1239.8                        | 2063.8              | 64.26                | 18.70                                          | 29.27                                          | 806                               |
| 100                        | 205.62                           | 8362.                                                                                              | 0.453                                                                      | 1259.8                        | 2093.2              | 64.55                | 18.87                                          | 29.38                                          | 809                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

45.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM/GMOLE | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 15.250                     | 25.38              | 28966.                                                                                 | 9.544                                                            | -618.1                        | -502.3              | 10.21                | 9.97                                  | 13.10                                 | 1383                              |
| 16                         | 25.55              | 27778.                                                                                 | 9.562                                                            | -608.8                        | -492.3              | 10.86                | 10.20                                 | 13.69                                 | 1368                              |
| 17                         | 25.78              | 26526.                                                                                 | 9.533                                                            | -595.8                        | -478.2              | 11.71                | 10.51                                 | 14.44                                 | 1353                              |
| 18                         | 26.02              | 25253.                                                                                 | 9.470                                                            | -582.1                        | -463.4              | 12.55                | 10.81                                 | 15.19                                 | 1336                              |
| 19                         | 26.29              | 24043.                                                                                 | 9.378                                                            | -567.7                        | -447.9              | 13.40                | 11.08                                 | 15.95                                 | 1319                              |
| 20                         | 26.56              | 22824.                                                                                 | 9.263                                                            | -552.7                        | -431.5              | 14.23                | 11.33                                 | 16.71                                 | 1300                              |
| 21                         | 26.86              | 21649.                                                                                 | 9.136                                                            | -536.9                        | -414.5              | 15.07                | 11.57                                 | 17.48                                 | 1282                              |
| 22                         | 27.17              | 20465.                                                                                 | 8.994                                                            | -520.5                        | -396.6              | 15.90                | 11.78                                 | 18.28                                 | 1264                              |
| 23                         | 27.51              | 19320.                                                                                 | 8.835                                                            | -503.3                        | -377.9              | 16.73                | 11.97                                 | 19.09                                 | 1245                              |
| 24                         | 27.86              | 18163.                                                                                 | 8.659                                                            | -485.4                        | -358.4              | 17.56                | 12.14                                 | 19.93                                 | 1224                              |
| 25                         | 28.25              | 17013.                                                                                 | 8.467                                                            | -466.8                        | -338.0              | 18.39                | 12.29                                 | 20.81                                 | 1203                              |
| 26                         | 28.66              | 15881.                                                                                 | 8.258                                                            | -447.4                        | -316.8              | 19.22                | 12.42                                 | 21.71                                 | 1181                              |
| 27                         | 29.10              | 14771.                                                                                 | 8.032                                                            | -427.3                        | -294.6              | 20.06                | 12.54                                 | 22.66                                 | 1158                              |
| 28                         | 29.58              | 13700.                                                                                 | 7.788                                                            | -406.3                        | -271.5              | 20.90                | 12.64                                 | 23.64                                 | 1135                              |
| 29                         | 30.10              | 12644.                                                                                 | 7.529                                                            | -384.6                        | -247.3              | 21.75                | 12.74                                 | 24.67                                 | 1110                              |
| 30                         | 30.66              | 11629.                                                                                 | 7.255                                                            | -361.9                        | -222.1              | 22.60                | 12.81                                 | 25.74                                 | 1084                              |
| 31                         | 31.27              | 10633.                                                                                 | 6.968                                                            | -338.4                        | -195.8              | 23.47                | 12.88                                 | 26.91                                 | 1057                              |
| 32                         | 31.94              | 9680.                                                                                  | 6.671                                                            | -314.0                        | -168.3              | 24.34                | 12.94                                 | 28.15                                 | 1029                              |
| 33                         | 32.68              | 8765.                                                                                  | 6.362                                                            | -288.5                        | -139.5              | 25.22                | 13.00                                 | 29.49                                 | 1000                              |
| 34                         | 33.49              | 7927.                                                                                  | 6.048                                                            | -262.1                        | -109.4              | 26.12                | 13.04                                 | 30.88                                 | 971                               |
| 35                         | 34.40              | 7121.                                                                                  | 5.724                                                            | -234.6                        | -77.8               | 27.04                | 13.09                                 | 32.40                                 | 941                               |
| 36                         | 35.40              | 6371.                                                                                  | 5.395                                                            | -206.0                        | -44.6               | 27.98                | 13.14                                 | 34.02                                 | 911                               |
| 37                         | 36.52              | 5687.                                                                                  | 5.064                                                            | -176.3                        | -9.7                | 28.93                | 13.18                                 | 35.73                                 | 880                               |
| 38                         | 37.78              | 5069.                                                                                  | 4.733                                                            | -145.4                        | 26.9                | 29.91                | 13.22                                 | 37.51                                 | 850                               |
| 39                         | 39.20              | 4523.                                                                                  | 4.406                                                            | -113.4                        | 65.3                | 30.90                | 13.25                                 | 39.32                                 | 821                               |
| 40                         | 40.78              | 4056.                                                                                  | 4.087                                                            | -80.4                         | 105.5               | 31.92                | 13.29                                 | 41.06                                 | 794                               |
| 41                         | 42.56              | 3669.                                                                                  | 3.780                                                            | -46.6                         | 147.4               | 32.96                | 13.33                                 | 42.70                                 | 768                               |
| 42                         | 44.53              | 3349.                                                                                  | 3.488                                                            | -12.2                         | 190.9               | 34.00                | 13.37                                 | 44.11                                 | 744                               |
| 43                         | 46.69              | 3097.                                                                                  | 3.216                                                            | 22.6                          | 235.5               | 35.05                | 13.42                                 | 45.19                                 | 723                               |
| 44                         | 49.05              | 2917.                                                                                  | 2.966                                                            | 57.4                          | 281.0               | 36.10                | 13.46                                 | 45.81                                 | 706                               |
| 45                         | 51.57              | 2801.                                                                                  | 2.738                                                            | 91.8                          | 326.9               | 37.13                | 13.50                                 | 45.94                                 | 692                               |
| 46                         | 54.24              | 2738.                                                                                  | 2.532                                                            | 125.5                         | 372.8               | 38.14                | 13.53                                 | 45.64                                 | 681                               |
| 47                         | 57.01              | 2718.                                                                                  | 2.348                                                            | 158.2                         | 418.1               | 39.12                | 13.56                                 | 44.95                                 | 673                               |
| 48                         | 59.85              | 2734.                                                                                  | 2.185                                                            | 189.8                         | 462.7               | 40.06                | 13.58                                 | 43.99                                 | 667                               |
| 49                         | 62.73              | 2778.                                                                                  | 2.039                                                            | 220.1                         | 506.1               | 40.95                | 13.59                                 | 42.84                                 | 664                               |
| 50                         | 65.63              | 2844.                                                                                  | 1.912                                                            | 249.2                         | 548.4               | 41.81                | 13.60                                 | 41.63                                 | 662                               |
| 51                         | 68.52              | 2927.                                                                                  | 1.798                                                            | 277.0                         | 589.4               | 42.62                | 13.60                                 | 40.40                                 | 661                               |
| 52                         | 71.39              | 3022.                                                                                  | 1.698                                                            | 303.7                         | 629.2               | 43.39                | 13.61                                 | 39.22                                 | 661                               |
| 53                         | 74.24              | 3126.                                                                                  | 1.608                                                            | 329.4                         | 667.9               | 44.13                | 13.63                                 | 38.11                                 | 663                               |
| 54                         | 77.06              | 3237.                                                                                  | 1.528                                                            | 354.1                         | 705.5               | 44.83                | 13.65                                 | 37.09                                 | 665                               |
| 55                         | 79.85              | 3353.                                                                                  | 1.456                                                            | 378.0                         | 742.1               | 45.50                | 13.67                                 | 36.15                                 | 668                               |
| 56                         | 82.60              | 3472.                                                                                  | 1.392                                                            | 401.7                         | 778.3               | 46.16                | 13.69                                 | 35.29                                 | 671                               |
| 57                         | 85.31              | 3594.                                                                                  | 1.333                                                            | 424.2                         | 813.2               | 46.77                | 13.71                                 | 34.50                                 | 674                               |
| 58                         | 88.00              | 3717.                                                                                  | 1.280                                                            | 446.1                         | 847.3               | 47.37                | 13.74                                 | 33.79                                 | 678                               |
| 59                         | 90.65              | 3840.                                                                                  | 1.231                                                            | 467.5                         | 880.8               | 47.94                | 13.77                                 | 33.14                                 | 682                               |
| 60                         | 93.26              | 3965.                                                                                  | 1.186                                                            | 488.4                         | 913.6               | 48.49                | 13.81                                 | 32.57                                 | 685                               |
| 61                         | 95.85              | 4089.                                                                                  | 1.144                                                            | 508.9                         | 945.9               | 49.02                | 13.86                                 | 32.04                                 | 689                               |
| 62                         | 98.41              | 4213.                                                                                  | 1.106                                                            | 529.0                         | 977.7               | 49.54                | 13.91                                 | 31.57                                 | 693                               |
| 63                         | 100.94             | 4337.                                                                                  | 1.071                                                            | 548.8                         | 1009.1              | 50.04                | 13.96                                 | 31.15                                 | 697                               |
| 64                         | 103.44             | 4460.                                                                                  | 1.038                                                            | 568.4                         | 1040.0              | 50.53                | 14.02                                 | 30.77                                 | 701                               |
| 65                         | 105.91             | 4583.                                                                                  | 1.007                                                            | 587.7                         | 1070.6              | 51.01                | 14.09                                 | 30.43                                 | 705                               |
| 66                         | 108.37             | 4705.                                                                                  | 0.978                                                            | 606.8                         | 1100.9              | 51.47                | 14.16                                 | 30.13                                 | 709                               |
| 67                         | 110.80             | 4826.                                                                                  | 0.951                                                            | 625.7                         | 1130.9              | 51.92                | 14.24                                 | 29.85                                 | 713                               |
| 68                         | 113.20             | 4947.                                                                                  | 0.925                                                            | 644.4                         | 1160.6              | 52.36                | 14.32                                 | 29.61                                 | 717                               |
| 69                         | 115.59             | 5067.                                                                                  | 0.902                                                            | 663.1                         | 1190.1              | 52.79                | 14.41                                 | 29.40                                 | 721                               |
| 70                         | 117.96             | 5186.                                                                                  | 0.879                                                            | 681.6                         | 1219.4              | 53.21                | 14.51                                 | 29.20                                 | 724                               |
| 71                         | 120.31             | 5304.                                                                                  | 0.858                                                            | 700.0                         | 1248.5              | 53.62                | 14.60                                 | 29.04                                 | 728                               |
| 72                         | 122.64             | 5420.                                                                                  | 0.837                                                            | 718.3                         | 1277.5              | 54.03                | 14.71                                 | 28.90                                 | 732                               |
| 73                         | 124.96             | 5536.                                                                                  | 0.818                                                            | 736.6                         | 1306.3              | 54.43                | 14.81                                 | 28.77                                 | 735                               |
| 74                         | 127.25             | 5652.                                                                                  | 0.800                                                            | 754.8                         | 1335.0              | 54.82                | 14.93                                 | 28.67                                 | 739                               |
| 75                         | 129.54             | 5766.                                                                                  | 0.782                                                            | 773.0                         | 1363.7              | 55.20                | 15.04                                 | 28.58                                 | 742                               |
| 76                         | 131.81             | 5880.                                                                                  | 0.766                                                            | 791.2                         | 1392.2              | 55.58                | 15.16                                 | 28.50                                 | 745                               |
| 77                         | 134.08             | 5995.                                                                                  | 0.750                                                            | 809.4                         | 1420.8              | 55.95                | 15.29                                 | 28.44                                 | 749                               |
| 78                         | 136.32             | 6109.                                                                                  | 0.735                                                            | 827.6                         | 1449.2              | 56.32                | 15.42                                 | 28.39                                 | 752                               |
| 79                         | 138.54             | 6229.                                                                                  | 0.720                                                            | 845.8                         | 1477.5              | 56.68                | 15.55                                 | 28.35                                 | 755                               |
| 80                         | 140.76             | 6331.                                                                                  | 0.706                                                            | 864.0                         | 1505.8              | 57.04                | 15.68                                 | 28.32                                 | 758                               |
| 81                         | 142.96             | 6441.                                                                                  | 0.692                                                            | 882.3                         | 1534.1              | 57.39                | 15.82                                 | 28.31                                 | 761                               |
| 82                         | 145.15             | 6551.                                                                                  | 0.680                                                            | 900.6                         | 1562.5              | 57.74                | 15.97                                 | 28.31                                 | 764                               |
| 83                         | 147.33             | 6660.                                                                                  | 0.668                                                            | 919.0                         | 1590.8              | 58.08                | 16.11                                 | 28.33                                 | 767                               |
| 84                         | 149.50             | 6768.                                                                                  | 0.656                                                            | 937.5                         | 1619.1              | 58.42                | 16.26                                 | 28.36                                 | 770                               |
| 85                         | 151.66             | 6876.                                                                                  | 0.645                                                            | 956.0                         | 1647.5              | 58.75                | 16.42                                 | 28.40                                 | 773                               |
| 86                         | 153.82             | 6983.                                                                                  | 0.634                                                            | 974.6                         | 1675.9              | 59.09                | 16.57                                 | 28.44                                 | 776                               |
| 87                         | 155.96             | 7090.                                                                                  | 0.624                                                            | 993.3                         | 1704.4              | 59.42                | 16.73                                 | 28.49                                 | 779                               |
| 88                         | 158.10             | 7196.                                                                                  | 0.614                                                            | 1012.1                        | 1732.9              | 59.74                | 16.89                                 | 28.55                                 | 782                               |
| 89                         | 160.22             | 7301.                                                                                  | 0.604                                                            | 1030.9                        | 1761.5              | 60.06                | 17.05                                 | 28.62                                 | 785                               |
| 90                         | 162.34             | 7406.                                                                                  | 0.595                                                            | 1049.9                        | 1790.2              | 60.39                | 17.21                                 | 28.69                                 | 788                               |
| 91                         | 164.46             | 7511.                                                                                  | 0.586                                                            | 1069.0                        | 1818.9              | 60.70                | 17.38                                 | 28.77                                 | 791                               |
| 92                         | 166.56             | 7615.                                                                                  | 0.577                                                            | 1088.2                        | 1847.7              | 61.02                | 17.54                                 | 28.85                                 | 793                               |
| 93                         | 168.66             | 7718.                                                                                  | 0.569                                                            | 1107.6                        | 1876.6              | 61.33                | 17.71                                 | 28.94                                 | 796                               |
| 94                         | 170.75             | 7821.                                                                                  | 0.560                                                            | 1127.0                        | 1905.6              | 61.64                | 17.88                                 | 29.03                                 | 799                               |
| 95                         | 172.84             | 7924.                                                                                  | 0.553                                                            | 1146.6                        | 1934.7              | 61.95                | 18.05                                 | 29.13                                 | 802                               |
| 96                         | 174.92             | 8026.                                                                                  | 0.545                                                            | 1166.3                        | 1963.8              | 62.25                | 18.22                                 | 29.22                                 | 804                               |
| 97                         | 177.00             | 8128.                                                                                  | 0.537                                                            | 1186.1                        | 1993.1              | 62.56                | 18.39                                 | 29.33                                 | 807                               |
| 98                         | 179.06             | 8229.                                                                                  | 0.530                                                            | 1206.0                        | 2022.5              | 62.86                | 18.55                                 | 29.43                                 | 810                               |
| 99                         | 181.13             | 8330.                                                                                  | 0.523                                                            | 1226.1                        | 2052.0              | 63.16                | 18.72                                 | 29.54                                 | 813                               |
| 100                        | 183.19             | 8431.                                                                                  | 0.516                                                            | 1246.3                        | 2081.6              | 63.45                | 18.89                                 | 29.65                                 | 815                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMOODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

## 50.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 15.402                   | 25.30                            | 29559.                                                                                             | 9.567                                                                       | -617.3                        | -489.2              | 10.24                | 10.00                                          | 13.09                                          | 1395                              |
| 16                         | 25.43                            | 28594.                                                                                             | 9.590                                                                       | -610.0                        | -481.2              | 10.74                | 10.19                                          | 13.57                                          | 1383                              |
| 17                         | 25.66                            | 27324.                                                                                             | 9.581                                                                       | -597.2                        | -467.2              | 11.59                | 10.50                                          | 14.31                                          | 1368                              |
| 18                         | 25.89                            | 26057.                                                                                             | 9.529                                                                       | -583.7                        | -452.5              | 12.43                | 10.80                                          | 15.06                                          | 1351                              |
| 19                         | 26.14                            | 24877.                                                                                             | 9.448                                                                       | -569.6                        | -437.1              | 13.26                | 11.07                                          | 15.79                                          | 1335                              |
| 20                         | 26.41                            | 23679.                                                                                             | 9.344                                                                       | -554.8                        | -421.0              | 14.09                | 11.32                                          | 16.54                                          | 1318                              |
| 21                         | 26.70                            | 22500.                                                                                             | 9.224                                                                       | -539.3                        | -404.1              | 14.92                | 11.56                                          | 17.29                                          | 1301                              |
| 22                         | 27.00                            | 21333.                                                                                             | 9.091                                                                       | -523.2                        | -386.4              | 15.74                | 11.77                                          | 18.06                                          | 1283                              |
| 23                         | 27.32                            | 20191.                                                                                             | 8.939                                                                       | -506.3                        | -367.9              | 16.56                | 11.96                                          | 18.84                                          | 1264                              |
| 24                         | 27.66                            | 19057.                                                                                             | 8.771                                                                       | -488.8                        | -348.7              | 17.38                | 12.13                                          | 19.64                                          | 1245                              |
| 25                         | 28.02                            | 17914.                                                                                             | 8.587                                                                       | -470.6                        | -328.7              | 18.19                | 12.28                                          | 20.47                                          | 1225                              |
| 26                         | 28.41                            | 16801.                                                                                             | 8.388                                                                       | -451.7                        | -307.8              | 19.01                | 12.42                                          | 21.32                                          | 1204                              |
| 27                         | 28.83                            | 15707.                                                                                             | 8.172                                                                       | -432.1                        | -286.0              | 19.83                | 12.54                                          | 22.21                                          | 1182                              |
| 28                         | 29.28                            | 14650.                                                                                             | 7.941                                                                       | -411.7                        | -263.4              | 20.66                | 12.65                                          | 23.11                                          | 1160                              |
| 29                         | 29.76                            | 13609.                                                                                             | 7.696                                                                       | -390.5                        | -239.8              | 21.49                | 12.74                                          | 24.07                                          | 1137                              |
| 30                         | 30.28                            | 12607.                                                                                             | 7.436                                                                       | -368.6                        | -215.2              | 22.32                | 12.82                                          | 25.04                                          | 1112                              |
| 31                         | 30.84                            | 11627.                                                                                             | 7.164                                                                       | -345.9                        | -189.7              | 23.16                | 12.89                                          | 26.08                                          | 1087                              |
| 32                         | 31.45                            | 10679.                                                                                             | 6.882                                                                       | -322.4                        | -163.1              | 24.00                | 12.95                                          | 27.18                                          | 10                                |
| 33                         | 32.12                            | 9777.                                                                                              | 6.591                                                                       | -298.1                        | -135.4              | 24.85                | 13.01                                          | 28.34                                          | 1034                              |
| 34                         | 32.84                            | 8936.                                                                                              | 6.294                                                                       | -272.8                        | -106.5              | 25.72                | 13.06                                          | 29.53                                          | 1008                              |
| 35                         | 33.64                            | 8133.                                                                                              | 5.991                                                                       | -246.7                        | -76.3               | 26.59                | 13.10                                          | 30.81                                          | 980                               |
| 36                         | 34.51                            | 7377.                                                                                              | 5.683                                                                       | -219.7                        | -44.8               | 27.48                | 13.14                                          | 32.16                                          | 953                               |
| 37                         | 35.47                            | 6681.                                                                                              | 5.371                                                                       | -191.7                        | -12.0               | 28.38                | 13.18                                          | 33.55                                          | 925                               |
| 38                         | 36.54                            | 6045.                                                                                              | 5.061                                                                       | -162.9                        | 22.3                | 29.29                | 13.21                                          | 34.99                                          | 897                               |
| 39                         | 37.71                            | 5477.                                                                                              | 4.753                                                                       | -133.1                        | 58.0                | 30.22                | 13.24                                          | 36.44                                          | 870                               |
| 40                         | 39.01                            | 4967.                                                                                              | 4.451                                                                       | -102.5                        | 95.1                | 31.16                | 13.26                                          | 37.86                                          | 844                               |
| 41                         | 40.44                            | 4527.                                                                                              | 4.157                                                                       | -71.2                         | 133.7               | 32.11                | 13.29                                          | 39.23                                          | 820                               |
| 42                         | 42.02                            | 4155.                                                                                              | 3.875                                                                       | -39.3                         | 173.5               | 33.07                | 13.32                                          | 40.47                                          | 797                               |
| 43                         | 43.74                            | 3845.                                                                                              | 3.607                                                                       | -7.0                          | 214.5               | 34.04                | 13.36                                          | 41.56                                          | 775                               |
| 44                         | 45.60                            | 3601.                                                                                              | 3.355                                                                       | 25.5                          | 256.5               | 35.00                | 13.39                                          | 42.38                                          | 757                               |
| 45                         | 47.61                            | 3417.                                                                                              | 3.121                                                                       | 57.9                          | 299.1               | 35.96                | 13.43                                          | 42.88                                          | 741                               |
| 46                         | 49.74                            | 3287.                                                                                              | 2.907                                                                       | 90.2                          | 342.2               | 36.91                | 13.47                                          | 43.10                                          | 727                               |
| 47                         | 51.97                            | 3207.                                                                                              | 2.710                                                                       | 121.9                         | 385.3               | 37.83                | 13.51                                          | 43.02                                          | 716                               |
| 48                         | 54.30                            | 3157.                                                                                              | 2.531                                                                       | 153.0                         | 428.1               | 38.74                | 13.54                                          | 42.65                                          | 707                               |
| 49                         | 56.70                            | 3149.                                                                                              | 2.370                                                                       | 183.3                         | 470.5               | 39.61                | 13.57                                          | 42.05                                          | 700                               |
| 50                         | 59.14                            | 3166.                                                                                              | 2.225                                                                       | 212.6                         | 512.2               | 40.45                | 13.59                                          | 41.29                                          | 695                               |
| 51                         | 61.61                            | 3207.                                                                                              | 2.095                                                                       | 241.0                         | 553.1               | 41.26                | 13.61                                          | 40.44                                          | 692                               |
| 52                         | 64.10                            | 3267.                                                                                              | 1.977                                                                       | 268.4                         | 593.1               | 42.04                | 13.63                                          | 39.53                                          | 690                               |
| 53                         | 66.58                            | 3347.                                                                                              | 1.872                                                                       | 294.8                         | 632.2               | 42.78                | 13.65                                          | 38.61                                          | 689                               |
| 54                         | 69.06                            | 3426.                                                                                              | 1.777                                                                       | 320.4                         | 670.3               | 43.50                | 13.67                                          | 37.72                                          | 689                               |
| 55                         | 71.52                            | 3521.                                                                                              | 1.692                                                                       | 345.2                         | 707.6               | 44.18                | 13.69                                          | 36.88                                          | 690                               |
| 56                         | 73.97                            | 3627.                                                                                              | 1.615                                                                       | 369.8                         | 744.6               | 44.85                | 13.72                                          | 36.07                                          | 692                               |
| 57                         | 76.40                            | 3729.                                                                                              | 1.545                                                                       | 393.2                         | 780.2               | 45.48                | 13.74                                          | 35.32                                          | 694                               |
| 58                         | 78.81                            | 3839.                                                                                              | 1.481                                                                       | 415.9                         | 815.2               | 46.09                | 13.77                                          | 34.62                                          | 696                               |
| 59                         | 81.19                            | 3951.                                                                                              | 1.422                                                                       | 438.1                         | 849.5               | 46.67                | 13.80                                          | 33.98                                          | 699                               |
| 60                         | 83.55                            | 4067.                                                                                              | 1.369                                                                       | 459.9                         | 883.1               | 47.24                | 13.84                                          | 33.39                                          | 702                               |
| 61                         | 85.89                            | 4187.                                                                                              | 1.319                                                                       | 481.1                         | 916.3               | 47.78                | 13.89                                          | 32.86                                          | 705                               |
| 62                         | 88.20                            | 4301.                                                                                              | 1.274                                                                       | 502.0                         | 948.9               | 48.32                | 13.94                                          | 32.37                                          | 709                               |
| 63                         | 90.49                            | 4419.                                                                                              | 1.231                                                                       | 522.5                         | 981.0               | 48.83                | 13.99                                          | 31.92                                          | 712                               |
| 64                         | 92.76                            | 4538.                                                                                              | 1.192                                                                       | 542.8                         | 1012.7              | 49.33                | 14.06                                          | 31.53                                          | 715                               |
| 65                         | 95.01                            | 4657.                                                                                              | 1.155                                                                       | 562.7                         | 1044.1              | 49.81                | 14.12                                          | 31.16                                          | 719                               |
| 66                         | 97.24                            | 4776.                                                                                              | 1.121                                                                       | 582.4                         | 1075.1              | 50.29                | 14.20                                          | 30.84                                          | 722                               |
| 67                         | 99.45                            | 4895.                                                                                              | 1.089                                                                       | 601.9                         | 1105.7              | 50.75                | 14.28                                          | 30.54                                          | 725                               |
| 68                         | 101.64                           | 5014.                                                                                              | 1.059                                                                       | 621.2                         | 1136.1              | 51.20                | 14.36                                          | 30.28                                          | 729                               |
| 69                         | 103.82                           | 5132.                                                                                              | 1.031                                                                       | 640.3                         | 1166.3              | 51.64                | 14.45                                          | 30.04                                          | 732                               |
| 70                         | 105.97                           | 5250.                                                                                              | 1.004                                                                       | 659.4                         | 1196.2              | 52.07                | 14.54                                          | 29.83                                          | 736                               |
| 71                         | 108.11                           | 5366.                                                                                              | 0.979                                                                       | 678.3                         | 1226.0              | 52.49                | 14.64                                          | 29.65                                          | 739                               |
| 72                         | 110.24                           | 5487.                                                                                              | 0.955                                                                       | 697.1                         | 1255.5              | 52.91                | 14.74                                          | 29.48                                          | 742                               |
| 73                         | 112.34                           | 5598.                                                                                              | 0.932                                                                       | 715.8                         | 1284.9              | 53.31                | 14.85                                          | 29.34                                          | 745                               |
| 74                         | 114.44                           | 5713.                                                                                              | 0.911                                                                       | 734.4                         | 1314.2              | 53.71                | 14.97                                          | 29.22                                          | 749                               |
| 75                         | 116.52                           | 5827.                                                                                              | 0.890                                                                       | 753.1                         | 1343.4              | 54.10                | 15.08                                          | 29.11                                          | 752                               |
| 76                         | 118.58                           | 5941.                                                                                              | 0.871                                                                       | 771.6                         | 1372.4              | 54.49                | 15.20                                          | 29.02                                          | 755                               |
| 77                         | 120.64                           | 6055.                                                                                              | 0.852                                                                       | 790.2                         | 1401.4              | 54.87                | 15.33                                          | 28.95                                          | 758                               |
| 78                         | 122.68                           | 6169.                                                                                              | 0.835                                                                       | 808.8                         | 1430.3              | 55.24                | 15.46                                          | 28.89                                          | 761                               |
| 79                         | 124.71                           | 6287.                                                                                              | 0.817                                                                       | 827.4                         | 1459.2              | 55.61                | 15.59                                          | 28.84                                          | 764                               |
| 80                         | 126.73                           | 6397.                                                                                              | 0.801                                                                       | 845.9                         | 1488.0              | 55.97                | 15.72                                          | 28.81                                          | 767                               |
| 81                         | 128.73                           | 6504.                                                                                              | 0.786                                                                       | 864.6                         | 1516.8              | 56.33                | 15.86                                          | 28.79                                          | 770                               |
| 82                         | 130.73                           | 6614.                                                                                              | 0.771                                                                       | 883.2                         | 1545.5              | 56.68                | 16.01                                          | 28.77                                          | 773                               |
| 83                         | 132.72                           | 6725.                                                                                              | 0.757                                                                       | 901.9                         | 1574.3              | 57.03                | 16.15                                          | 28.77                                          | 776                               |
| 84                         | 134.69                           | 6839.                                                                                              | 0.743                                                                       | 920.7                         | 1603.0              | 57.37                | 16.30                                          | 28.78                                          | 779                               |
| 85                         | 136.66                           | 6939.                                                                                              | 0.730                                                                       | 939.5                         | 1631.8              | 57.71                | 16.45                                          | 28.80                                          | 781                               |
| 86                         | 138.62                           | 7047.                                                                                              | 0.717                                                                       | 958.4                         | 1660.6              | 58.05                | 16.60                                          | 28.83                                          | 784                               |
| 87                         | 140.57                           | 7154.                                                                                              | 0.705                                                                       | 977.3                         | 1689.5              | 58.38                | 16.76                                          | 28.86                                          | 787                               |
| 88                         | 142.51                           | 7262.                                                                                              | 0.693                                                                       | 996.3                         | 1718.3              | 58.71                | 16.92                                          | 28.90                                          | 790                               |
| 89                         | 144.45                           | 7368.                                                                                              | 0.682                                                                       | 1015.5                        | 1747.3              | 59.04                | 17.08                                          | 28.96                                          | 792                               |
| 90                         | 146.37                           | 7474.                                                                                              | 0.671                                                                       | 1034.7                        | 1776.2              | 59.36                | 17.24                                          | 29.02                                          | 795                               |
| 91                         | 148.29                           | 7580.                                                                                              | 0.661                                                                       | 1054.0                        | 1805.3              | 59.68                | 17.40                                          | 29.09                                          | 798                               |
| 92                         | 150.21                           | 7685.                                                                                              | 0.651                                                                       | 1073.4                        | 1834.4              | 60.00                | 17.57                                          | 29.16                                          | 801                               |
| 93                         | 152.12                           | 7789.                                                                                              | 0.641                                                                       | 1093.0                        | 1863.6              | 60.32                | 17.74                                          | 29.24                                          | 803                               |
| 94                         | 154.02                           | 7893.                                                                                              | 0.632                                                                       | 1112.6                        | 1892.9              | 60.63                | 17.90                                          | 29.32                                          | 806                               |
| 95                         | 155.91                           | 7997.                                                                                              | 0.623                                                                       | 1132.4                        | 1922.3              | 60.94                | 18.07                                          | 29.41                                          | 809                               |
| 96                         | 157.80                           | 8100.                                                                                              | 0.614                                                                       | 1152.3                        | 1951.7              | 61.25                | 18.24                                          | 29.50                                          | 811                               |
| 97                         | 159.69                           | 8203.                                                                                              | 0.605                                                                       | 1172.3                        | 1981.3              | 61.56                | 18.41                                          | 29.60                                          | 814                               |
| 98                         | 161.56                           | 8305.                                                                                              | 0.597                                                                       | 1192.4                        | 2010.9              | 61.86                | 18.58                                          | 29.69                                          | 817                               |
| 99                         | 163.44                           | 8407.                                                                                              | 0.589                                                                       | 1212.7                        | 2040.7              | 62.16                | 18.74                                          | 29.79                                          | 820                               |
| 100                        | 165.31                           | 8509.                                                                                              | 0.581                                                                       | 1233.0                        | 2070.5              | 62.46                | 18.91                                          | 29.90                                          | 822                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

60.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM/GMOLE | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 15.701                     | 25.15              | 30691.                                                                                 | 9.606                                                            | -615.8                        | -462.9              | 10.28                | 10.06                                 | 13.09                                 | 1416                              |
| 16                         | 25.21              | 30202.                                                                                 | 9.634                                                            | -612.2                        | -458.9              | 10.53                | 10.16                                 | 13.33                                 | 1411                              |
| 17                         | 25.42              | 28867.                                                                                 | 9.664                                                            | -599.8                        | -445.2              | 11.36                | 10.48                                 | 14.08                                 | 1396                              |
| 18                         | 25.65              | 27627.                                                                                 | 9.637                                                            | -586.7                        | -430.8              | 12.19                | 10.78                                 | 14.81                                 | 1381                              |
| 19                         | 25.88              | 26486.                                                                                 | 9.577                                                            | -572.9                        | -415.6              | 13.01                | 11.05                                 | 15.52                                 | 1367                              |
| 20                         | 26.13              | 25335.                                                                                 | 9.491                                                            | -558.6                        | -399.7              | 13.82                | 11.31                                 | 16.22                                 | 1352                              |
| 21                         | 26.39              | 24150.                                                                                 | 9.385                                                            | -543.6                        | -383.1              | 14.63                | 11.54                                 | 16.94                                 | 1335                              |
| 22                         | 26.67              | 23018.                                                                                 | 9.265                                                            | -528.0                        | -365.9              | 15.44                | 11.75                                 | 17.66                                 | 1319                              |
| 23                         | 26.97              | 21877.                                                                                 | 9.130                                                            | -511.8                        | -347.8              | 16.24                | 11.94                                 | 18.40                                 | 1302                              |
| 24                         | 27.28              | 20760.                                                                                 | 8.977                                                            | -494.9                        | -329.1              | 17.04                | 12.12                                 | 19.14                                 | 1284                              |
| 25                         | 27.61              | 19659.                                                                                 | 8.809                                                            | -477.4                        | -309.5              | 17.83                | 12.27                                 | 19.89                                 | 1266                              |
| 26                         | 27.96              | 18574.                                                                                 | 8.626                                                            | -459.3                        | -289.3              | 18.63                | 12.41                                 | 20.66                                 | 1247                              |
| 27                         | 28.34              | 17508.                                                                                 | 8.429                                                            | -440.5                        | -268.2              | 19.42                | 12.54                                 | 21.45                                 | 1227                              |
| 28                         | 28.74              | 16471.                                                                                 | 8.218                                                            | -421.1                        | -246.4              | 20.22                | 12.65                                 | 22.26                                 | 1207                              |
| 29                         | 29.16              | 15455.                                                                                 | 7.994                                                            | -401.0                        | -223.7              | 21.01                | 12.76                                 | 23.09                                 | 1186                              |
| 30                         | 29.62              | 14464.                                                                                 | 7.757                                                            | -380.3                        | -200.2              | 21.81                | 12.84                                 | 23.93                                 | 1164                              |
| 31                         | 30.10              | 13510.                                                                                 | 7.510                                                            | -358.9                        | -175.9              | 22.61                | 12.91                                 | 24.80                                 | 1142                              |
| 32                         | 30.62              | 12584.                                                                                 | 7.254                                                            | -336.8                        | -150.6              | 23.41                | 12.98                                 | 25.70                                 | 1119                              |
| 33                         | 31.18              | 11697.                                                                                 | 6.990                                                            | -314.1                        | -124.5              | 24.21                | 13.04                                 | 26.62                                 | 1096                              |
| 34                         | 31.79              | 10854.                                                                                 | 6.720                                                            | -290.7                        | -97.4               | 25.02                | 13.09                                 | 27.57                                 | 1072                              |
| 35                         | 32.43              | 10055.                                                                                 | 6.445                                                            | -266.6                        | -69.4               | 25.83                | 13.13                                 | 28.55                                 | 1048                              |
| 36                         | 33.14              | 9293.                                                                                  | 6.168                                                            | -241.8                        | -40.3               | 26.65                | 13.17                                 | 29.57                                 | 1024                              |
| 37                         | 33.89              | 8579.                                                                                  | 5.887                                                            | -216.3                        | -10.2               | 27.48                | 13.21                                 | 30.60                                 | 1000                              |
| 38                         | 34.71              | 7920.                                                                                  | 5.607                                                            | -190.2                        | 20.9                | 28.31                | 13.23                                 | 31.65                                 | 976                               |
| 39                         | 35.60              | 7310.                                                                                  | 5.327                                                            | -163.4                        | 53.0                | 29.14                | 13.25                                 | 32.69                                 | 952                               |
| 40                         | 36.56              | 6754.                                                                                  | 5.052                                                            | -136.0                        | 86.2                | 29.98                | 13.26                                 | 33.73                                 | 929                               |
| 41                         | 37.60              | 6255.                                                                                  | 4.780                                                            | -108.1                        | 120.5               | 30.83                | 13.28                                 | 34.74                                 | 907                               |
| 42                         | 38.72              | 5813.                                                                                  | 4.517                                                            | -79.8                         | 155.7               | 31.67                | 13.29                                 | 35.69                                 | 886                               |
| 43                         | 39.93              | 5427.                                                                                  | 4.261                                                            | -51.0                         | 191.8               | 32.52                | 13.32                                 | 36.58                                 | 865                               |
| 44                         | 41.23              | 5086.                                                                                  | 4.017                                                            | -21.9                         | 228.8               | 33.37                | 13.34                                 | 37.39                                 | 846                               |
| 45                         | 42.61              | 4803.                                                                                  | 3.784                                                            | 7.4                           | 266.5               | 34.22                | 13.37                                 | 38.05                                 | 829                               |
| 46                         | 44.08              | 4577.                                                                                  | 3.564                                                            | 36.8                          | 304.8               | 35.07                | 13.41                                 | 38.59                                 | 813                               |
| 47                         | 45.64              | 4384.                                                                                  | 3.358                                                            | 66.1                          | 343.6               | 35.90                | 13.45                                 | 38.97                                 | 799                               |
| 48                         | 47.27              | 4238.                                                                                  | 3.165                                                            | 95.2                          | 382.6               | 36.72                | 13.49                                 | 39.18                                 | 786                               |
| 49                         | 48.97              | 4131.                                                                                  | 2.986                                                            | 124.1                         | 421.8               | 37.53                | 13.53                                 | 39.23                                 | 776                               |
| 50                         | 50.73              | 4059.                                                                                  | 2.820                                                            | 152.6                         | 461.0               | 38.32                | 13.57                                 | 39.13                                 | 767                               |
| 51                         | 52.55              | 4015.                                                                                  | 2.667                                                            | 180.6                         | 500.0               | 39.10                | 13.60                                 | 38.88                                 | 760                               |
| 52                         | 54.40              | 3997.                                                                                  | 2.527                                                            | 208.0                         | 538.8               | 39.85                | 13.63                                 | 38.54                                 | 754                               |
| 53                         | 56.28              | 4007.                                                                                  | 2.398                                                            | 234.9                         | 577.1               | 40.58                | 13.67                                 | 38.10                                 | 749                               |
| 54                         | 58.19              | 4026.                                                                                  | 2.279                                                            | 261.2                         | 614.9               | 41.28                | 13.70                                 | 37.60                                 | 745                               |
| 55                         | 60.11              | 4066.                                                                                  | 2.170                                                            | 286.8                         | 652.2               | 41.97                | 13.73                                 | 37.06                                 | 743                               |
| 56                         | 62.05              | 4110.                                                                                  | 2.071                                                            | 312.3                         | 689.5               | 42.64                | 13.76                                 | 36.51                                 | 741                               |
| 57                         | 63.98              | 4183.                                                                                  | 1.980                                                            | 336.8                         | 725.7               | 43.28                | 13.79                                 | 35.94                                 | 740                               |
| 58                         | 65.91              | 4257.                                                                                  | 1.896                                                            | 360.6                         | 761.4               | 43.90                | 13.82                                 | 35.38                                 | 740                               |
| 59                         | 67.84              | 4338.                                                                                  | 1.819                                                            | 384.0                         | 796.4               | 44.50                | 13.85                                 | 34.85                                 | 741                               |
| 60                         | 69.77              | 4425.                                                                                  | 1.748                                                            | 406.8                         | 831.0               | 45.08                | 13.89                                 | 34.34                                 | 741                               |
| 61                         | 71.68              | 4518.                                                                                  | 1.683                                                            | 429.3                         | 865.1               | 45.65                | 13.94                                 | 33.85                                 | 743                               |
| 62                         | 73.59              | 4615.                                                                                  | 1.622                                                            | 451.3                         | 898.7               | 46.19                | 13.99                                 | 33.40                                 | 744                               |
| 63                         | 75.49              | 4715.                                                                                  | 1.566                                                            | 472.9                         | 931.8               | 46.72                | 14.05                                 | 32.98                                 | 746                               |
| 64                         | 77.37              | 4817.                                                                                  | 1.514                                                            | 494.2                         | 964.6               | 47.24                | 14.12                                 | 32.59                                 | 748                               |
| 65                         | 79.25              | 4927.                                                                                  | 1.465                                                            | 515.2                         | 997.0               | 47.74                | 14.18                                 | 32.23                                 | 750                               |
| 66                         | 81.11              | 5029.                                                                                  | 1.420                                                            | 535.9                         | 1029.0              | 48.23                | 14.26                                 | 31.90                                 | 752                               |
| 67                         | 82.96              | 5137.                                                                                  | 1.377                                                            | 556.4                         | 1060.8              | 48.71                | 14.34                                 | 31.59                                 | 754                               |
| 68                         | 84.80              | 5246.                                                                                  | 1.337                                                            | 576.7                         | 1092.2              | 49.17                | 14.42                                 | 31.32                                 | 757                               |
| 69                         | 86.63              | 5356.                                                                                  | 1.300                                                            | 596.8                         | 1123.4              | 49.63                | 14.51                                 | 31.06                                 | 759                               |
| 70                         | 88.44              | 5467.                                                                                  | 1.265                                                            | 616.7                         | 1154.4              | 50.07                | 14.61                                 | 30.84                                 | 762                               |
| 71                         | 90.25              | 5578.                                                                                  | 1.231                                                            | 636.4                         | 1185.1              | 50.51                | 14.71                                 | 30.63                                 | 764                               |
| 72                         | 92.04              | 5688.                                                                                  | 1.200                                                            | 656.1                         | 1215.6              | 50.94                | 14.81                                 | 30.45                                 | 767                               |
| 73                         | 93.82              | 5799.                                                                                  | 1.170                                                            | 675.6                         | 1246.0              | 51.36                | 14.92                                 | 30.29                                 | 769                               |
| 74                         | 95.59              | 5910.                                                                                  | 1.141                                                            | 695.1                         | 1276.2              | 51.77                | 15.04                                 | 30.14                                 | 772                               |
| 75                         | 97.35              | 6021.                                                                                  | 1.115                                                            | 714.4                         | 1306.3              | 52.17                | 15.15                                 | 30.02                                 | 774                               |
| 76                         | 99.10              | 6133.                                                                                  | 1.089                                                            | 733.8                         | 1336.2              | 52.57                | 15.28                                 | 29.90                                 | 777                               |
| 77                         | 100.84             | 6243.                                                                                  | 1.065                                                            | 753.0                         | 1366.1              | 52.96                | 15.40                                 | 29.81                                 | 779                               |
| 78                         | 102.56             | 6354.                                                                                  | 1.042                                                            | 772.3                         | 1395.8              | 53.34                | 15.53                                 | 29.73                                 | 782                               |
| 79                         | 104.28             | 6465.                                                                                  | 1.020                                                            | 791.5                         | 1425.5              | 53.72                | 15.67                                 | 29.66                                 | 784                               |
| 80                         | 105.99             | 6576.                                                                                  | 0.998                                                            | 810.8                         | 1455.2              | 54.09                | 15.80                                 | 29.61                                 | 787                               |
| 81                         | 107.69             | 6686.                                                                                  | 0.978                                                            | 830.0                         | 1484.7              | 54.46                | 15.94                                 | 29.57                                 | 789                               |
| 82                         | 109.39             | 6796.                                                                                  | 0.959                                                            | 849.3                         | 1514.3              | 54.82                | 16.09                                 | 29.54                                 | 792                               |
| 83                         | 111.07             | 6906.                                                                                  | 0.940                                                            | 868.6                         | 1543.8              | 55.18                | 16.23                                 | 29.52                                 | 794                               |
| 84                         | 112.75             | 7015.                                                                                  | 0.923                                                            | 887.9                         | 1573.3              | 55.53                | 16.38                                 | 29.51                                 | 797                               |
| 85                         | 114.41             | 7124.                                                                                  | 0.906                                                            | 907.3                         | 1602.8              | 55.88                | 16.53                                 | 29.51                                 | 799                               |
| 86                         | 116.07             | 7237.                                                                                  | 0.889                                                            | 926.7                         | 1632.3              | 56.23                | 16.69                                 | 29.52                                 | 802                               |
| 87                         | 117.73             | 7340.                                                                                  | 0.873                                                            | 946.2                         | 1661.9              | 56.57                | 16.84                                 | 29.53                                 | 804                               |
| 88                         | 119.37             | 7447.                                                                                  | 0.858                                                            | 965.7                         | 1691.4              | 56.91                | 17.00                                 | 29.56                                 | 807                               |
| 89                         | 121.01             | 7554.                                                                                  | 0.844                                                            | 985.3                         | 1721.0              | 57.24                | 17.16                                 | 29.60                                 | 809                               |
| 90                         | 122.64             | 7661.                                                                                  | 0.829                                                            | 1005.0                        | 1750.6              | 57.57                | 17.32                                 | 29.63                                 | 812                               |
| 91                         | 124.27             | 7767.                                                                                  | 0.816                                                            | 1024.8                        | 1780.3              | 57.90                | 17.48                                 | 29.68                                 | 814                               |
| 92                         | 125.89             | 7877.                                                                                  | 0.803                                                            | 1044.6                        | 1810.0              | 58.22                | 17.64                                 | 29.73                                 | 817                               |
| 93                         | 127.50             | 7976.                                                                                  | 0.790                                                            | 1064.6                        | 1839.7              | 58.55                | 17.80                                 | 29.79                                 | 819                               |
| 94                         | 129.11             | 8081.                                                                                  | 0.778                                                            | 1084.6                        | 1869.5              | 58.87                | 17.97                                 | 29.85                                 | 821                               |
| 95                         | 130.71             | 8184.                                                                                  | 0.766                                                            | 1104.8                        | 1899.4              | 59.18                | 18.13                                 | 29.92                                 | 824                               |
| 96                         | 132.30             | 8288.                                                                                  | 0.754                                                            | 1125.0                        | 1929.4              | 59.49                | 18.29                                 | 29.98                                 | 826                               |
| 97                         | 133.89             | 8387.                                                                                  | 0.743                                                            | 1145.4                        | 1959.4              | 59.81                | 18.46                                 | 30.07                                 | 829                               |
| 98                         | 135.48             | 8487.                                                                                  | 0.733                                                            | 1165.8                        | 1989.5              | 60.12                | 18.62                                 | 30.16                                 | 831                               |
| 99                         | 137.07             | 8590.                                                                                  | 0.723                                                            | 1186.4                        | 2019.7              | 60.42                | 18.79                                 | 30.25                                 | 834                               |
| 100                        | 138.65             | 8693.                                                                                  | 0.713                                                            | 1207.1                        | 2050.0              | 60.73                | 18.95                                 | 30.34                                 | 836                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

70.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| * 15.995                   | 25.01                            | 31786.                                                                                | 9.663                                                             | -614.1                        | -436.7              | 10.33                | 10.12                                 | 13.10                                 | 1438                              |
| 16                         | 25.01                            | 31777.                                                                                | 9.664                                                             | -614.0                        | -436.6              | 10.33                | 10.12                                 | 13.10                                 | 1438                              |
| 17                         | 25.21                            | 30345.                                                                                | 9.736                                                             | -601.9                        | -423.2              | 11.15                | 10.45                                 | 13.87                                 | 1423                              |
| 18                         | 25.42                            | 29148.                                                                                | 9.736                                                             | -589.2                        | -408.9              | 11.96                | 10.75                                 | 14.58                                 | 1410                              |
| 19                         | 25.64                            | 28046.                                                                                | 9.693                                                             | -575.9                        | -394.0              | 12.77                | 11.03                                 | 15.27                                 | 1397                              |
| 20                         | 25.87                            | 26929.                                                                                | 9.624                                                             | -561.9                        | -378.4              | 13.57                | 11.29                                 | 15.95                                 | 1383                              |
| 21                         | 26.12                            | 25746.                                                                                | 9.532                                                             | -547.3                        | -362.1              | 14.37                | 11.52                                 | 16.64                                 | 1367                              |
| 22                         | 26.38                            | 24639.                                                                                | 9.423                                                             | -532.2                        | -345.1              | 15.16                | 11.73                                 | 17.32                                 | 1352                              |
| 23                         | 26.65                            | 23507.                                                                                | 9.300                                                             | -516.5                        | -327.4              | 15.94                | 11.93                                 | 18.02                                 | 1336                              |
| 24                         | 26.94                            | 22418.                                                                                | 9.163                                                             | -500.2                        | -309.1              | 16.72                | 12.10                                 | 18.71                                 | 1320                              |
| 25                         | 27.24                            | 21337.                                                                                | 9.009                                                             | -483.3                        | -290.0              | 17.50                | 12.26                                 | 19.42                                 | 1303                              |
| 26                         | 27.57                            | 20271.                                                                                | 8.840                                                             | -465.8                        | -270.3              | 18.28                | 12.41                                 | 20.12                                 | 1286                              |
| 27                         | 27.91                            | 19227.                                                                                | 8.659                                                             | -447.7                        | -249.8              | 19.05                | 12.54                                 | 20.85                                 | 1268                              |
| 28                         | 28.27                            | 18206.                                                                                | 8.464                                                             | -429.1                        | -228.6              | 19.82                | 12.66                                 | 21.58                                 | 1249                              |
| 29                         | 28.65                            | 17209.                                                                                | 8.257                                                             | -409.8                        | -206.6              | 20.59                | 12.77                                 | 22.32                                 | 1230                              |
| 30                         | 29.05                            | 16239.                                                                                | 8.040                                                             | -390.0                        | -184.0              | 21.36                | 12.85                                 | 23.07                                 | 1210                              |
| 31                         | 29.49                            | 15299.                                                                                | 7.811                                                             | -369.6                        | -160.5              | 22.13                | 12.94                                 | 23.83                                 | 1190                              |
| 32                         | 29.94                            | 14387.                                                                                | 7.575                                                             | -348.7                        | -136.3              | 22.90                | 13.01                                 | 24.60                                 | 1169                              |
| 33                         | 30.43                            | 13516.                                                                                | 7.331                                                             | -327.1                        | -111.3              | 23.67                | 13.07                                 | 25.38                                 | 1149                              |
| 34                         | 30.95                            | 12668.                                                                                | 7.082                                                             | -305.0                        | -85.5               | 24.43                | 13.12                                 | 26.19                                 | 1127                              |
| 35                         | 31.50                            | 11869.                                                                                | 6.829                                                             | -282.4                        | -59.0               | 25.21                | 13.17                                 | 26.99                                 | 1106                              |
| 36                         | 32.09                            | 11104.                                                                                | 6.572                                                             | -259.2                        | -31.5               | 25.98                | 13.21                                 | 27.82                                 | 1084                              |
| 37                         | 32.72                            | 10389.                                                                                | 6.313                                                             | -235.4                        | -3.3                | 26.75                | 13.25                                 | 28.66                                 | 1062                              |
| 38                         | 33.39                            | 9704.                                                                                 | 6.056                                                             | -211.1                        | 25.8                | 27.53                | 13.27                                 | 29.50                                 | 1041                              |
| 39                         | 34.11                            | 9072.                                                                                 | 5.797                                                             | -186.3                        | 55.7                | 28.30                | 13.29                                 | 30.32                                 | 1020                              |
| 40                         | 34.88                            | 8481.                                                                                 | 5.540                                                             | -161.0                        | 86.4                | 29.08                | 13.29                                 | 31.14                                 | 999                               |
| 41                         | 35.70                            | 7943.                                                                                 | 5.287                                                             | -135.3                        | 117.9               | 29.86                | 13.31                                 | 31.94                                 | 979                               |
| 42                         | 36.58                            | 7457.                                                                                 | 5.039                                                             | -109.2                        | 150.2               | 30.64                | 13.32                                 | 32.71                                 | 959                               |
| 43                         | 37.51                            | 7016.                                                                                 | 4.797                                                             | -82.8                         | 183.3               | 31.42                | 13.34                                 | 33.44                                 | 940                               |
| 44                         | 38.50                            | 6621.                                                                                 | 4.562                                                             | -56.0                         | 217.1               | 32.19                | 13.35                                 | 34.13                                 | 922                               |
| 45                         | 39.55                            | 6272.                                                                                 | 4.336                                                             | -29.0                         | 251.5               | 32.97                | 13.37                                 | 34.76                                 | 905                               |
| 46                         | 40.66                            | 5970.                                                                                 | 4.119                                                             | -1.9                          | 286.5               | 33.74                | 13.41                                 | 35.31                                 | 889                               |
| 47                         | 41.83                            | 5709.                                                                                 | 3.912                                                             | 25.4                          | 322.1               | 34.50                | 13.45                                 | 35.78                                 | 874                               |
| 48                         | 43.06                            | 5490.                                                                                 | 3.715                                                             | 52.6                          | 358.0               | 35.26                | 13.49                                 | 36.16                                 | 860                               |
| 49                         | 44.34                            | 5306.                                                                                 | 3.529                                                             | 79.9                          | 394.3               | 36.01                | 13.53                                 | 36.44                                 | 848                               |
| 50                         | 45.67                            | 5159.                                                                                 | 3.354                                                             | 106.9                         | 430.8               | 36.75                | 13.57                                 | 36.62                                 | 836                               |
| 51                         | 47.05                            | 5042.                                                                                 | 3.191                                                             | 133.8                         | 467.5               | 37.47                | 13.61                                 | 36.70                                 | 827                               |
| 52                         | 48.47                            | 4955.                                                                                 | 3.037                                                             | 160.4                         | 504.2               | 38.18                | 13.65                                 | 36.68                                 | 818                               |
| 53                         | 49.92                            | 4894.                                                                                 | 2.893                                                             | 186.7                         | 540.8               | 38.88                | 13.69                                 | 36.58                                 | 811                               |
| 54                         | 51.41                            | 4856.                                                                                 | 2.759                                                             | 212.7                         | 577.3               | 39.56                | 13.73                                 | 36.40                                 | 805                               |
| 55                         | 52.93                            | 4838.                                                                                 | 2.635                                                             | 238.2                         | 613.6               | 40.23                | 13.77                                 | 36.17                                 | 799                               |
| 56                         | 54.46                            | 4837.                                                                                 | 2.519                                                             | 263.9                         | 650.2               | 40.89                | 13.80                                 | 35.88                                 | 795                               |
| 57                         | 56.01                            | 4853.                                                                                 | 2.412                                                             | 288.6                         | 685.9               | 41.52                | 13.83                                 | 35.55                                 | 792                               |
| 58                         | 57.58                            | 4882.                                                                                 | 2.312                                                             | 312.8                         | 721.2               | 42.14                | 13.86                                 | 35.20                                 | 789                               |
| 59                         | 59.15                            | 4922.                                                                                 | 2.219                                                             | 336.7                         | 756.2               | 42.73                | 13.90                                 | 34.83                                 | 787                               |
| 60                         | 60.73                            | 4974.                                                                                 | 2.133                                                             | 360.1                         | 790.8               | 43.32                | 13.95                                 | 34.46                                 | 786                               |
| 61                         | 62.31                            | 5033.                                                                                 | 2.053                                                             | 383.2                         | 825.1               | 43.88                | 13.99                                 | 34.09                                 | 785                               |
| 62                         | 63.89                            | 5101.                                                                                 | 1.979                                                             | 405.8                         | 859.0               | 44.43                | 14.05                                 | 33.74                                 | 785                               |
| 63                         | 65.47                            | 5175.                                                                                 | 1.910                                                             | 428.1                         | 892.5               | 44.97                | 14.10                                 | 33.39                                 | 785                               |
| 64                         | 67.05                            | 5254.                                                                                 | 1.845                                                             | 450.1                         | 925.7               | 45.49                | 14.17                                 | 33.06                                 | 785                               |
| 65                         | 68.62                            | 5338.                                                                                 | 1.785                                                             | 471.9                         | 958.6               | 46.00                | 14.24                                 | 32.75                                 | 786                               |
| 66                         | 70.19                            | 5425.                                                                                 | 1.729                                                             | 493.3                         | 991.2               | 46.50                | 14.31                                 | 32.46                                 | 786                               |
| 67                         | 71.76                            | 5516.                                                                                 | 1.676                                                             | 514.5                         | 1023.5              | 46.99                | 14.39                                 | 32.19                                 | 787                               |
| 68                         | 73.32                            | 5609.                                                                                 | 1.626                                                             | 535.5                         | 1055.5              | 47.46                | 14.48                                 | 31.94                                 | 789                               |
| 69                         | 74.88                            | 5705.                                                                                 | 1.579                                                             | 556.3                         | 1087.3              | 47.93                | 14.57                                 | 31.71                                 | 790                               |
| 70                         | 76.42                            | 5803.                                                                                 | 1.535                                                             | 576.9                         | 1118.9              | 48.38                | 14.67                                 | 31.49                                 | 791                               |
| 71                         | 77.96                            | 5903.                                                                                 | 1.494                                                             | 597.3                         | 1150.3              | 48.83                | 14.77                                 | 31.29                                 | 793                               |
| 72                         | 79.50                            | 6004.                                                                                 | 1.454                                                             | 617.7                         | 1181.5              | 49.26                | 14.87                                 | 31.11                                 | 794                               |
| 73                         | 81.03                            | 6106.                                                                                 | 1.417                                                             | 637.9                         | 1212.5              | 49.69                | 14.99                                 | 30.96                                 | 796                               |
| 74                         | 82.55                            | 6209.                                                                                 | 1.382                                                             | 658.0                         | 1243.4              | 50.11                | 15.10                                 | 30.81                                 | 798                               |
| 75                         | 84.06                            | 6317.                                                                                 | 1.348                                                             | 678.0                         | 1274.2              | 50.52                | 15.22                                 | 30.68                                 | 800                               |
| 76                         | 85.56                            | 6416.                                                                                 | 1.316                                                             | 697.9                         | 1304.8              | 50.93                | 15.34                                 | 30.57                                 | 802                               |
| 77                         | 87.06                            | 6521.                                                                                 | 1.286                                                             | 717.8                         | 1335.3              | 51.33                | 15.47                                 | 30.47                                 | 803                               |
| 78                         | 88.55                            | 6626.                                                                                 | 1.257                                                             | 737.6                         | 1365.7              | 51.72                | 15.60                                 | 30.39                                 | 805                               |
| 79                         | 90.04                            | 6737.                                                                                 | 1.230                                                             | 757.5                         | 1396.1              | 52.11                | 15.74                                 | 30.31                                 | 807                               |
| 80                         | 91.52                            | 6838.                                                                                 | 1.203                                                             | 777.3                         | 1426.4              | 52.49                | 15.87                                 | 30.25                                 | 809                               |
| 81                         | 92.99                            | 6944.                                                                                 | 1.178                                                             | 797.1                         | 1456.6              | 52.86                | 16.02                                 | 30.21                                 | 811                               |
| 82                         | 94.45                            | 7050.                                                                                 | 1.154                                                             | 816.9                         | 1486.8              | 53.23                | 16.16                                 | 30.17                                 | 813                               |
| 83                         | 95.91                            | 7156.                                                                                 | 1.131                                                             | 836.7                         | 1516.9              | 53.60                | 16.31                                 | 30.14                                 | 815                               |
| 84                         | 97.36                            | 7267.                                                                                 | 1.109                                                             | 856.5                         | 1547.0              | 53.96                | 16.46                                 | 30.12                                 | 817                               |
| 85                         | 98.80                            | 7369.                                                                                 | 1.088                                                             | 876.4                         | 1577.1              | 54.32                | 16.61                                 | 30.11                                 | 819                               |
| 86                         | 100.24                           | 7475.                                                                                 | 1.067                                                             | 896.3                         | 1607.3              | 54.67                | 16.76                                 | 30.11                                 | 821                               |
| 87                         | 101.67                           | 7581.                                                                                 | 1.048                                                             | 916.2                         | 1637.4              | 55.02                | 16.92                                 | 30.12                                 | 824                               |
| 88                         | 103.10                           | 7687.                                                                                 | 1.029                                                             | 936.3                         | 1667.5              | 55.36                | 17.08                                 | 30.14                                 | 826                               |
| 89                         | 104.52                           | 7797.                                                                                 | 1.011                                                             | 956.3                         | 1697.6              | 55.70                | 17.24                                 | 30.16                                 | 828                               |
| 90                         | 105.93                           | 7898.                                                                                 | 0.993                                                             | 976.5                         | 1727.8              | 56.04                | 17.40                                 | 30.18                                 | 830                               |
| 91                         | 107.34                           | 8003.                                                                                 | 0.977                                                             | 996.7                         | 1758.0              | 56.37                | 17.56                                 | 30.22                                 | 832                               |
| 92                         | 108.74                           | 8107.                                                                                 | 0.960                                                             | 1017.0                        | 1788.2              | 56.70                | 17.72                                 | 30.26                                 | 834                               |
| 93                         | 110.14                           | 8211.                                                                                 | 0.945                                                             | 1037.3                        | 1818.5              | 57.03                | 17.89                                 | 30.31                                 | 836                               |
| 94                         | 111.53                           | 8315.                                                                                 | 0.929                                                             | 1057.8                        | 1848.8              | 57.35                | 18.05                                 | 30.36                                 | 838                               |
| 95                         | 112.92                           | 8419.                                                                                 | 0.915                                                             | 1078.3                        | 1879.2              | 57.67                | 18.22                                 | 30.42                                 | 841                               |
| 96                         | 114.30                           | 8527.                                                                                 | 0.901                                                             | 1099.0                        | 1909.7              | 57.99                | 18.38                                 | 30.48                                 | 843                               |
| 97                         | 115.68                           | 8625.                                                                                 | 0.887                                                             | 1119.7                        | 1940.2              | 58.31                | 18.55                                 | 30.54                                 | 845                               |
| 98                         | 117.05                           | 8728.                                                                                 | 0.873                                                             | 1140.5                        | 1970.8              | 58.62                | 18.71                                 | 30.60                                 | 847                               |
| 99                         | 118.42                           | 8831.                                                                                 | 0.861                                                             | 1161.5                        | 2001.4              | 58.93                | 18.88                                 | 30.68                                 | 849                               |
| 100                        | 119.79                           | 8933.                                                                                 | 0.848                                                             | 1182.5                        | 2032.1              | 59.24                | 19.04                                 | 30.75                                 | 852                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISO8ARS-CONTINUED

80.0 ATMOSPHERE ISO8AR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial P$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 16.283                   | 24.87                            | 32867.                                                                                          | 9.729                                                                       | -612.3                        | -410.7              | 10.37                | 10.17                                          | 13.11                                          | 1459                              |
| 17                         | 25.00                            | 31776.                                                                                          | 9.799                                                                       | -603.8                        | -401.1              | 10.95                | 10.41                                          | 13.67                                          | 1448                              |
| 18                         | 25.20                            | 30634.                                                                                          | 9.827                                                                       | -591.4                        | -387.1              | 11.75                | 10.72                                          | 14.37                                          | 1437                              |
| 19                         | 25.41                            | 29554.                                                                                          | 9.803                                                                       | -578.4                        | -372.4              | 12.55                | 11.01                                          | 15.05                                          | 1425                              |
| 20                         | 25.63                            | 28465.                                                                                          | 9.746                                                                       | -564.8                        | -357.0              | 13.33                | 11.26                                          | 15.71                                          | 1412                              |
| 21                         | 25.86                            | 27295.                                                                                          | 9.668                                                                       | -550.6                        | -341.0              | 14.12                | 11.50                                          | 16.37                                          | 1398                              |
| 22                         | 26.11                            | 26208.                                                                                          | 9.570                                                                       | -535.9                        | -324.3              | 14.90                | 11.72                                          | 17.02                                          | 1384                              |
| 23                         | 26.36                            | 25078.                                                                                          | 9.456                                                                       | -520.6                        | -306.9              | 15.67                | 11.91                                          | 17.69                                          | 1368                              |
| 24                         | 26.63                            | 24010.                                                                                          | 9.331                                                                       | -504.8                        | -288.9              | 16.43                | 12.09                                          | 18.34                                          | 1353                              |
| 25                         | 26.91                            | 22945.                                                                                          | 9.191                                                                       | -488.4                        | -270.2              | 17.20                | 12.25                                          | 19.01                                          | 1337                              |
| 26                         | 27.21                            | 21904.                                                                                          | 9.035                                                                       | -471.5                        | -250.9              | 17.95                | 12.40                                          | 19.67                                          | 1321                              |
| 27                         | 27.52                            | 20879.                                                                                          | 8.867                                                                       | -454.0                        | -230.9              | 18.71                | 12.54                                          | 20.34                                          | 1305                              |
| 28                         | 27.85                            | 19870.                                                                                          | 8.686                                                                       | -436.0                        | -210.2              | 19.46                | 12.66                                          | 21.02                                          | 1288                              |
| 29                         | 28.20                            | 18888.                                                                                          | 8.494                                                                       | -417.5                        | -188.9              | 20.21                | 12.77                                          | 21.70                                          | 1270                              |
| 30                         | 28.57                            | 17918.                                                                                          | 8.291                                                                       | -398.4                        | -166.8              | 20.96                | 12.87                                          | 22.38                                          | 1252                              |
| 31                         | 28.96                            | 17007.                                                                                          | 8.079                                                                       | -378.8                        | -144.1              | 21.70                | 12.95                                          | 23.06                                          | 1234                              |
| 32                         | 29.37                            | 16107.                                                                                          | 7.858                                                                       | -358.7                        | -120.7              | 22.44                | 13.03                                          | 23.75                                          | 1215                              |
| 33                         | 29.80                            | 15259.                                                                                          | 7.632                                                                       | -338.2                        | -96.6               | 23.19                | 13.10                                          | 24.44                                          | 1196                              |
| 34                         | 30.26                            | 14394.                                                                                          | 7.399                                                                       | -317.1                        | -71.8               | 23.93                | 13.15                                          | 25.15                                          | 1176                              |
| 35                         | 30.74                            | 13597.                                                                                          | 7.162                                                                       | -295.5                        | -46.3               | 24.67                | 13.20                                          | 25.85                                          | 1157                              |
| 36                         | 31.25                            | 12831.                                                                                          | 6.922                                                                       | -273.4                        | -20.1               | 25.40                | 13.25                                          | 26.55                                          | 1137                              |
| 37                         | 31.79                            | 12100.                                                                                          | 6.681                                                                       | -250.9                        | 6.8                 | 26.14                | 13.29                                          | 27.26                                          | 1117                              |
| 38                         | 32.37                            | 11415.                                                                                          | 6.438                                                                       | -228.0                        | 34.4                | 26.88                | 13.31                                          | 27.96                                          | 1098                              |
| 39                         | 32.98                            | 10764.                                                                                          | 6.196                                                                       | -204.6                        | 62.7                | 27.61                | 13.33                                          | 28.66                                          | 1079                              |
| 40                         | 33.62                            | 10153.                                                                                          | 5.955                                                                       | -180.8                        | 91.7                | 28.35                | 13.34                                          | 29.34                                          | 1059                              |
| 41                         | 34.30                            | 9586.                                                                                           | 5.717                                                                       | -156.7                        | 121.4               | 29.08                | 13.35                                          | 30.02                                          | 1041                              |
| 42                         | 35.03                            | 9066.                                                                                           | 5.481                                                                       | -132.2                        | 151.7               | 29.81                | 13.36                                          | 30.66                                          | 1023                              |
| 43                         | 35.79                            | 8590.                                                                                           | 5.251                                                                       | -107.4                        | 182.7               | 30.54                | 13.37                                          | 31.28                                          | 1005                              |
| 44                         | 36.59                            | 8156.                                                                                           | 5.026                                                                       | -82.4                         | 214.2               | 31.26                | 13.39                                          | 31.88                                          | 988                               |
| 45                         | 37.44                            | 7760.                                                                                           | 4.807                                                                       | -57.1                         | 246.4               | 31.99                | 13.41                                          | 32.44                                          | 971                               |
| 46                         | 38.33                            | 7406.                                                                                           | 4.595                                                                       | -31.6                         | 279.1               | 32.71                | 13.44                                          | 32.96                                          | 955                               |
| 47                         | 39.26                            | 7092.                                                                                           | 4.391                                                                       | -5.9                          | 312.3               | 33.42                | 13.48                                          | 33.43                                          | 940                               |
| 48                         | 40.23                            | 6817.                                                                                           | 4.195                                                                       | 19.8                          | 345.9               | 34.13                | 13.52                                          | 33.84                                          | 926                               |
| 49                         | 41.25                            | 6575.                                                                                           | 4.008                                                                       | 45.6                          | 379.9               | 34.83                | 13.55                                          | 34.19                                          | 913                               |
| 50                         | 42.30                            | 6368.                                                                                           | 3.829                                                                       | 71.3                          | 414.2               | 35.52                | 13.59                                          | 34.47                                          | 901                               |
| 51                         | 43.40                            | 6192.                                                                                           | 3.660                                                                       | 97.0                          | 448.8               | 36.21                | 13.63                                          | 34.69                                          | 890                               |
| 52                         | 44.53                            | 6047.                                                                                           | 3.499                                                                       | 122.6                         | 483.5               | 36.88                | 13.68                                          | 34.83                                          | 880                               |
| 53                         | 45.69                            | 5929.                                                                                           | 3.348                                                                       | 148.1                         | 518.4               | 37.55                | 13.72                                          | 34.91                                          | 871                               |
| 54                         | 46.88                            | 5837.                                                                                           | 3.205                                                                       | 173.3                         | 553.3               | 38.20                | 13.76                                          | 34.93                                          | 863                               |
| 55                         | 48.10                            | 5767.                                                                                           | 3.071                                                                       | 198.3                         | 588.2               | 38.84                | 13.80                                          | 34.89                                          | 856                               |
| 56                         | 49.35                            | 5715.                                                                                           | 2.944                                                                       | 223.6                         | 623.6               | 39.48                | 13.84                                          | 34.80                                          | 850                               |
| 57                         | 50.61                            | 5682.                                                                                           | 2.825                                                                       | 248.1                         | 658.4               | 40.09                | 13.88                                          | 34.66                                          | 845                               |
| 58                         | 51.89                            | 5664.                                                                                           | 2.714                                                                       | 272.3                         | 692.9               | 40.69                | 13.91                                          | 34.48                                          | 840                               |
| 59                         | 53.19                            | 5665.                                                                                           | 2.609                                                                       | 296.1                         | 727.3               | 41.28                | 13.95                                          | 34.28                                          | 836                               |
| 60                         | 54.50                            | 5677.                                                                                           | 2.511                                                                       | 319.7                         | 761.4               | 41.86                | 14.00                                          | 34.05                                          | 833                               |
| 61                         | 55.81                            | 5700.                                                                                           | 2.419                                                                       | 342.9                         | 795.4               | 42.42                | 14.05                                          | 33.82                                          | 830                               |
| 62                         | 57.14                            | 5734.                                                                                           | 2.333                                                                       | 365.9                         | 829.0               | 42.96                | 14.10                                          | 33.57                                          | 828                               |
| 63                         | 58.47                            | 5777.                                                                                           | 2.253                                                                       | 388.5                         | 862.5               | 43.50                | 14.16                                          | 33.33                                          | 827                               |
| 64                         | 59.80                            | 5829.                                                                                           | 2.177                                                                       | 410.9                         | 895.6               | 44.02                | 14.22                                          | 33.08                                          | 825                               |
| 65                         | 61.13                            | 5887.                                                                                           | 2.106                                                                       | 433.0                         | 928.6               | 44.53                | 14.29                                          | 32.84                                          | 825                               |
| 66                         | 62.47                            | 5950.                                                                                           | 2.039                                                                       | 454.9                         | 961.3               | 45.03                | 14.37                                          | 32.61                                          | 824                               |
| 67                         | 63.81                            | 6019.                                                                                           | 1.977                                                                       | 476.6                         | 993.8               | 45.52                | 14.45                                          | 32.40                                          | 824                               |
| 68                         | 65.14                            | 6092.                                                                                           | 1.918                                                                       | 498.0                         | 1026.1              | 46.00                | 14.53                                          | 32.19                                          | 824                               |
| 69                         | 66.48                            | 6170.                                                                                           | 1.862                                                                       | 519.3                         | 1058.2              | 46.47                | 14.63                                          | 32.00                                          | 824                               |
| 70                         | 67.81                            | 6251.                                                                                           | 1.810                                                                       | 540.4                         | 1090.0              | 46.93                | 14.72                                          | 31.82                                          | 824                               |
| 71                         | 69.14                            | 6335.                                                                                           | 1.761                                                                       | 561.3                         | 1121.8              | 47.38                | 14.82                                          | 31.65                                          | 824                               |
| 72                         | 70.47                            | 6422.                                                                                           | 1.714                                                                       | 582.1                         | 1153.3              | 47.82                | 14.93                                          | 31.50                                          | 825                               |
| 73                         | 71.79                            | 6511.                                                                                           | 1.669                                                                       | 602.8                         | 1184.8              | 48.25                | 15.04                                          | 31.35                                          | 826                               |
| 74                         | 73.11                            | 6603.                                                                                           | 1.627                                                                       | 623.4                         | 1216.1              | 48.68                | 15.16                                          | 31.23                                          | 827                               |
| 75                         | 74.42                            | 6696.                                                                                           | 1.587                                                                       | 644.0                         | 1247.2              | 49.10                | 15.28                                          | 31.11                                          | 828                               |
| 76                         | 75.73                            | 6790.                                                                                           | 1.549                                                                       | 664.4                         | 1278.3              | 49.51                | 15.40                                          | 31.01                                          | 829                               |
| 77                         | 77.04                            | 6885.                                                                                           | 1.513                                                                       | 684.8                         | 1309.3              | 49.91                | 15.53                                          | 30.92                                          | 830                               |
| 78                         | 78.34                            | 6981.                                                                                           | 1.478                                                                       | 705.1                         | 1340.1              | 50.31                | 15.66                                          | 30.85                                          | 831                               |
| 79                         | 79.64                            | 7079.                                                                                           | 1.445                                                                       | 725.4                         | 1371.0              | 50.70                | 15.80                                          | 30.78                                          | 832                               |
| 80                         | 80.93                            | 7177.                                                                                           | 1.414                                                                       | 745.7                         | 1401.7              | 51.09                | 15.94                                          | 30.72                                          | 834                               |
| 81                         | 82.22                            | 7276.                                                                                           | 1.384                                                                       | 765.9                         | 1432.4              | 51.47                | 16.08                                          | 30.68                                          | 835                               |
| 82                         | 83.50                            | 7376.                                                                                           | 1.355                                                                       | 786.2                         | 1463.1              | 51.85                | 16.23                                          | 30.64                                          | 837                               |
| 83                         | 84.78                            | 7476.                                                                                           | 1.327                                                                       | 806.5                         | 1493.7              | 52.22                | 16.38                                          | 30.62                                          | 838                               |
| 84                         | 86.06                            | 7577.                                                                                           | 1.300                                                                       | 826.7                         | 1524.3              | 52.59                | 16.53                                          | 30.60                                          | 840                               |
| 85                         | 87.32                            | 7679.                                                                                           | 1.275                                                                       | 847.0                         | 1554.9              | 52.95                | 16.68                                          | 30.59                                          | 841                               |
| 86                         | 88.59                            | 7780.                                                                                           | 1.251                                                                       | 867.4                         | 1585.5              | 53.30                | 16.84                                          | 30.59                                          | 843                               |
| 87                         | 89.85                            | 7882.                                                                                           | 1.227                                                                       | 887.8                         | 1616.1              | 53.66                | 16.99                                          | 30.59                                          | 844                               |
| 88                         | 91.10                            | 7984.                                                                                           | 1.204                                                                       | 908.2                         | 1646.6              | 54.01                | 17.15                                          | 30.60                                          | 846                               |
| 89                         | 92.35                            | 8086.                                                                                           | 1.183                                                                       | 928.7                         | 1677.3              | 54.35                | 17.31                                          | 30.62                                          | 848                               |
| 90                         | 93.60                            | 8189.                                                                                           | 1.162                                                                       | 949.2                         | 1707.9              | 54.70                | 17.48                                          | 30.65                                          | 850                               |
| 91                         | 94.84                            | 8292.                                                                                           | 1.142                                                                       | 969.8                         | 1738.5              | 55.03                | 17.64                                          | 30.68                                          | 851                               |
| 92                         | 96.07                            | 8394.                                                                                           | 1.122                                                                       | 990.5                         | 1769.2              | 55.37                | 17.80                                          | 30.71                                          | 853                               |
| 93                         | 97.30                            | 8497.                                                                                           | 1.104                                                                       | 1011.2                        | 1800.0              | 55.70                | 17.97                                          | 30.76                                          | 855                               |
| 94                         | 98.53                            | 8599.                                                                                           | 1.085                                                                       | 1032.0                        | 1830.7              | 56.03                | 18.13                                          | 30.80                                          | 857                               |
| 95                         | 99.75                            | 8702.                                                                                           | 1.068                                                                       | 1053.0                        | 1861.5              | 56.36                | 18.30                                          | 30.85                                          | 859                               |
| 96                         | 100.97                           | 8803.                                                                                           | 1.051                                                                       | 1073.9                        | 1892.4              | 56.68                | 18.47                                          | 30.90                                          | 861                               |
| 97                         | 102.19                           | 8905.                                                                                           | 1.034                                                                       | 1095.0                        | 1923.4              | 57.00                | 18.63                                          | 30.97                                          | 862                               |
| 98                         | 103.40                           | 9006.                                                                                           | 1.019                                                                       | 1116.2                        | 1954.3              | 57.32                | 18.80                                          | 31.03                                          | 864                               |
| 99                         | 104.60                           | 9108.                                                                                           | 1.003                                                                       | 1137.5                        | 1985.4              | 57.63                | 18.96                                          | 31.09                                          | 866                               |
| 100                        | 105.81                           | 9209.                                                                                           | 0.988                                                                       | 1158.8                        | 2016.5              | 57.95                | 19.13                                          | 31.16                                          | 868                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

90.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 16.566                   | 24.74                            | 33854.                                                                                              | 9.806                                                                       | -610.5                        | -384.9              | 10.42                | 10.22                                          | 13.13                                          | 1479                              |
| 17                         | 24.81                            | 33147.                                                                                              | 9.857                                                                       | -605.4                        | -379.1              | 10.76                | 10.37                                          | 13.48                                          | 1472                              |
| 18                         | 25.00                            | 32093.                                                                                              | 9.911                                                                       | -593.3                        | -365.3              | 11.55                | 10.69                                          | 14.18                                          | 1463                              |
| 19                         | 25.20                            | 31026.                                                                                              | 9.906                                                                       | -580.6                        | -350.8              | 12.34                | 10.98                                          | 14.85                                          | 1452                              |
| 20                         | 25.41                            | 29943.                                                                                              | 9.863                                                                       | -567.3                        | -335.6              | 13.11                | 11.24                                          | 15.49                                          | 1440                              |
| 21                         | 25.63                            | 28801.                                                                                              | 9.794                                                                       | -553.5                        | -319.8              | 13.89                | 11.48                                          | 16.13                                          | 1426                              |
| 22                         | 25.85                            | 27737.                                                                                              | 9.708                                                                       | -539.1                        | -303.3              | 14.65                | 11.70                                          | 16.76                                          | 1413                              |
| 23                         | 26.09                            | 26610.                                                                                              | 9.604                                                                       | -524.2                        | -286.2              | 15.41                | 11.90                                          | 17.40                                          | 1398                              |
| 24                         | 26.35                            | 25556.                                                                                              | 9.485                                                                       | -508.8                        | -268.5              | 16.16                | 12.08                                          | 18.02                                          | 1384                              |
| 25                         | 26.61                            | 24507.                                                                                              | 9.356                                                                       | -492.9                        | -250.2              | 16.91                | 12.24                                          | 18.65                                          | 1370                              |
| 26                         | 26.89                            | 23483.                                                                                              | 9.214                                                                       | -476.4                        | -231.2              | 17.66                | 12.40                                          | 19.28                                          | 1355                              |
| 27                         | 27.18                            | 22473.                                                                                              | 9.057                                                                       | -459.5                        | -211.7              | 18.40                | 12.54                                          | 19.91                                          | 1339                              |
| 28                         | 27.48                            | 21473.                                                                                              | 8.888                                                                       | -442.0                        | -191.4              | 19.13                | 12.67                                          | 20.55                                          | 1323                              |
| 29                         | 27.80                            | 20505.                                                                                              | 8.709                                                                       | -424.1                        | -170.6              | 19.86                | 12.78                                          | 21.18                                          | 1307                              |
| 30                         | 28.14                            | 19545.                                                                                              | 8.519                                                                       | -405.7                        | -149.1              | 20.59                | 12.88                                          | 21.82                                          | 1290                              |
| 31                         | 28.49                            | 18645.                                                                                              | 8.320                                                                       | -386.8                        | -126.9              | 21.32                | 12.97                                          | 22.44                                          | 1273                              |
| 32                         | 28.86                            | 17757.                                                                                              | 8.114                                                                       | -367.4                        | -104.2              | 22.04                | 13.05                                          | 23.07                                          | 1256                              |
| 33                         | 29.26                            | 16907.                                                                                              | 7.901                                                                       | -347.6                        | -80.8               | 22.76                | 13.12                                          | 23.69                                          | 1238                              |
| 34                         | 29.67                            | 16052.                                                                                              | 7.682                                                                       | -327.3                        | -56.8               | 23.48                | 13.18                                          | 24.33                                          | 1220                              |
| 35                         | 30.10                            | 15253.                                                                                              | 7.458                                                                       | -306.6                        | -32.1               | 24.19                | 13.24                                          | 24.95                                          | 1202                              |
| 36                         | 30.55                            | 14488.                                                                                              | 7.232                                                                       | -285.5                        | -6.9                | 24.90                | 13.28                                          | 25.58                                          | 1184                              |
| 37                         | 31.03                            | 13753.                                                                                              | 7.004                                                                       | -264.0                        | 19.0                | 25.61                | 13.33                                          | 26.20                                          | 1166                              |
| 38                         | 31.53                            | 13060.                                                                                              | 6.775                                                                       | -242.0                        | 45.5                | 26.32                | 13.36                                          | 26.81                                          | 1148                              |
| 39                         | 32.06                            | 12399.                                                                                              | 6.546                                                                       | -219.7                        | 72.6                | 27.02                | 13.37                                          | 27.41                                          | 1130                              |
| 40                         | 32.62                            | 11773.                                                                                              | 6.317                                                                       | -197.1                        | 100.4               | 27.72                | 13.39                                          | 28.00                                          | 1113                              |
| 41                         | 33.21                            | 11185.                                                                                              | 6.091                                                                       | -174.2                        | 128.6               | 28.42                | 13.40                                          | 28.59                                          | 1095                              |
| 42                         | 33.82                            | 10638.                                                                                              | 5.866                                                                       | -150.9                        | 157.5               | 29.12                | 13.41                                          | 29.15                                          | 1078                              |
| 43                         | 34.47                            | 10136.                                                                                              | 5.645                                                                       | -127.4                        | 186.9               | 29.81                | 13.42                                          | 29.70                                          | 1062                              |
| 44                         | 35.14                            | 9673.                                                                                               | 5.429                                                                       | -103.6                        | 216.9               | 30.50                | 13.44                                          | 30.22                                          | 1046                              |
| 45                         | 35.85                            | 9240.                                                                                               | 5.217                                                                       | -79.6                         | 247.4               | 31.18                | 13.45                                          | 30.72                                          | 1030                              |
| 46                         | 36.60                            | 8847.                                                                                               | 5.011                                                                       | -55.4                         | 278.4               | 31.87                | 13.49                                          | 31.21                                          | 1014                              |
| 47                         | 37.37                            | 8492.                                                                                               | 4.812                                                                       | -31.0                         | 309.8               | 32.54                | 13.52                                          | 31.65                                          | 1000                              |
| 48                         | 38.18                            | 8174.                                                                                               | 4.618                                                                       | -6.5                          | 341.6               | 33.21                | 13.56                                          | 32.05                                          | 986                               |
| 49                         | 39.02                            | 7886.                                                                                               | 4.432                                                                       | 18.0                          | 373.9               | 33.88                | 13.59                                          | 32.42                                          | 972                               |
| 50                         | 39.89                            | 7633.                                                                                               | 4.253                                                                       | 42.7                          | 406.4               | 34.54                | 13.63                                          | 32.74                                          | 960                               |
| 51                         | 40.79                            | 7408.                                                                                               | 4.082                                                                       | 67.3                          | 439.3               | 35.19                | 13.67                                          | 33.01                                          | 948                               |
| 52                         | 41.72                            | 7215.                                                                                               | 3.919                                                                       | 91.9                          | 472.4               | 35.83                | 13.71                                          | 33.23                                          | 937                               |
| 53                         | 42.68                            | 7050.                                                                                               | 3.763                                                                       | 116.5                         | 505.7               | 36.46                | 13.76                                          | 33.40                                          | 927                               |
| 54                         | 43.66                            | 6911.                                                                                               | 3.615                                                                       | 141.0                         | 539.1               | 37.09                | 13.80                                          | 33.52                                          | 918                               |
| 55                         | 44.67                            | 6796.                                                                                               | 3.474                                                                       | 165.4                         | 572.7               | 37.71                | 13.85                                          | 33.59                                          | 910                               |
| 56                         | 45.70                            | 6698.                                                                                               | 3.340                                                                       | 190.1                         | 606.8               | 38.32                | 13.89                                          | 33.62                                          | 903                               |
| 57                         | 46.75                            | 6622.                                                                                               | 3.214                                                                       | 214.1                         | 640.5               | 38.92                | 13.92                                          | 33.61                                          | 896                               |
| 58                         | 47.82                            | 6564.                                                                                               | 3.094                                                                       | 238.0                         | 674.1               | 39.50                | 13.96                                          | 33.56                                          | 891                               |
| 59                         | 48.91                            | 6523.                                                                                               | 2.981                                                                       | 261.6                         | 707.6               | 40.07                | 14.00                                          | 33.48                                          | 885                               |
| 60                         | 50.01                            | 6497.                                                                                               | 2.873                                                                       | 285.0                         | 741.0               | 40.64                | 14.05                                          | 33.37                                          | 881                               |
| 61                         | 51.12                            | 6484.                                                                                               | 2.773                                                                       | 308.2                         | 774.3               | 41.19                | 14.10                                          | 33.25                                          | 877                               |
| 62                         | 52.24                            | 6484.                                                                                               | 2.678                                                                       | 331.1                         | 807.5               | 41.73                | 14.16                                          | 33.11                                          | 873                               |
| 63                         | 53.37                            | 6495.                                                                                               | 2.588                                                                       | 353.8                         | 840.5               | 42.25                | 14.22                                          | 32.96                                          | 870                               |
| 64                         | 54.51                            | 6516.                                                                                               | 2.503                                                                       | 376.3                         | 873.4               | 42.77                | 14.28                                          | 32.81                                          | 867                               |
| 65                         | 55.65                            | 6547.                                                                                               | 2.423                                                                       | 398.6                         | 906.1               | 43.28                | 14.35                                          | 32.64                                          | 865                               |
| 66                         | 56.80                            | 6584.                                                                                               | 2.347                                                                       | 420.7                         | 938.7               | 43.78                | 14.42                                          | 32.48                                          | 863                               |
| 67                         | 57.95                            | 6628.                                                                                               | 2.276                                                                       | 442.6                         | 971.1               | 44.26                | 14.50                                          | 32.33                                          | 862                               |
| 68                         | 59.11                            | 6679.                                                                                               | 2.209                                                                       | 464.3                         | 1003.3              | 44.74                | 14.59                                          | 32.18                                          | 860                               |
| 69                         | 60.26                            | 6736.                                                                                               | 2.145                                                                       | 485.9                         | 1035.4              | 45.21                | 14.68                                          | 32.03                                          | 859                               |
| 70                         | 61.42                            | 6797.                                                                                               | 2.085                                                                       | 507.3                         | 1067.3              | 45.67                | 14.78                                          | 31.89                                          | 859                               |
| 71                         | 62.57                            | 6863.                                                                                               | 2.028                                                                       | 528.5                         | 1099.2              | 46.12                | 14.88                                          | 31.76                                          | 858                               |
| 72                         | 63.73                            | 6933.                                                                                               | 1.974                                                                       | 549.7                         | 1130.9              | 46.56                | 14.99                                          | 31.64                                          | 858                               |
| 73                         | 64.89                            | 7007.                                                                                               | 1.923                                                                       | 570.7                         | 1162.4              | 47.00                | 15.10                                          | 31.53                                          | 858                               |
| 74                         | 66.04                            | 7084.                                                                                               | 1.874                                                                       | 591.7                         | 1193.9              | 47.43                | 15.21                                          | 31.43                                          | 858                               |
| 75                         | 67.19                            | 7164.                                                                                               | 1.828                                                                       | 612.6                         | 1225.3              | 47.85                | 15.33                                          | 31.34                                          | 858                               |
| 76                         | 68.35                            | 7245.                                                                                               | 1.784                                                                       | 633.4                         | 1256.6              | 48.26                | 15.46                                          | 31.26                                          | 858                               |
| 77                         | 69.50                            | 7328.                                                                                               | 1.742                                                                       | 654.1                         | 1287.8              | 48.67                | 15.59                                          | 31.19                                          | 858                               |
| 78                         | 70.64                            | 7413.                                                                                               | 1.702                                                                       | 674.8                         | 1319.0              | 49.07                | 15.72                                          | 31.13                                          | 859                               |
| 79                         | 71.79                            | 7501.                                                                                               | 1.663                                                                       | 695.5                         | 1350.1              | 49.47                | 15.86                                          | 31.08                                          | 860                               |
| 80                         | 72.93                            | 7590.                                                                                               | 1.627                                                                       | 716.1                         | 1381.2              | 49.86                | 16.00                                          | 31.03                                          | 860                               |
| 81                         | 74.07                            | 7679.                                                                                               | 1.592                                                                       | 736.7                         | 1412.2              | 50.25                | 16.14                                          | 31.00                                          | 861                               |
| 82                         | 75.20                            | 7770.                                                                                               | 1.558                                                                       | 757.4                         | 1443.2              | 50.63                | 16.29                                          | 30.98                                          | 862                               |
| 83                         | 76.34                            | 7863.                                                                                               | 1.526                                                                       | 778.0                         | 1474.1              | 51.00                | 16.44                                          | 30.96                                          | 863                               |
| 84                         | 77.47                            | 7956.                                                                                               | 1.495                                                                       | 798.7                         | 1505.1              | 51.37                | 16.59                                          | 30.94                                          | 864                               |
| 85                         | 78.59                            | 8051.                                                                                               | 1.466                                                                       | 819.3                         | 1536.0              | 51.74                | 16.75                                          | 30.94                                          | 865                               |
| 86                         | 79.71                            | 8146.                                                                                               | 1.437                                                                       | 840.0                         | 1567.0              | 52.10                | 16.90                                          | 30.94                                          | 866                               |
| 87                         | 80.83                            | 8242.                                                                                               | 1.410                                                                       | 860.8                         | 1597.9              | 52.46                | 17.06                                          | 30.95                                          | 867                               |
| 88                         | 81.95                            | 8339.                                                                                               | 1.384                                                                       | 881.5                         | 1628.9              | 52.81                | 17.22                                          | 30.97                                          | 868                               |
| 89                         | 83.06                            | 8436.                                                                                               | 1.358                                                                       | 902.4                         | 1659.8              | 53.16                | 17.38                                          | 30.99                                          | 869                               |
| 90                         | 84.17                            | 8534.                                                                                               | 1.334                                                                       | 923.3                         | 1690.8              | 53.51                | 17.55                                          | 31.01                                          | 871                               |
| 91                         | 85.27                            | 8633.                                                                                               | 1.310                                                                       | 944.2                         | 1721.8              | 53.85                | 17.71                                          | 31.05                                          | 872                               |
| 92                         | 86.38                            | 8732.                                                                                               | 1.287                                                                       | 965.2                         | 1752.9              | 54.19                | 17.88                                          | 31.08                                          | 873                               |
| 93                         | 87.47                            | 8832.                                                                                               | 1.265                                                                       | 986.3                         | 1784.0              | 54.53                | 18.04                                          | 31.12                                          | 875                               |
| 94                         | 88.57                            | 8931.                                                                                               | 1.244                                                                       | 1007.5                        | 1815.1              | 54.86                | 18.21                                          | 31.17                                          | 876                               |
| 95                         | 89.66                            | 9031.                                                                                               | 1.224                                                                       | 1028.7                        | 1846.3              | 55.19                | 18.38                                          | 31.21                                          | 878                               |
| 96                         | 90.75                            | 9130.                                                                                               | 1.204                                                                       | 1050.0                        | 1877.6              | 55.52                | 18.54                                          | 31.26                                          | 880                               |
| 97                         | 91.83                            | 9229.                                                                                               | 1.185                                                                       | 1071.4                        | 1908.9              | 55.84                | 18.71                                          | 31.32                                          | 881                               |
| 98                         | 92.91                            | 9328.                                                                                               | 1.166                                                                       | 1092.9                        | 1940.2              | 56.16                | 18.88                                          | 31.38                                          | 883                               |
| 99                         | 93.99                            | 9427.                                                                                               | 1.148                                                                       | 1114.5                        | 1971.6              | 56.48                | 19.04                                          | 31.44                                          | 884                               |
| 100                        | 95.06                            | 9526.                                                                                               | 1.131                                                                       | 1136.2                        | 2003.1              | 56.80                | 19.21                                          | 31.50                                          | 886                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

100.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 16.844                     | 24.61                            | 34738.                                                                                 | 9.897                                                            | -608.5                        | -359.2              | 10.46                | 10.26                                 | 13.17                                 | 1497                              |
| 17                         | 24.64                            | 34467.                                                                                 | 9.915                                                            | -606.7                        | -357.1              | 10.58                | 10.32                                 | 13.30                                 | 1494                              |
| 18                         | 24.81                            | 33531.                                                                                 | 9.992                                                            | -594.9                        | -343.5              | 11.36                | 10.65                                 | 13.99                                 | 1488                              |
| 19                         | 25.00                            | 32456.                                                                                 | 10.004                                                           | -582.5                        | -329.2              | 12.13                | 10.95                                 | 14.66                                 | 1478                              |
| 20                         | 25.20                            | 31387.                                                                                 | 9.974                                                            | -569.5                        | -314.2              | 12.90                | 11.22                                 | 15.29                                 | 1467                              |
| 21                         | 25.41                            | 30267.                                                                                 | 9.915                                                            | -556.0                        | -298.6              | 13.66                | 11.46                                 | 15.92                                 | 1454                              |
| 22                         | 25.62                            | 29207.                                                                                 | 9.836                                                            | -541.9                        | -282.3              | 14.42                | 11.68                                 | 16.53                                 | 1441                              |
| 23                         | 25.85                            | 28104.                                                                                 | 9.742                                                            | -527.4                        | -265.5              | 15.17                | 11.88                                 | 17.14                                 | 1427                              |
| 24                         | 26.09                            | 27059.                                                                                 | 9.633                                                            | -512.4                        | -248.1              | 15.91                | 12.07                                 | 17.74                                 | 1414                              |
| 25                         | 26.33                            | 26025.                                                                                 | 9.510                                                            | -496.8                        | -230.0              | 16.65                | 12.23                                 | 18.34                                 | 1400                              |
| 26                         | 26.59                            | 25014.                                                                                 | 9.378                                                            | -480.8                        | -211.4              | 17.38                | 12.39                                 | 18.94                                 | 1386                              |
| 27                         | 26.86                            | 24010.                                                                                 | 9.233                                                            | -464.3                        | -192.1              | 18.10                | 12.53                                 | 19.54                                 | 1372                              |
| 28                         | 27.15                            | 23026.                                                                                 | 9.075                                                            | -447.4                        | -172.3              | 18.83                | 12.67                                 | 20.15                                 | 1357                              |
| 29                         | 27.44                            | 22069.                                                                                 | 8.906                                                            | -429.9                        | -151.8              | 19.54                | 12.79                                 | 20.74                                 | 1341                              |
| 30                         | 27.76                            | 21118.                                                                                 | 8.728                                                            | -412.0                        | -130.8              | 20.26                | 12.89                                 | 21.34                                 | 1326                              |
| 31                         | 28.08                            | 20226.                                                                                 | 8.541                                                            | -393.7                        | -109.2              | 20.97                | 12.99                                 | 21.92                                 | 1310                              |
| 32                         | 28.42                            | 19345.                                                                                 | 8.346                                                            | -375.0                        | -87.0               | 21.67                | 13.07                                 | 22.50                                 | 1294                              |
| 33                         | 28.78                            | 18499.                                                                                 | 8.145                                                            | -355.8                        | -64.2               | 22.37                | 13.15                                 | 23.08                                 | 1278                              |
| 34                         | 29.15                            | 17649.                                                                                 | 7.938                                                            | -336.2                        | -40.8               | 23.07                | 13.21                                 | 23.66                                 | 1260                              |
| 35                         | 29.54                            | 16850.                                                                                 | 7.726                                                            | -316.2                        | -16.8               | 23.76                | 13.27                                 | 24.23                                 | 1244                              |
| 36                         | 29.95                            | 16085.                                                                                 | 7.511                                                            | -295.8                        | 7.7                 | 24.45                | 13.32                                 | 24.80                                 | 1227                              |
| 37                         | 30.38                            | 15348.                                                                                 | 7.295                                                            | -275.1                        | 32.8                | 25.14                | 13.36                                 | 25.36                                 | 1210                              |
| 38                         | 30.83                            | 14648.                                                                                 | 7.077                                                            | -254.0                        | 58.4                | 25.83                | 13.40                                 | 25.91                                 | 1193                              |
| 39                         | 31.30                            | 13980.                                                                                 | 6.858                                                            | -232.6                        | 84.6                | 26.51                | 13.42                                 | 26.44                                 | 1177                              |
| 40                         | 31.79                            | 13344.                                                                                 | 6.640                                                            | -210.9                        | 111.3               | 27.18                | 13.43                                 | 26.97                                 | 1160                              |
| 41                         | 32.31                            | 12741.                                                                                 | 6.423                                                            | -188.9                        | 138.5               | 27.85                | 13.44                                 | 27.49                                 | 1144                              |
| 42                         | 32.85                            | 12176.                                                                                 | 6.208                                                            | -166.6                        | 166.2               | 28.52                | 13.46                                 | 27.99                                 | 1128                              |
| 43                         | 33.41                            | 11649.                                                                                 | 5.995                                                            | -144.0                        | 194.5               | 29.19                | 13.47                                 | 28.48                                 | 1112                              |
| 44                         | 34.00                            | 11163.                                                                                 | 5.787                                                            | -121.3                        | 223.2               | 29.85                | 13.49                                 | 28.94                                 | 1097                              |
| 45                         | 34.61                            | 10702.                                                                                 | 5.582                                                            | -98.3                         | 252.4               | 30.50                | 13.50                                 | 29.40                                 | 1082                              |
| 46                         | 35.24                            | 10279.                                                                                 | 5.382                                                            | -75.1                         | 282.0               | 31.16                | 13.54                                 | 29.85                                 | 1067                              |
| 47                         | 35.91                            | 9891.                                                                                  | 5.186                                                            | -51.8                         | 312.1               | 31.80                | 13.57                                 | 30.27                                 | 1053                              |
| 48                         | 36.60                            | 9539.                                                                                  | 4.997                                                            | -28.3                         | 342.6               | 32.44                | 13.61                                 | 30.66                                 | 1039                              |
| 49                         | 37.31                            | 9215.                                                                                  | 4.813                                                            | -4.7                          | 373.4               | 33.08                | 13.64                                 | 31.02                                 | 1026                              |
| 50                         | 38.05                            | 8923.                                                                                  | 4.635                                                            | 19.0                          | 404.6               | 33.71                | 13.68                                 | 31.34                                 | 1014                              |
| 51                         | 38.81                            | 8659.                                                                                  | 4.464                                                            | 42.8                          | 436.0               | 34.33                | 13.72                                 | 31.64                                 | 1002                              |
| 52                         | 39.60                            | 8425.                                                                                  | 4.299                                                            | 66.5                          | 467.8               | 34.95                | 13.76                                 | 31.89                                 | 991                               |
| 53                         | 40.41                            | 8219.                                                                                  | 4.142                                                            | 90.3                          | 499.8               | 35.56                | 13.80                                 | 32.11                                 | 980                               |
| 54                         | 41.25                            | 8041.                                                                                  | 3.990                                                            | 114.0                         | 532.0               | 36.16                | 13.85                                 | 32.28                                 | 971                               |
| 55                         | 42.10                            | 7886.                                                                                  | 3.846                                                            | 137.7                         | 564.3               | 36.75                | 13.89                                 | 32.42                                 | 962                               |
| 56                         | 42.97                            | 7757.                                                                                  | 3.708                                                            | 161.9                         | 597.3               | 37.35                | 13.93                                 | 32.52                                 | 954                               |
| 57                         | 43.87                            | 7635.                                                                                  | 3.576                                                            | 185.4                         | 629.9               | 37.93                | 13.97                                 | 32.59                                 | 946                               |
| 58                         | 44.78                            | 7537.                                                                                  | 3.451                                                            | 208.8                         | 662.5               | 38.49                | 14.01                                 | 32.62                                 | 939                               |
| 59                         | 45.70                            | 7467.                                                                                  | 3.331                                                            | 232.0                         | 695.1               | 39.05                | 14.06                                 | 32.63                                 | 933                               |
| 60                         | 46.64                            | 7407.                                                                                  | 3.218                                                            | 255.1                         | 727.7               | 39.60                | 14.10                                 | 32.60                                 | 927                               |
| 61                         | 47.59                            | 7354.                                                                                  | 3.110                                                            | 278.1                         | 760.3               | 40.14                | 14.15                                 | 32.57                                 | 922                               |
| 62                         | 48.56                            | 7321.                                                                                  | 3.008                                                            | 300.8                         | 792.9               | 40.67                | 14.21                                 | 32.52                                 | 918                               |
| 63                         | 49.53                            | 7300.                                                                                  | 2.911                                                            | 323.5                         | 825.3               | 41.19                | 14.27                                 | 32.45                                 | 913                               |
| 64                         | 50.51                            | 7297.                                                                                  | 2.819                                                            | 345.9                         | 857.7               | 41.70                | 14.34                                 | 32.36                                 | 910                               |
| 65                         | 51.50                            | 7297.                                                                                  | 2.731                                                            | 368.2                         | 890.1               | 42.20                | 14.41                                 | 32.27                                 | 906                               |
| 66                         | 52.50                            | 7300.                                                                                  | 2.648                                                            | 390.3                         | 922.3               | 42.69                | 14.48                                 | 32.18                                 | 903                               |
| 67                         | 53.50                            | 7324.                                                                                  | 2.570                                                            | 412.3                         | 954.4               | 43.17                | 14.56                                 | 32.08                                 | 901                               |
| 68                         | 54.51                            | 7357.                                                                                  | 2.495                                                            | 434.1                         | 986.4               | 43.65                | 14.65                                 | 31.98                                 | 898                               |
| 69                         | 55.52                            | 7386.                                                                                  | 2.424                                                            | 455.8                         | 1018.4              | 44.11                | 14.74                                 | 31.88                                 | 896                               |
| 70                         | 56.53                            | 7427.                                                                                  | 2.357                                                            | 477.4                         | 1050.2              | 44.57                | 14.83                                 | 31.79                                 | 894                               |
| 71                         | 57.54                            | 7477.                                                                                  | 2.294                                                            | 498.9                         | 1081.9              | 45.02                | 14.93                                 | 31.70                                 | 893                               |
| 72                         | 58.56                            | 7525.                                                                                  | 2.233                                                            | 520.2                         | 1113.6              | 45.46                | 15.04                                 | 31.62                                 | 892                               |
| 73                         | 59.58                            | 7581.                                                                                  | 2.176                                                            | 541.5                         | 1145.2              | 45.90                | 15.15                                 | 31.54                                 | 891                               |
| 74                         | 60.60                            | 7647.                                                                                  | 2.120                                                            | 562.6                         | 1176.7              | 46.33                | 15.27                                 | 31.47                                 | 890                               |
| 75                         | 61.62                            | 7707.                                                                                  | 2.069                                                            | 583.8                         | 1208.1              | 46.75                | 15.39                                 | 31.41                                 | 889                               |
| 76                         | 62.64                            | 7777.                                                                                  | 2.019                                                            | 604.8                         | 1239.5              | 47.17                | 15.51                                 | 31.35                                 | 889                               |
| 77                         | 63.65                            | 7847.                                                                                  | 1.971                                                            | 625.8                         | 1270.8              | 47.58                | 15.64                                 | 31.30                                 | 888                               |
| 78                         | 64.67                            | 7916.                                                                                  | 1.926                                                            | 646.8                         | 1302.1              | 47.98                | 15.77                                 | 31.26                                 | 888                               |
| 79                         | 65.69                            | 7991.                                                                                  | 1.883                                                            | 667.7                         | 1333.3              | 48.38                | 15.91                                 | 31.23                                 | 888                               |
| 80                         | 66.71                            | 8069.                                                                                  | 1.841                                                            | 688.6                         | 1364.6              | 48.77                | 16.05                                 | 31.20                                 | 888                               |
| 81                         | 67.72                            | 8149.                                                                                  | 1.801                                                            | 709.6                         | 1395.8              | 49.16                | 16.20                                 | 31.19                                 | 888                               |
| 82                         | 68.73                            | 8229.                                                                                  | 1.763                                                            | 730.5                         | 1426.9              | 49.54                | 16.34                                 | 31.17                                 | 888                               |
| 83                         | 69.75                            | 8317.                                                                                  | 1.727                                                            | 751.4                         | 1458.1              | 49.92                | 16.50                                 | 31.17                                 | 889                               |
| 84                         | 70.76                            | 8396.                                                                                  | 1.692                                                            | 772.3                         | 1489.3              | 50.29                | 16.65                                 | 31.17                                 | 889                               |
| 85                         | 71.76                            | 8487.                                                                                  | 1.658                                                            | 793.3                         | 1520.5              | 50.66                | 16.80                                 | 31.18                                 | 889                               |
| 86                         | 72.77                            | 8577.                                                                                  | 1.626                                                            | 814.3                         | 1551.6              | 51.03                | 16.96                                 | 31.19                                 | 890                               |
| 87                         | 73.77                            | 8659.                                                                                  | 1.594                                                            | 835.3                         | 1582.8              | 51.39                | 17.12                                 | 31.21                                 | 891                               |
| 88                         | 74.77                            | 8749.                                                                                  | 1.565                                                            | 856.4                         | 1614.0              | 51.74                | 17.28                                 | 31.23                                 | 891                               |
| 89                         | 75.77                            | 8840.                                                                                  | 1.536                                                            | 877.5                         | 1645.3              | 52.10                | 17.45                                 | 31.26                                 | 892                               |
| 90                         | 76.77                            | 8931.                                                                                  | 1.508                                                            | 898.7                         | 1676.6              | 52.45                | 17.61                                 | 31.29                                 | 893                               |
| 91                         | 77.76                            | 9025.                                                                                  | 1.481                                                            | 919.9                         | 1707.9              | 52.79                | 17.78                                 | 31.33                                 | 894                               |
| 92                         | 78.75                            | 9119.                                                                                  | 1.455                                                            | 941.3                         | 1739.2              | 53.13                | 17.94                                 | 31.37                                 | 895                               |
| 93                         | 79.74                            | 9214.                                                                                  | 1.430                                                            | 962.6                         | 1770.6              | 53.47                | 18.11                                 | 31.41                                 | 896                               |
| 94                         | 80.72                            | 9309.                                                                                  | 1.406                                                            | 984.1                         | 1802.0              | 53.81                | 18.28                                 | 31.46                                 | 897                               |
| 95                         | 81.71                            | 9405.                                                                                  | 1.382                                                            | 1005.6                        | 1833.5              | 54.14                | 18.45                                 | 31.51                                 | 899                               |
| 96                         | 82.69                            | 9500.                                                                                  | 1.360                                                            | 1027.2                        | 1865.0              | 54.47                | 18.62                                 | 31.56                                 | 900                               |
| 97                         | 83.66                            | 9595.                                                                                  | 1.338                                                            | 1048.9                        | 1896.6              | 54.80                | 18.78                                 | 31.62                                 | 901                               |
| 98                         | 84.64                            | 9691.                                                                                  | 1.317                                                            | 1070.6                        | 1928.2              | 55.12                | 18.95                                 | 31.68                                 | 902                               |
| 99                         | 85.61                            | 9787.                                                                                  | 1.296                                                            | 1092.5                        | 1960.0              | 55.45                | 19.12                                 | 31.74                                 | 904                               |
| 100                        | 86.58                            | 9883.                                                                                  | 1.276                                                            | 1114.5                        | 1991.7              | 55.77                | 19.29                                 | 31.80                                 | 905                               |

• TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

120.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 17.388                   | 24.37                            | 36787.                                                                                             | 10.082                                                                     | -604.4                        | -308.1              | 10.54                | 10.36                                          | 13.25                                          | 1538                              |
| 18                         | 24.47                            | 36357.                                                                                             | 10.139                                                                     | -597.4                        | -299.9              | 11.01                | 10.57                                          | 13.65                                          | 1537                              |
| 19                         | 24.64                            | 35214.                                                                                             | 10.185                                                                     | -585.5                        | -285.9              | 11.76                | 10.88                                          | 14.33                                          | 1526                              |
| 20                         | 24.82                            | 34149.                                                                                             | 10.182                                                                     | -573.0                        | -271.3              | 12.51                | 11.16                                          | 14.95                                          | 1516                              |
| 21                         | 25.00                            | 33101.                                                                                             | 10.141                                                                     | -560.1                        | -256.1              | 13.26                | 11.41                                          | 15.55                                          | 1505                              |
| 22                         | 25.20                            | 32048.                                                                                             | 10.078                                                                     | -546.6                        | -240.2              | 13.99                | 11.64                                          | 16.13                                          | 1494                              |
| 23                         | 25.40                            | 30991.                                                                                             | 9.997                                                                      | -532.7                        | -223.8              | 14.72                | 11.85                                          | 16.70                                          | 1482                              |
| 24                         | 25.62                            | 29959.                                                                                             | 9.903                                                                      | -518.3                        | -206.8              | 15.45                | 12.04                                          | 17.26                                          | 1469                              |
| 25                         | 25.84                            | 28950.                                                                                             | 9.796                                                                      | -503.4                        | -189.3              | 16.16                | 12.21                                          | 17.82                                          | 1457                              |
| 26                         | 26.07                            | 27954.                                                                                             | 9.677                                                                      | -488.1                        | -171.2              | 16.87                | 12.37                                          | 18.37                                          | 1444                              |
| 27                         | 26.31                            | 26987.                                                                                             | 9.548                                                                      | -472.4                        | -152.5              | 17.58                | 12.52                                          | 18.92                                          | 1431                              |
| 28                         | 26.56                            | 26006.                                                                                             | 9.409                                                                      | -456.3                        | -133.3              | 18.27                | 12.67                                          | 19.48                                          | 1418                              |
| 29                         | 26.82                            | 25067.                                                                                             | 9.260                                                                      | -439.7                        | -113.6              | 18.97                | 12.79                                          | 20.02                                          | 1404                              |
| 30                         | 27.09                            | 24131.                                                                                             | 9.100                                                                      | -422.7                        | -93.3               | 19.66                | 12.90                                          | 20.56                                          | 1390                              |
| 31                         | 27.37                            | 23241.                                                                                             | 8.933                                                                      | -405.3                        | -72.5               | 20.34                | 13.01                                          | 21.09                                          | 1376                              |
| 32                         | 27.67                            | 22369.                                                                                             | 8.757                                                                      | -387.5                        | -51.1               | 21.02                | 13.10                                          | 21.61                                          | 1362                              |
| 33                         | 27.97                            | 21522.                                                                                             | 8.576                                                                      | -369.3                        | -29.2               | 21.69                | 13.18                                          | 22.12                                          | 1347                              |
| 34                         | 28.29                            | 20695.                                                                                             | 8.388                                                                      | -350.8                        | -6.8                | 22.36                | 13.26                                          | 22.63                                          | 1333                              |
| 35                         | 28.62                            | 19895.                                                                                             | 8.196                                                                      | -332.0                        | 16.0                | 23.02                | 13.32                                          | 23.13                                          | 1318                              |
| 36                         | 28.97                            | 19137.                                                                                             | 8.000                                                                      | -312.8                        | 39.4                | 23.68                | 13.38                                          | 23.62                                          | 1303                              |
| 37                         | 29.32                            | 18397.                                                                                             | 7.802                                                                      | -293.3                        | 63.3                | 24.33                | 13.43                                          | 24.10                                          | 1288                              |
| 38                         | 29.70                            | 17687.                                                                                             | 7.601                                                                      | -273.5                        | 87.6                | 24.98                | 13.47                                          | 24.56                                          | 1273                              |
| 39                         | 30.08                            | 17007.                                                                                             | 7.400                                                                      | -253.4                        | 112.4               | 25.63                | 13.49                                          | 25.01                                          | 1259                              |
| 40                         | 30.48                            | 16357.                                                                                             | 7.199                                                                      | -233.0                        | 137.6               | 26.26                | 13.51                                          | 25.45                                          | 1244                              |
| 41                         | 30.90                            | 15734.                                                                                             | 6.999                                                                      | -212.4                        | 163.3               | 26.90                | 13.53                                          | 25.88                                          | 1230                              |
| 42                         | 31.33                            | 15147.                                                                                             | 6.799                                                                      | -191.6                        | 189.4               | 27.53                | 13.55                                          | 26.30                                          | 1216                              |
| 43                         | 31.78                            | 14581.                                                                                             | 6.600                                                                      | -170.5                        | 215.9               | 28.15                | 13.57                                          | 26.72                                          | 1201                              |
| 44                         | 32.25                            | 14058.                                                                                             | 6.404                                                                      | -149.3                        | 242.8               | 28.77                | 13.59                                          | 27.11                                          | 1187                              |
| 45                         | 32.73                            | 13559.                                                                                             | 6.211                                                                      | -127.8                        | 270.1               | 29.38                | 13.61                                          | 27.50                                          | 1174                              |
| 46                         | 33.23                            | 13097.                                                                                             | 6.020                                                                      | -106.2                        | 297.9               | 30.00                | 13.64                                          | 27.89                                          | 1160                              |
| 47                         | 33.75                            | 12654.                                                                                             | 5.833                                                                      | -84.4                         | 326.0               | 30.60                | 13.68                                          | 28.26                                          | 1146                              |
| 48                         | 34.28                            | 12250.                                                                                             | 5.651                                                                      | -62.4                         | 354.4               | 31.20                | 13.71                                          | 28.61                                          | 1133                              |
| 49                         | 34.83                            | 11871.                                                                                             | 5.473                                                                      | -40.3                         | 383.2               | 31.79                | 13.75                                          | 28.95                                          | 1121                              |
| 50                         | 35.40                            | 11523.                                                                                             | 5.300                                                                      | -18.1                         | 412.3               | 32.38                | 13.78                                          | 29.26                                          | 1109                              |
| 51                         | 35.99                            | 11196.                                                                                             | 5.131                                                                      | 4.2                           | 441.7               | 32.96                | 13.82                                          | 29.56                                          | 1097                              |
| 52                         | 36.59                            | 10898.                                                                                             | 4.967                                                                      | 26.5                          | 471.4               | 33.54                | 13.86                                          | 29.83                                          | 1086                              |
| 53                         | 37.21                            | 10629.                                                                                             | 4.809                                                                      | 49.0                          | 501.3               | 34.11                | 13.91                                          | 30.08                                          | 1075                              |
| 54                         | 37.84                            | 10386.                                                                                             | 4.656                                                                      | 71.4                          | 531.5               | 34.67                | 13.95                                          | 30.30                                          | 1065                              |
| 55                         | 38.49                            | 10167.                                                                                             | 4.508                                                                      | 94.0                          | 561.9               | 35.23                | 14.00                                          | 30.50                                          | 1055                              |
| 56                         | 39.15                            | 9966.                                                                                              | 4.366                                                                      | 117.0                         | 593.0               | 35.79                | 14.04                                          | 30.67                                          | 1046                              |
| 57                         | 39.83                            | 9786.                                                                                              | 4.229                                                                      | 139.5                         | 623.8               | 36.34                | 14.07                                          | 30.82                                          | 1038                              |
| 58                         | 40.52                            | 9628.                                                                                              | 4.097                                                                      | 161.9                         | 654.7               | 36.87                | 14.12                                          | 30.94                                          | 1030                              |
| 59                         | 41.23                            | 9490.                                                                                              | 3.970                                                                      | 184.4                         | 685.6               | 37.40                | 14.16                                          | 31.04                                          | 1023                              |
| 60                         | 41.94                            | 9370.                                                                                              | 3.849                                                                      | 206.7                         | 716.7               | 37.93                | 14.21                                          | 31.12                                          | 1016                              |
| 61                         | 42.67                            | 9261.                                                                                              | 3.732                                                                      | 229.0                         | 747.9               | 38.44                | 14.26                                          | 31.19                                          | 1009                              |
| 62                         | 43.41                            | 9170.                                                                                              | 3.620                                                                      | 251.3                         | 779.1               | 38.95                | 14.32                                          | 31.24                                          | 1003                              |
| 63                         | 44.16                            | 9097.                                                                                              | 3.514                                                                      | 273.4                         | 810.4               | 39.45                | 14.38                                          | 31.28                                          | 997                               |
| 64                         | 44.92                            | 9030.                                                                                              | 3.411                                                                      | 295.5                         | 841.7               | 39.94                | 14.45                                          | 31.31                                          | 992                               |
| 65                         | 45.69                            | 8980.                                                                                              | 3.313                                                                      | 317.5                         | 873.0               | 40.43                | 14.52                                          | 31.32                                          | 987                               |
| 66                         | 46.46                            | 8940.                                                                                              | 3.219                                                                      | 339.4                         | 904.3               | 40.91                | 14.59                                          | 31.33                                          | 982                               |
| 67                         | 47.24                            | 8911.                                                                                              | 3.130                                                                      | 361.2                         | 935.6               | 41.38                | 14.67                                          | 31.33                                          | 978                               |
| 68                         | 48.03                            | 8891.                                                                                              | 3.044                                                                      | 383.0                         | 967.0               | 41.84                | 14.76                                          | 31.32                                          | 974                               |
| 69                         | 48.82                            | 8882.                                                                                              | 2.962                                                                      | 404.7                         | 998.3               | 42.30                | 14.85                                          | 31.31                                          | 970                               |
| 70                         | 49.62                            | 8881.                                                                                              | 2.884                                                                      | 426.3                         | 1029.6              | 42.75                | 14.94                                          | 31.29                                          | 967                               |
| 71                         | 50.42                            | 8886.                                                                                              | 2.809                                                                      | 447.8                         | 1060.9              | 43.19                | 15.04                                          | 31.28                                          | 964                               |
| 72                         | 51.22                            | 8898.                                                                                              | 2.737                                                                      | 469.3                         | 1092.1              | 43.63                | 15.15                                          | 31.27                                          | 961                               |
| 73                         | 52.03                            | 8918.                                                                                              | 2.669                                                                      | 490.7                         | 1123.4              | 44.06                | 15.26                                          | 31.26                                          | 958                               |
| 74                         | 52.84                            | 8944.                                                                                              | 2.604                                                                      | 512.1                         | 1154.6              | 44.49                | 15.37                                          | 31.24                                          | 956                               |
| 75                         | 53.66                            | 8976.                                                                                              | 2.541                                                                      | 533.4                         | 1185.9              | 44.90                | 15.49                                          | 31.23                                          | 954                               |
| 76                         | 54.47                            | 9011.                                                                                              | 2.481                                                                      | 554.7                         | 1217.1              | 45.32                | 15.61                                          | 31.23                                          | 952                               |
| 77                         | 55.29                            | 9052.                                                                                              | 2.424                                                                      | 576.0                         | 1248.3              | 45.73                | 15.74                                          | 31.23                                          | 950                               |
| 78                         | 56.11                            | 9097.                                                                                              | 2.369                                                                      | 597.3                         | 1279.5              | 46.13                | 15.87                                          | 31.23                                          | 948                               |
| 79                         | 56.93                            | 9146.                                                                                              | 2.317                                                                      | 618.5                         | 1310.7              | 46.53                | 16.01                                          | 31.23                                          | 947                               |
| 80                         | 57.75                            | 9199.                                                                                              | 2.266                                                                      | 639.8                         | 1342.0              | 46.92                | 16.15                                          | 31.25                                          | 946                               |
| 81                         | 58.57                            | 9255.                                                                                              | 2.218                                                                      | 661.0                         | 1373.2              | 47.31                | 16.30                                          | 31.26                                          | 945                               |
| 82                         | 59.39                            | 9314.                                                                                              | 2.172                                                                      | 682.3                         | 1404.5              | 47.69                | 16.44                                          | 31.29                                          | 944                               |
| 83                         | 60.22                            | 9376.                                                                                              | 2.127                                                                      | 703.6                         | 1435.8              | 48.07                | 16.59                                          | 31.31                                          | 943                               |
| 84                         | 61.04                            | 9440.                                                                                              | 2.084                                                                      | 724.9                         | 1467.1              | 48.45                | 16.75                                          | 31.34                                          | 942                               |
| 85                         | 61.86                            | 9507.                                                                                              | 2.043                                                                      | 746.3                         | 1498.5              | 48.82                | 16.90                                          | 31.38                                          | 942                               |
| 86                         | 62.69                            | 9576.                                                                                              | 2.003                                                                      | 767.7                         | 1529.9              | 49.18                | 17.06                                          | 31.41                                          | 941                               |
| 87                         | 63.51                            | 9647.                                                                                              | 1.965                                                                      | 789.1                         | 1561.3              | 49.55                | 17.22                                          | 31.46                                          | 941                               |
| 88                         | 64.33                            | 9720.                                                                                              | 1.928                                                                      | 810.6                         | 1592.8              | 49.91                | 17.39                                          | 31.50                                          | 941                               |
| 89                         | 65.15                            | 9795.                                                                                              | 1.893                                                                      | 832.2                         | 1624.3              | 50.26                | 17.55                                          | 31.55                                          | 941                               |
| 90                         | 65.97                            | 9872.                                                                                              | 1.858                                                                      | 853.8                         | 1655.9              | 50.62                | 17.72                                          | 31.60                                          | 941                               |
| 91                         | 66.79                            | 9950.                                                                                              | 1.825                                                                      | 875.4                         | 1687.5              | 50.97                | 17.89                                          | 31.65                                          | 941                               |
| 92                         | 67.60                            | 10030.                                                                                             | 1.793                                                                      | 897.2                         | 1719.2              | 51.31                | 18.06                                          | 31.71                                          | 941                               |
| 93                         | 68.42                            | 10111.                                                                                             | 1.762                                                                      | 919.0                         | 1750.9              | 51.66                | 18.22                                          | 31.77                                          | 941                               |
| 94                         | 69.24                            | 10194.                                                                                             | 1.732                                                                      | 940.9                         | 1782.7              | 52.00                | 18.39                                          | 31.83                                          | 942                               |
| 95                         | 70.05                            | 10279.                                                                                             | 1.703                                                                      | 962.9                         | 1814.6              | 52.33                | 18.57                                          | 31.90                                          | 942                               |
| 96                         | 70.86                            | 10363.                                                                                             | 1.675                                                                      | 984.9                         | 1846.5              | 52.67                | 18.74                                          | 31.96                                          | 943                               |
| 97                         | 71.67                            | 10448.                                                                                             | 1.648                                                                      | 1007.0                        | 1878.5              | 53.00                | 18.91                                          | 32.03                                          | 943                               |
| 98                         | 72.48                            | 10534.                                                                                             | 1.622                                                                      | 1029.3                        | 1910.6              | 53.33                | 19.08                                          | 32.10                                          | 944                               |
| 99                         | 73.29                            | 10621.                                                                                             | 1.596                                                                      | 1051.6                        | 1942.7              | 53.65                | 19.25                                          | 32.17                                          | 945                               |
| 100                        | 74.10                            | 10709.                                                                                             | 1.571                                                                      | 1074.0                        | 1974.9              | 53.98                | 19.42                                          | 32.24                                          | 945                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

140.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>OEG. KELVIN | VOLUME<br>CM/GMOLE | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_p$<br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| * 17.916                   | 24.14              | 39197.                                                                              | 10.248                                                         | -600.0                        | -257.6              | 10.62                | 10.45                                 | 13.28                                 | 1583                              |
| 18                         | 24.15              | 39161.                                                                              | 10.258                                                         | -599.1                        | -256.5              | 10.68                | 10.48                                 | 13.34                                 | 1583                              |
| 19                         | 24.31              | 37863.                                                                              | 10.337                                                         | -587.7                        | -242.8              | 11.42                | 10.81                                 | 14.02                                 | 1571                              |
| 20                         | 24.47              | 36809.                                                                              | 10.359                                                         | -575.7                        | -228.5              | 12.16                | 11.11                                 | 14.64                                 | 1562                              |
| 21                         | 24.65              | 35818.                                                                              | 10.347                                                         | -563.2                        | -213.6              | 12.89                | 11.37                                 | 15.23                                 | 1553                              |
| 22                         | 24.83              | 34764.                                                                              | 10.299                                                         | -550.2                        | -198.0              | 13.61                | 11.60                                 | 15.79                                 | 1542                              |
| 23                         | 25.01              | 33760.                                                                              | 10.230                                                         | -536.8                        | -182.0              | 14.32                | 11.82                                 | 16.34                                 | 1532                              |
| 24                         | 25.20              | 32739.                                                                              | 10.147                                                         | -522.9                        | -165.4              | 15.03                | 12.01                                 | 16.87                                 | 1520                              |
| 25                         | 25.40              | 31746.                                                                              | 10.053                                                         | -508.6                        | -148.2              | 15.73                | 12.19                                 | 17.39                                 | 1509                              |
| 26                         | 25.61              | 30759.                                                                              | 9.947                                                          | -493.9                        | -130.6              | 16.42                | 12.36                                 | 17.91                                 | 1497                              |
| 27                         | 25.83              | 29801.                                                                              | 9.831                                                          | -478.8                        | -112.4              | 17.11                | 12.51                                 | 18.43                                 | 1485                              |
| 28                         | 26.05              | 28841.                                                                              | 9.704                                                          | -463.3                        | -93.7               | 17.79                | 12.66                                 | 18.95                                 | 1473                              |
| 29                         | 26.29              | 27911.                                                                              | 9.570                                                          | -447.4                        | -74.5               | 18.46                | 12.79                                 | 19.46                                 | 1461                              |
| 30                         | 26.53              | 27000.                                                                              | 9.426                                                          | -431.1                        | -54.8               | 19.13                | 12.91                                 | 19.95                                 | 1448                              |
| 31                         | 26.78              | 26097.                                                                              | 9.274                                                          | -414.5                        | -34.6               | 19.79                | 13.02                                 | 20.45                                 | 1435                              |
| 32                         | 27.04              | 25229.                                                                              | 9.115                                                          | -397.5                        | -13.9               | 20.45                | 13.12                                 | 20.93                                 | 1422                              |
| 33                         | 27.31              | 24377.                                                                              | 8.948                                                          | -380.1                        | 7.3                 | 21.10                | 13.21                                 | 21.40                                 | 1409                              |
| 34                         | 27.58              | 23579.                                                                              | 8.777                                                          | -362.4                        | 28.9                | 21.74                | 13.29                                 | 21.86                                 | 1396                              |
| 35                         | 27.87              | 22779.                                                                              | 8.600                                                          | -344.4                        | 51.0                | 22.38                | 13.37                                 | 22.31                                 | 1382                              |
| 36                         | 28.17              | 22015.                                                                              | 8.420                                                          | -326.1                        | 73.5                | 23.02                | 13.43                                 | 22.75                                 | 1369                              |
| 37                         | 28.48              | 21277.                                                                              | 8.236                                                          | -307.5                        | 96.5                | 23.65                | 13.49                                 | 23.18                                 | 1356                              |
| 38                         | 28.80              | 20557.                                                                              | 8.050                                                          | -288.7                        | 119.9               | 24.27                | 13.53                                 | 23.60                                 | 1342                              |
| 39                         | 29.13              | 19871.                                                                              | 7.863                                                          | -269.6                        | 143.7               | 24.89                | 13.56                                 | 23.99                                 | 1329                              |
| 40                         | 29.47              | 19221.                                                                              | 7.675                                                          | -250.2                        | 167.8               | 25.50                | 13.59                                 | 24.37                                 | 1317                              |
| 41                         | 29.82              | 18586.                                                                              | 7.486                                                          | -230.7                        | 192.4               | 26.11                | 13.61                                 | 24.75                                 | 1303                              |
| 42                         | 30.19              | 17979.                                                                              | 7.299                                                          | -210.9                        | 217.3               | 26.71                | 13.63                                 | 25.12                                 | 1291                              |
| 43                         | 30.56              | 17391.                                                                              | 7.112                                                          | -190.9                        | 242.7               | 27.31                | 13.65                                 | 25.49                                 | 1278                              |
| 44                         | 30.95              | 16839.                                                                              | 6.927                                                          | -170.8                        | 268.3               | 27.90                | 13.68                                 | 25.85                                 | 1265                              |
| 45                         | 31.35              | 16315.                                                                              | 6.744                                                          | -150.4                        | 294.4               | 28.48                | 13.70                                 | 26.19                                 | 1252                              |
| 46                         | 31.77              | 15819.                                                                              | 6.562                                                          | -129.9                        | 320.8               | 29.06                | 13.74                                 | 26.54                                 | 1239                              |
| 47                         | 32.19              | 15347.                                                                              | 6.383                                                          | -109.2                        | 347.5               | 29.64                | 13.77                                 | 26.87                                 | 1227                              |
| 48                         | 32.63              | 14905.                                                                              | 6.208                                                          | -88.3                         | 374.5               | 30.21                | 13.81                                 | 27.20                                 | 1215                              |
| 49                         | 33.08              | 14489.                                                                              | 6.035                                                          | -67.4                         | 401.8               | 30.77                | 13.85                                 | 27.50                                 | 1203                              |
| 50                         | 33.54              | 14100.                                                                              | 5.865                                                          | -46.3                         | 429.5               | 31.33                | 13.89                                 | 27.79                                 | 1191                              |
| 51                         | 34.01              | 13729.                                                                              | 5.701                                                          | -25.1                         | 457.4               | 31.88                | 13.93                                 | 28.08                                 | 1179                              |
| 52                         | 34.50              | 13385.                                                                              | 5.539                                                          | -3.7                          | 485.7               | 32.43                | 13.97                                 | 28.34                                 | 1168                              |
| 53                         | 35.00              | 13067.                                                                              | 5.383                                                          | 17.7                          | 514.1               | 32.97                | 14.01                                 | 28.60                                 | 1158                              |
| 54                         | 35.51              | 12773.                                                                              | 5.231                                                          | 39.1                          | 542.9               | 33.51                | 14.06                                 | 28.84                                 | 1148                              |
| 55                         | 36.03              | 12505.                                                                              | 5.083                                                          | 60.7                          | 571.8               | 34.04                | 14.10                                 | 29.05                                 | 1138                              |
| 56                         | 36.57              | 12252.                                                                              | 4.939                                                          | 82.8                          | 601.5               | 34.58                | 14.14                                 | 29.25                                 | 1129                              |
| 57                         | 37.11              | 12022.                                                                              | 4.800                                                          | 104.4                         | 630.8               | 35.10                | 14.18                                 | 29.43                                 | 1120                              |
| 58                         | 37.66              | 11813.                                                                              | 4.666                                                          | 126.0                         | 660.3               | 35.61                | 14.22                                 | 29.58                                 | 1111                              |
| 59                         | 38.23              | 11624.                                                                              | 4.536                                                          | 147.7                         | 690.0               | 36.12                | 14.27                                 | 29.73                                 | 1103                              |
| 60                         | 38.80              | 11454.                                                                              | 4.410                                                          | 169.3                         | 719.8               | 36.62                | 14.31                                 | 29.86                                 | 1096                              |
| 61                         | 39.39              | 11297.                                                                              | 4.289                                                          | 190.9                         | 749.7               | 37.11                | 14.37                                 | 29.98                                 | 1088                              |
| 62                         | 39.98              | 11157.                                                                              | 4.171                                                          | 212.5                         | 779.7               | 37.60                | 14.42                                 | 30.09                                 | 1081                              |
| 63                         | 40.58              | 11032.                                                                              | 4.059                                                          | 234.1                         | 809.8               | 38.08                | 14.49                                 | 30.19                                 | 1075                              |
| 64                         | 41.19              | 10923.                                                                              | 3.950                                                          | 255.7                         | 840.1               | 38.56                | 14.55                                 | 30.28                                 | 1069                              |
| 65                         | 41.81              | 10827.                                                                              | 3.846                                                          | 277.3                         | 870.4               | 39.03                | 14.62                                 | 30.35                                 | 1063                              |
| 66                         | 42.44              | 10747.                                                                              | 3.745                                                          | 298.8                         | 900.8               | 39.49                | 14.70                                 | 30.42                                 | 1057                              |
| 67                         | 43.07              | 10669.                                                                              | 3.648                                                          | 320.3                         | 931.2               | 39.95                | 14.78                                 | 30.49                                 | 1052                              |
| 68                         | 43.70              | 10607.                                                                              | 3.555                                                          | 341.8                         | 961.7               | 40.40                | 14.86                                 | 30.54                                 | 1047                              |
| 69                         | 44.35              | 10557.                                                                              | 3.465                                                          | 363.2                         | 992.3               | 40.85                | 14.95                                 | 30.59                                 | 1042                              |
| 70                         | 45.00              | 10517.                                                                              | 3.379                                                          | 384.6                         | 1022.9              | 41.29                | 15.05                                 | 30.64                                 | 1037                              |
| 71                         | 45.65              | 10482.                                                                              | 3.296                                                          | 406.0                         | 1053.6              | 41.72                | 15.15                                 | 30.68                                 | 1033                              |
| 72                         | 46.31              | 10457.                                                                              | 3.216                                                          | 427.4                         | 1084.3              | 42.15                | 15.25                                 | 30.73                                 | 1029                              |
| 73                         | 46.97              | 10440.                                                                              | 3.140                                                          | 448.8                         | 1115.0              | 42.58                | 15.36                                 | 30.77                                 | 1025                              |
| 74                         | 47.63              | 10431.                                                                              | 3.066                                                          | 470.1                         | 1145.8              | 42.99                | 15.47                                 | 30.80                                 | 1022                              |
| 75                         | 48.30              | 10429.                                                                              | 2.995                                                          | 491.5                         | 1176.6              | 43.41                | 15.59                                 | 30.85                                 | 1018                              |
| 76                         | 48.97              | 10434.                                                                              | 2.927                                                          | 512.8                         | 1207.5              | 43.82                | 15.71                                 | 30.88                                 | 1015                              |
| 77                         | 49.64              | 10445.                                                                              | 2.862                                                          | 534.1                         | 1238.4              | 44.22                | 15.84                                 | 30.92                                 | 1012                              |
| 78                         | 50.32              | 10461.                                                                              | 2.799                                                          | 555.5                         | 1269.3              | 44.62                | 15.97                                 | 30.96                                 | 1010                              |
| 79                         | 51.00              | 10483.                                                                              | 2.739                                                          | 576.8                         | 1300.3              | 45.01                | 16.11                                 | 31.01                                 | 1007                              |
| 80                         | 51.68              | 10510.                                                                              | 2.681                                                          | 598.2                         | 1331.3              | 45.40                | 16.25                                 | 31.05                                 | 1005                              |
| 81                         | 52.36              | 10542.                                                                              | 2.625                                                          | 619.6                         | 1362.4              | 45.79                | 16.39                                 | 31.10                                 | 1003                              |
| 82                         | 53.04              | 10577.                                                                              | 2.572                                                          | 641.0                         | 1393.5              | 46.17                | 16.54                                 | 31.15                                 | 1001                              |
| 83                         | 53.73              | 10617.                                                                              | 2.520                                                          | 662.5                         | 1424.7              | 46.55                | 16.68                                 | 31.20                                 | 999                               |
| 84                         | 54.41              | 10660.                                                                              | 2.470                                                          | 684.0                         | 1455.9              | 46.92                | 16.84                                 | 31.26                                 | 997                               |
| 85                         | 55.10              | 10706.                                                                              | 2.422                                                          | 705.6                         | 1487.2              | 47.29                | 16.99                                 | 31.32                                 | 996                               |
| 86                         | 55.79              | 10755.                                                                              | 2.376                                                          | 727.2                         | 1518.5              | 47.66                | 17.15                                 | 31.38                                 | 995                               |
| 87                         | 56.47              | 10807.                                                                              | 2.331                                                          | 748.8                         | 1549.9              | 48.02                | 17.31                                 | 31.45                                 | 993                               |
| 88                         | 57.16              | 10861.                                                                              | 2.288                                                          | 770.5                         | 1581.4              | 48.38                | 17.47                                 | 31.52                                 | 992                               |
| 89                         | 57.85              | 10918.                                                                              | 2.247                                                          | 792.3                         | 1613.0              | 48.74                | 17.64                                 | 31.59                                 | 991                               |
| 90                         | 58.54              | 10978.                                                                              | 2.206                                                          | 814.2                         | 1644.6              | 49.09                | 17.81                                 | 31.66                                 | 991                               |
| 91                         | 59.23              | 11037.                                                                              | 2.168                                                          | 836.1                         | 1676.3              | 49.44                | 17.97                                 | 31.74                                 | 990                               |
| 92                         | 59.92              | 11099.                                                                              | 2.130                                                          | 858.1                         | 1708.1              | 49.79                | 18.14                                 | 31.82                                 | 989                               |
| 93                         | 60.61              | 11163.                                                                              | 2.093                                                          | 880.2                         | 1740.0              | 50.14                | 18.31                                 | 31.90                                 | 989                               |
| 94                         | 61.30              | 11230.                                                                              | 2.058                                                          | 902.4                         | 1771.9              | 50.48                | 18.48                                 | 31.99                                 | 988                               |
| 95                         | 61.99              | 11299.                                                                              | 2.024                                                          | 924.7                         | 1803.9              | 50.82                | 18.66                                 | 32.07                                 | 988                               |
| 96                         | 62.67              | 11370.                                                                              | 1.991                                                          | 947.0                         | 1836.1              | 51.15                | 18.83                                 | 32.15                                 | 988                               |
| 97                         | 63.36              | 11442.                                                                              | 1.959                                                          | 969.4                         | 1868.3              | 51.49                | 19.00                                 | 32.24                                 | 988                               |
| 98                         | 64.05              | 11515.                                                                              | 1.928                                                          | 992.0                         | 1900.5              | 51.82                | 19.17                                 | 32.32                                 | 988                               |
| 99                         | 64.73              | 11591.                                                                              | 1.898                                                          | 1014.6                        | 1932.9              | 52.15                | 19.34                                 | 32.41                                 | 988                               |
| 100                        | 65.42              | 11667.                                                                              | 1.869                                                          | 1037.3                        | 1965.3              | 52.47                | 19.52                                 | 32.49                                 | 988                               |

\* TWO-PHASE BOUNDARY

TABLE X. THERMOODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

160.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 18.431                     | 23.93                            | 41276.                                                                                             | 10.460                                                                     | -595.5                        | -207.6              | 10.69                | 10.54                                          | 13.38                                          | 1622                              |
| 19                         | 24.01                            | 4042.                                                                                              | 10.491                                                                     | -589.1                        | -199.8              | 11.11                | 10.74                                          | 13.76                                          | 1614                              |
| 20                         | 24.16                            | 39417.                                                                                             | 10.522                                                                     | -577.5                        | -185.8              | 11.83                | 11.05                                          | 14.37                                          | 1605                              |
| 21                         | 24.32                            | 38434.                                                                                             | 10.521                                                                     | -565.4                        | -171.1              | 12.54                | 11.32                                          | 14.95                                          | 1597                              |
| 22                         | 24.49                            | 37387.                                                                                             | 10.493                                                                     | -552.9                        | -155.9              | 13.25                | 11.56                                          | 15.50                                          | 1587                              |
| 23                         | 24.66                            | 36428.                                                                                             | 10.442                                                                     | -539.9                        | -140.1              | 13.95                | 11.78                                          | 16.03                                          | 1578                              |
| 24                         | 24.84                            | 35417.                                                                                             | 10.369                                                                     | -526.5                        | -123.8              | 14.65                | 11.98                                          | 16.54                                          | 1567                              |
| 25                         | 25.02                            | 34435.                                                                                             | 10.285                                                                     | -512.7                        | -107.1              | 15.33                | 12.17                                          | 17.04                                          | 1557                              |
| 26                         | 25.21                            | 33451.                                                                                             | 10.189                                                                     | -498.5                        | -89.8               | 16.01                | 12.34                                          | 17.53                                          | 1546                              |
| 27                         | 25.41                            | 32503.                                                                                             | 10.085                                                                     | -483.9                        | -72.0               | 16.68                | 12.50                                          | 18.03                                          | 1535                              |
| 28                         | 25.61                            | 31560.                                                                                             | 9.972                                                                      | -468.9                        | -53.7               | 17.34                | 12.65                                          | 18.51                                          | 1524                              |
| 29                         | 25.82                            | 30630.                                                                                             | 9.848                                                                      | -453.6                        | -35.0               | 18.00                | 12.79                                          | 18.99                                          | 1512                              |
| 30                         | 26.04                            | 29744.                                                                                             | 9.717                                                                      | -437.9                        | -15.7               | 18.65                | 12.91                                          | 19.46                                          | 1501                              |
| 31                         | 26.27                            | 28830.                                                                                             | 9.578                                                                      | -421.9                        | 4.0                 | 19.30                | 13.03                                          | 19.93                                          | 1489                              |
| 32                         | 26.50                            | 27967.                                                                                             | 9.432                                                                      | -405.5                        | 24.1                | 19.94                | 13.14                                          | 20.38                                          | 1477                              |
| 33                         | 26.74                            | 27110.                                                                                             | 9.279                                                                      | -388.8                        | 44.7                | 20.57                | 13.24                                          | 20.83                                          | 1464                              |
| 34                         | 26.99                            | 26331.                                                                                             | 9.120                                                                      | -371.8                        | 65.7                | 21.20                | 13.32                                          | 21.25                                          | 1453                              |
| 35                         | 27.24                            | 25533.                                                                                             | 8.956                                                                      | -354.5                        | 87.2                | 21.82                | 13.40                                          | 21.67                                          | 1441                              |
| 36                         | 27.51                            | 24766.                                                                                             | 8.788                                                                      | -336.9                        | 109.1               | 22.44                | 13.47                                          | 22.08                                          | 1428                              |
| 37                         | 27.78                            | 24027.                                                                                             | 8.617                                                                      | -319.0                        | 131.4               | 23.05                | 13.53                                          | 22.48                                          | 1416                              |
| 38                         | 28.06                            | 23301.                                                                                             | 8.443                                                                      | -300.9                        | 154.0               | 23.66                | 13.58                                          | 22.86                                          | 1404                              |
| 39                         | 28.35                            | 22611.                                                                                             | 8.268                                                                      | -282.6                        | 177.1               | 24.25                | 13.62                                          | 23.22                                          | 1392                              |
| 40                         | 28.65                            | 21952.                                                                                             | 8.091                                                                      | -264.0                        | 200.5               | 24.85                | 13.65                                          | 23.57                                          | 1380                              |
| 41                         | 28.96                            | 21310.                                                                                             | 7.913                                                                      | -245.2                        | 224.2               | 25.43                | 13.67                                          | 23.91                                          | 1368                              |
| 42                         | 29.27                            | 20693.                                                                                             | 7.736                                                                      | -226.3                        | 248.3               | 26.01                | 13.70                                          | 24.24                                          | 1357                              |
| 43                         | 29.60                            | 20080.                                                                                             | 7.558                                                                      | -207.1                        | 272.7               | 26.59                | 13.73                                          | 24.58                                          | 1345                              |
| 44                         | 29.93                            | 19515.                                                                                             | 7.381                                                                      | -187.8                        | 297.4               | 27.16                | 13.75                                          | 24.90                                          | 1333                              |
| 45                         | 30.28                            | 18975.                                                                                             | 7.206                                                                      | -168.3                        | 322.5               | 27.72                | 13.78                                          | 25.22                                          | 1321                              |
| 46                         | 30.63                            | 18460.                                                                                             | 7.033                                                                      | -148.6                        | 347.9               | 28.28                | 13.82                                          | 25.54                                          | 1309                              |
| 47                         | 30.99                            | 17962.                                                                                             | 6.862                                                                      | -128.8                        | 373.6               | 28.83                | 13.86                                          | 25.85                                          | 1298                              |
| 48                         | 31.36                            | 17491.                                                                                             | 6.692                                                                      | -108.8                        | 399.6               | 29.38                | 13.90                                          | 26.15                                          | 1286                              |
| 49                         | 31.74                            | 17048.                                                                                             | 6.525                                                                      | -88.7                         | 425.9               | 29.92                | 13.94                                          | 26.44                                          | 1275                              |
| 50                         | 32.13                            | 16630.                                                                                             | 6.361                                                                      | -68.5                         | 452.5               | 30.46                | 13.98                                          | 26.71                                          | 1264                              |
| 51                         | 32.53                            | 16227.                                                                                             | 6.201                                                                      | -48.1                         | 479.3               | 30.99                | 14.03                                          | 26.98                                          | 1253                              |
| 52                         | 32.94                            | 15848.                                                                                             | 6.042                                                                      | -27.6                         | 506.4               | 31.52                | 14.07                                          | 27.24                                          | 1242                              |
| 53                         | 33.36                            | 15493.                                                                                             | 5.887                                                                      | -7.1                          | 533.8               | 32.04                | 14.11                                          | 27.48                                          | 1231                              |
| 54                         | 33.79                            | 15162.                                                                                             | 5.737                                                                      | 13.6                          | 561.4               | 32.55                | 14.16                                          | 27.72                                          | 1221                              |
| 55                         | 34.22                            | 14853.                                                                                             | 5.590                                                                      | 34.4                          | 589.2               | 33.06                | 14.20                                          | 27.94                                          | 1212                              |
| 56                         | 34.67                            | 14560.                                                                                             | 5.447                                                                      | 55.7                          | 617.8               | 33.58                | 14.24                                          | 28.14                                          | 1202                              |
| 57                         | 35.12                            | 14289.                                                                                             | 5.307                                                                      | 76.6                          | 646.0               | 34.08                | 14.28                                          | 28.33                                          | 1193                              |
| 58                         | 35.59                            | 14038.                                                                                             | 5.172                                                                      | 97.5                          | 674.4               | 34.57                | 14.32                                          | 28.51                                          | 1185                              |
| 59                         | 36.06                            | 13807.                                                                                             | 5.041                                                                      | 118.5                         | 703.0               | 35.06                | 14.37                                          | 28.67                                          | 1177                              |
| 60                         | 36.53                            | 13596.                                                                                             | 4.913                                                                      | 139.5                         | 731.8               | 35.55                | 14.42                                          | 28.82                                          | 1169                              |
| 61                         | 37.02                            | 13397.                                                                                             | 4.789                                                                      | 160.5                         | 760.7               | 36.02                | 14.47                                          | 28.97                                          | 1161                              |
| 62                         | 37.51                            | 13216.                                                                                             | 4.669                                                                      | 181.5                         | 789.7               | 36.50                | 14.53                                          | 29.11                                          | 1154                              |
| 63                         | 38.02                            | 13051.                                                                                             | 4.553                                                                      | 202.6                         | 818.9               | 36.96                | 14.59                                          | 29.24                                          | 1147                              |
| 64                         | 38.52                            | 12902.                                                                                             | 4.440                                                                      | 223.7                         | 848.2               | 37.42                | 14.66                                          | 29.36                                          | 1140                              |
| 65                         | 39.04                            | 12768.                                                                                             | 4.331                                                                      | 244.7                         | 877.6               | 37.88                | 14.73                                          | 29.47                                          | 1133                              |
| 66                         | 39.56                            | 12642.                                                                                             | 4.226                                                                      | 265.8                         | 907.1               | 38.33                | 14.80                                          | 29.59                                          | 1127                              |
| 67                         | 40.08                            | 12530.                                                                                             | 4.124                                                                      | 286.9                         | 936.8               | 38.78                | 14.88                                          | 29.69                                          | 1121                              |
| 68                         | 40.61                            | 12431.                                                                                             | 4.026                                                                      | 308.1                         | 966.5               | 39.22                | 14.97                                          | 29.79                                          | 1115                              |
| 69                         | 41.15                            | 12344.                                                                                             | 3.931                                                                      | 329.2                         | 996.3               | 39.65                | 15.06                                          | 29.88                                          | 1110                              |
| 70                         | 41.69                            | 12269.                                                                                             | 3.839                                                                      | 350.3                         | 1026.3              | 40.08                | 15.15                                          | 29.96                                          | 1104                              |
| 71                         | 42.24                            | 12199.                                                                                             | 3.751                                                                      | 371.5                         | 1056.3              | 40.51                | 15.25                                          | 30.05                                          | 1099                              |
| 72                         | 42.79                            | 12139.                                                                                             | 3.665                                                                      | 392.7                         | 1086.4              | 40.93                | 15.36                                          | 30.14                                          | 1094                              |
| 73                         | 43.34                            | 12088.                                                                                             | 3.582                                                                      | 413.8                         | 1116.5              | 41.35                | 15.46                                          | 30.22                                          | 1090                              |
| 74                         | 43.90                            | 12046.                                                                                             | 3.503                                                                      | 435.0                         | 1146.8              | 41.76                | 15.58                                          | 30.30                                          | 1085                              |
| 75                         | 44.46                            | 12013.                                                                                             | 3.426                                                                      | 456.3                         | 1177.1              | 42.16                | 15.69                                          | 30.37                                          | 1081                              |
| 76                         | 45.03                            | 11987.                                                                                             | 3.352                                                                      | 477.5                         | 1207.5              | 42.57                | 15.82                                          | 30.45                                          | 1077                              |
| 77                         | 45.60                            | 11969.                                                                                             | 3.280                                                                      | 498.8                         | 1238.0              | 42.97                | 15.94                                          | 30.52                                          | 1073                              |
| 78                         | 46.17                            | 11957.                                                                                             | 3.211                                                                      | 520.1                         | 1268.6              | 43.36                | 16.07                                          | 30.60                                          | 1070                              |
| 79                         | 46.74                            | 11953.                                                                                             | 3.144                                                                      | 541.4                         | 1299.2              | 43.75                | 16.20                                          | 30.67                                          | 1066                              |
| 80                         | 47.32                            | 11954.                                                                                             | 3.080                                                                      | 562.8                         | 1329.9              | 44.14                | 16.34                                          | 30.74                                          | 1063                              |
| 81                         | 47.89                            | 11960.                                                                                             | 3.018                                                                      | 584.2                         | 1360.6              | 44.52                | 16.48                                          | 30.82                                          | 1060                              |
| 82                         | 48.47                            | 11972.                                                                                             | 2.958                                                                      | 605.6                         | 1391.5              | 44.90                | 16.63                                          | 30.90                                          | 1057                              |
| 83                         | 49.06                            | 11988.                                                                                             | 2.900                                                                      | 627.1                         | 1422.4              | 45.27                | 16.78                                          | 30.97                                          | 1055                              |
| 84                         | 49.64                            | 12010.                                                                                             | 2.844                                                                      | 648.7                         | 1453.4              | 45.64                | 16.93                                          | 31.05                                          | 1052                              |
| 85                         | 50.22                            | 12036.                                                                                             | 2.790                                                                      | 670.3                         | 1484.5              | 46.01                | 17.08                                          | 31.13                                          | 1050                              |
| 86                         | 50.81                            | 12064.                                                                                             | 2.738                                                                      | 692.0                         | 1515.7              | 46.38                | 17.24                                          | 31.22                                          | 1048                              |
| 87                         | 51.39                            | 12095.                                                                                             | 2.688                                                                      | 713.8                         | 1546.9              | 46.74                | 17.40                                          | 31.30                                          | 1046                              |
| 88                         | 51.98                            | 12131.                                                                                             | 2.640                                                                      | 735.6                         | 1578.3              | 47.10                | 17.56                                          | 31.40                                          | 1044                              |
| 89                         | 52.57                            | 12170.                                                                                             | 2.592                                                                      | 757.5                         | 1609.7              | 47.45                | 17.72                                          | 31.48                                          | 1042                              |
| 90                         | 53.16                            | 12212.                                                                                             | 2.547                                                                      | 779.5                         | 1641.3              | 47.80                | 17.89                                          | 31.58                                          | 1041                              |
| 91                         | 53.75                            | 12251.                                                                                             | 2.503                                                                      | 801.5                         | 1672.9              | 48.15                | 18.05                                          | 31.68                                          | 1039                              |
| 92                         | 54.34                            | 12294.                                                                                             | 2.461                                                                      | 823.7                         | 1704.6              | 48.50                | 18.22                                          | 31.78                                          | 1038                              |
| 93                         | 54.93                            | 12340.                                                                                             | 2.419                                                                      | 845.9                         | 1736.5              | 48.84                | 18.39                                          | 31.88                                          | 1037                              |
| 94                         | 55.52                            | 12389.                                                                                             | 2.379                                                                      | 868.3                         | 1768.4              | 49.18                | 18.56                                          | 31.98                                          | 1036                              |
| 95                         | 56.12                            | 12441.                                                                                             | 2.341                                                                      | 890.7                         | 1800.4              | 49.52                | 18.73                                          | 32.08                                          | 1035                              |
| 96                         | 56.71                            | 12496.                                                                                             | 2.303                                                                      | 913.2                         | 1832.6              | 49.86                | 18.90                                          | 32.18                                          | 1034                              |
| 97                         | 57.30                            | 12554.                                                                                             | 2.267                                                                      | 935.8                         | 1864.8              | 50.19                | 19.08                                          | 32.28                                          | 1033                              |
| 98                         | 57.89                            | 12614.                                                                                             | 2.231                                                                      | 958.5                         | 1897.1              | 50.53                | 19.25                                          | 32.39                                          | 1033                              |
| 99                         | 58.49                            | 12675.                                                                                             | 2.197                                                                      | 981.4                         | 1929.6              | 50.86                | 19.42                                          | 32.49                                          | 1032                              |
| 100                        | 59.08                            | 12739.                                                                                             | 2.164                                                                      | 1004.3                        | 1962.1              | 51.18                | 19.59                                          | 32.59                                          | 1032                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

180.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial p$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>p</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 18.933                   | 23.73                            | 43024.                                                                                           | 10.680                                                                     | -590.7                        | -158.0              | 10.77                | 10.64                                          | 13.51                                          | 1657                              |
| 19                         | 23.74                            | 42905.                                                                                           | 10.679                                                                     | -590.0                        | -157.0              | 10.81                | 10.67                                          | 13.55                                          | 1655                              |
| 20                         | 23.88                            | 42002.                                                                                           | 10.692                                                                     | -578.7                        | -143.2              | 11.52                | 10.99                                          | 14.13                                          | 1648                              |
| 21                         | 24.03                            | 40960.                                                                                           | 10.692                                                                     | -567.0                        | -128.8              | 12.23                | 11.27                                          | 14.70                                          | 1639                              |
| 22                         | 24.18                            | 39921.                                                                                           | 10.671                                                                     | -554.8                        | -113.8              | 12.92                | 11.52                                          | 15.24                                          | 1629                              |
| 23                         | 24.34                            | 39001.                                                                                           | 10.629                                                                     | -542.2                        | -98.3               | 13.61                | 11.75                                          | 15.75                                          | 1621                              |
| 24                         | 24.50                            | 38007.                                                                                           | 10.570                                                                     | -529.2                        | -82.3               | 14.29                | 11.96                                          | 16.25                                          | 1611                              |
| 25                         | 24.67                            | 37033.                                                                                           | 10.495                                                                     | -515.8                        | -65.8               | 14.97                | 12.15                                          | 16.73                                          | 1601                              |
| 26                         | 24.85                            | 36049.                                                                                           | 10.408                                                                     | -502.1                        | -48.8               | 15.63                | 12.32                                          | 17.21                                          | 1591                              |
| 27                         | 25.03                            | 35106.                                                                                           | 10.314                                                                     | -487.9                        | -31.4               | 16.29                | 12.49                                          | 17.68                                          | 1581                              |
| 28                         | 25.22                            | 34181.                                                                                           | 10.210                                                                     | -473.4                        | -13.5               | 16.94                | 12.64                                          | 18.15                                          | 1570                              |
| 29                         | 25.41                            | 33267.                                                                                           | 10.099                                                                     | -458.6                        | 4.9                 | 17.59                | 12.79                                          | 18.60                                          | 1560                              |
| 30                         | 25.61                            | 32384.                                                                                           | 9.980                                                                      | -443.4                        | 23.7                | 18.23                | 12.91                                          | 19.05                                          | 1549                              |
| 31                         | 25.82                            | 31464.                                                                                           | 9.851                                                                      | -427.8                        | 43.0                | 18.86                | 13.04                                          | 19.49                                          | 1538                              |
| 32                         | 26.03                            | 30595.                                                                                           | 9.716                                                                      | -412.0                        | 62.7                | 19.48                | 13.15                                          | 19.93                                          | 1526                              |
| 33                         | 26.25                            | 29749.                                                                                           | 9.576                                                                      | -395.8                        | 82.8                | 20.10                | 13.25                                          | 20.35                                          | 1515                              |
| 34                         | 26.47                            | 28977.                                                                                           | 9.429                                                                      | -379.4                        | 103.4               | 20.72                | 13.35                                          | 20.75                                          | 1505                              |
| 35                         | 26.70                            | 28179.                                                                                           | 9.276                                                                      | -362.7                        | 124.3               | 21.32                | 13.43                                          | 21.15                                          | 1493                              |
| 36                         | 26.94                            | 27407.                                                                                           | 9.118                                                                      | -345.7                        | 145.7               | 21.92                | 13.51                                          | 21.54                                          | 1482                              |
| 37                         | 27.18                            | 26667.                                                                                           | 8.957                                                                      | -328.4                        | 167.4               | 22.52                | 13.57                                          | 21.91                                          | 1471                              |
| 38                         | 27.44                            | 25935.                                                                                           | 8.793                                                                      | -310.9                        | 189.5               | 23.11                | 13.63                                          | 22.27                                          | 1459                              |
| 39                         | 27.70                            | 25247.                                                                                           | 8.628                                                                      | -293.2                        | 211.9               | 23.69                | 13.67                                          | 22.61                                          | 1449                              |
| 40                         | 27.96                            | 24570.                                                                                           | 8.460                                                                      | -275.3                        | 234.7               | 24.27                | 13.70                                          | 22.93                                          | 1438                              |
| 41                         | 28.23                            | 23924.                                                                                           | 8.292                                                                      | -257.1                        | 257.8               | 24.84                | 13.73                                          | 23.25                                          | 1427                              |
| 42                         | 28.51                            | 23301.                                                                                           | 8.123                                                                      | -238.8                        | 281.2               | 25.40                | 13.76                                          | 23.56                                          | 1416                              |
| 43                         | 28.80                            | 22687.                                                                                           | 7.954                                                                      | -220.4                        | 304.9               | 25.96                | 13.79                                          | 23.87                                          | 1405                              |
| 44                         | 29.10                            | 22098.                                                                                           | 7.785                                                                      | -201.7                        | 328.9               | 26.51                | 13.82                                          | 24.18                                          | 1394                              |
| 45                         | 29.40                            | 21546.                                                                                           | 7.618                                                                      | -182.9                        | 353.3               | 27.06                | 13.85                                          | 24.47                                          | 1383                              |
| 46                         | 29.71                            | 21017.                                                                                           | 7.450                                                                      | -163.9                        | 377.9               | 27.60                | 13.90                                          | 24.76                                          | 1372                              |
| 47                         | 30.02                            | 20500.                                                                                           | 7.285                                                                      | -144.8                        | 402.8               | 28.14                | 13.94                                          | 25.05                                          | 1361                              |
| 48                         | 30.35                            | 20008.                                                                                           | 7.122                                                                      | -125.5                        | 428.0               | 28.67                | 13.98                                          | 25.34                                          | 1350                              |
| 49                         | 30.68                            | 19543.                                                                                           | 6.961                                                                      | -106.1                        | 453.5               | 29.19                | 14.03                                          | 25.61                                          | 1339                              |
| 50                         | 31.02                            | 19102.                                                                                           | 6.802                                                                      | -86.5                         | 479.2               | 29.71                | 14.07                                          | 25.87                                          | 1329                              |
| 51                         | 31.36                            | 18675.                                                                                           | 6.645                                                                      | -66.8                         | 505.2               | 30.23                | 14.11                                          | 26.13                                          | 1318                              |
| 52                         | 31.72                            | 18270.                                                                                           | 6.490                                                                      | -47.0                         | 531.5               | 30.74                | 14.16                                          | 26.38                                          | 1308                              |
| 53                         | 32.08                            | 17888.                                                                                           | 6.339                                                                      | -27.1                         | 557.9               | 31.24                | 14.20                                          | 26.62                                          | 1298                              |
| 54                         | 32.45                            | 17527.                                                                                           | 6.191                                                                      | -7.1                          | 584.7               | 31.74                | 14.25                                          | 26.84                                          | 1288                              |
| 55                         | 32.82                            | 17187.                                                                                           | 6.045                                                                      | 13.0                          | 611.6               | 32.24                | 14.30                                          | 27.06                                          | 1279                              |
| 56                         | 33.20                            | 16867.                                                                                           | 5.902                                                                      | 33.7                          | 639.3               | 32.74                | 14.34                                          | 27.26                                          | 1269                              |
| 57                         | 33.59                            | 16559.                                                                                           | 5.764                                                                      | 54.0                          | 666.6               | 33.22                | 14.38                                          | 27.45                                          | 1261                              |
| 58                         | 33.99                            | 16273.                                                                                           | 5.629                                                                      | 74.3                          | 694.2               | 33.70                | 14.42                                          | 27.64                                          | 1252                              |
| 59                         | 34.39                            | 16008.                                                                                           | 5.496                                                                      | 94.7                          | 721.9               | 34.17                | 14.47                                          | 27.81                                          | 1244                              |
| 60                         | 34.80                            | 15762.                                                                                           | 5.368                                                                      | 115.1                         | 749.8               | 34.64                | 14.52                                          | 27.98                                          | 1236                              |
| 61                         | 35.21                            | 15528.                                                                                           | 5.243                                                                      | 135.6                         | 777.9               | 35.11                | 14.57                                          | 28.14                                          | 1228                              |
| 62                         | 35.64                            | 15312.                                                                                           | 5.121                                                                      | 156.1                         | 806.1               | 35.57                | 14.63                                          | 28.29                                          | 1220                              |
| 63                         | 36.06                            | 15112.                                                                                           | 5.003                                                                      | 176.7                         | 834.4               | 36.02                | 14.69                                          | 28.44                                          | 1213                              |
| 64                         | 36.50                            | 14929.                                                                                           | 4.888                                                                      | 197.3                         | 862.9               | 36.47                | 14.76                                          | 28.58                                          | 1205                              |
| 65                         | 36.94                            | 14761.                                                                                           | 4.776                                                                      | 217.9                         | 891.6               | 36.91                | 14.83                                          | 28.72                                          | 1199                              |
| 66                         | 37.38                            | 14599.                                                                                           | 4.668                                                                      | 238.6                         | 920.4               | 37.35                | 14.90                                          | 28.85                                          | 1192                              |
| 67                         | 37.83                            | 14453.                                                                                           | 4.563                                                                      | 259.3                         | 949.3               | 37.79                | 14.98                                          | 28.98                                          | 1185                              |
| 68                         | 38.28                            | 14321.                                                                                           | 4.461                                                                      | 280.1                         | 978.3               | 38.22                | 15.07                                          | 29.10                                          | 1179                              |
| 69                         | 38.74                            | 14201.                                                                                           | 4.362                                                                      | 300.9                         | 1007.5              | 38.64                | 15.16                                          | 29.22                                          | 1173                              |
| 70                         | 39.21                            | 14094.                                                                                           | 4.266                                                                      | 321.7                         | 1036.8              | 39.06                | 15.25                                          | 29.33                                          | 1167                              |
| 71                         | 39.67                            | 13992.                                                                                           | 4.174                                                                      | 342.6                         | 1066.2              | 39.48                | 15.35                                          | 29.45                                          | 1162                              |
| 72                         | 40.15                            | 13901.                                                                                           | 4.084                                                                      | 363.5                         | 1095.7              | 39.89                | 15.45                                          | 29.56                                          | 1156                              |
| 73                         | 40.62                            | 13821.                                                                                           | 3.997                                                                      | 384.4                         | 1125.3              | 40.30                | 15.56                                          | 29.67                                          | 1151                              |
| 74                         | 41.10                            | 13749.                                                                                           | 3.913                                                                      | 405.4                         | 1155.0              | 40.71                | 15.68                                          | 29.78                                          | 1146                              |
| 75                         | 41.58                            | 13688.                                                                                           | 3.831                                                                      | 426.5                         | 1184.9              | 41.11                | 15.79                                          | 29.88                                          | 1141                              |
| 76                         | 42.07                            | 13632.                                                                                           | 3.752                                                                      | 447.5                         | 1214.8              | 41.50                | 15.91                                          | 29.99                                          | 1136                              |
| 77                         | 42.56                            | 13586.                                                                                           | 3.675                                                                      | 468.7                         | 1244.8              | 41.90                | 16.04                                          | 30.09                                          | 1132                              |
| 78                         | 43.05                            | 13547.                                                                                           | 3.602                                                                      | 489.8                         | 1275.0              | 42.28                | 16.17                                          | 30.19                                          | 1128                              |
| 79                         | 43.54                            | 13517.                                                                                           | 3.530                                                                      | 511.1                         | 1305.2              | 42.67                | 16.30                                          | 30.29                                          | 1124                              |
| 80                         | 44.04                            | 13493.                                                                                           | 3.461                                                                      | 532.4                         | 1335.5              | 43.05                | 16.44                                          | 30.39                                          | 1120                              |
| 81                         | 44.54                            | 13477.                                                                                           | 3.393                                                                      | 553.7                         | 1366.0              | 43.43                | 16.58                                          | 30.49                                          | 1116                              |
| 82                         | 45.04                            | 13467.                                                                                           | 3.328                                                                      | 575.1                         | 1396.5              | 43.80                | 16.72                                          | 30.59                                          | 1112                              |
| 83                         | 45.54                            | 13454.                                                                                           | 3.265                                                                      | 596.6                         | 1427.1              | 44.18                | 16.87                                          | 30.69                                          | 1109                              |
| 84                         | 46.04                            | 13457.                                                                                           | 3.205                                                                      | 618.1                         | 1457.9              | 44.54                | 17.02                                          | 30.79                                          | 1106                              |
| 85                         | 46.55                            | 13458.                                                                                           | 3.145                                                                      | 639.7                         | 1488.7              | 44.91                | 17.17                                          | 30.89                                          | 1103                              |
| 86                         | 47.05                            | 13465.                                                                                           | 3.089                                                                      | 661.4                         | 1519.6              | 45.27                | 17.32                                          | 30.99                                          | 1100                              |
| 87                         | 47.56                            | 13477.                                                                                           | 3.033                                                                      | 683.2                         | 1550.7              | 45.63                | 17.48                                          | 31.09                                          | 1098                              |
| 88                         | 48.07                            | 13493.                                                                                           | 2.980                                                                      | 705.0                         | 1581.8              | 45.99                | 17.64                                          | 31.20                                          | 1095                              |
| 89                         | 48.58                            | 13514.                                                                                           | 2.928                                                                      | 727.0                         | 1613.1              | 46.34                | 17.80                                          | 31.31                                          | 1093                              |
| 90                         | 49.10                            | 13538.                                                                                           | 2.878                                                                      | 749.0                         | 1644.5              | 46.69                | 17.97                                          | 31.41                                          | 1091                              |
| 91                         | 49.61                            | 13567.                                                                                           | 2.829                                                                      | 771.1                         | 1675.9              | 47.04                | 18.13                                          | 31.53                                          | 1089                              |
| 92                         | 50.12                            | 13585.                                                                                           | 2.782                                                                      | 793.3                         | 1707.5              | 47.38                | 18.30                                          | 31.64                                          | 1087                              |
| 93                         | 50.64                            | 13614.                                                                                           | 2.737                                                                      | 815.6                         | 1739.2              | 47.72                | 18.47                                          | 31.76                                          | 1085                              |
| 94                         | 51.16                            | 13644.                                                                                           | 2.692                                                                      | 838.1                         | 1771.0              | 48.07                | 18.64                                          | 31.87                                          | 1083                              |
| 95                         | 51.67                            | 13681.                                                                                           | 2.649                                                                      | 860.6                         | 1803.0              | 48.40                | 18.81                                          | 31.99                                          | 1082                              |
| 96                         | 52.19                            | 13727.                                                                                           | 2.608                                                                      | 883.2                         | 1835.0              | 48.74                | 18.98                                          | 32.11                                          | 1080                              |
| 97                         | 52.71                            | 13767.                                                                                           | 2.567                                                                      | 905.9                         | 1867.2              | 49.07                | 19.15                                          | 32.22                                          | 1079                              |
| 98                         | 53.22                            | 13807.                                                                                           | 2.528                                                                      | 928.7                         | 1899.5              | 49.40                | 19.32                                          | 32.34                                          | 1078                              |
| 99                         | 53.74                            | 13857.                                                                                           | 2.490                                                                      | 951.6                         | 1931.8              | 49.73                | 19.49                                          | 32.45                                          | 1077                              |
| 100                        | 54.26                            | 13907.                                                                                           | 2.453                                                                      | 974.7                         | 1964.3              | 50.06                | 19.66                                          | 32.57                                          | 1076                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

200.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 19.423                     | 23.54                            | 45057.                                                                                             | 10.878                                                                     | -585.8                        | -108.7              | 10.84                | 10.76                                          | 13.62                                          | 1693                              |
| 20                         | 23.62                            | 44615.                                                                                             | 10.866                                                                     | -579.4                        | -100.8              | 11.24                | 10.94                                          | 13.93                                          | 1690                              |
| 21                         | 23.76                            | 43405.                                                                                             | 10.857                                                                     | -568.0                        | -86.6               | 11.93                | 11.23                                          | 14.49                                          | 1678                              |
| 22                         | 23.90                            | 42396.                                                                                             | 10.840                                                                     | -556.2                        | -71.8               | 12.62                | 11.49                                          | 15.02                                          | 1669                              |
| 23                         | 24.05                            | 41484.                                                                                             | 10.805                                                                     | -543.9                        | -56.5               | 13.30                | 11.72                                          | 15.51                                          | 1661                              |
| 24                         | 24.20                            | 40517.                                                                                             | 10.754                                                                     | -531.3                        | -40.8               | 13.97                | 11.93                                          | 16.00                                          | 1652                              |
| 25                         | 24.36                            | 39544.                                                                                             | 10.690                                                                     | -518.2                        | -24.5               | 14.63                | 12.13                                          | 16.47                                          | 1643                              |
| 26                         | 24.52                            | 38567.                                                                                             | 10.611                                                                     | -504.8                        | -7.8                | 15.29                | 12.30                                          | 16.93                                          | 1633                              |
| 27                         | 24.69                            | 37625.                                                                                             | 10.521                                                                     | -491.1                        | 9.3                 | 15.93                | 12.47                                          | 17.38                                          | 1623                              |
| 28                         | 24.86                            | 36716.                                                                                             | 10.426                                                                     | -477.0                        | 26.9                | 16.57                | 12.63                                          | 17.83                                          | 1614                              |
| 29                         | 25.04                            | 35807.                                                                                             | 10.324                                                                     | -462.5                        | 45.0                | 17.21                | 12.78                                          | 18.27                                          | 1604                              |
| 30                         | 25.23                            | 34931.                                                                                             | 10.215                                                                     | -447.8                        | 63.4                | 17.83                | 12.91                                          | 18.69                                          | 1594                              |
| 31                         | 25.42                            | 34019.                                                                                             | 10.097                                                                     | -432.7                        | 82.3                | 18.45                | 13.04                                          | 19.12                                          | 1583                              |
| 32                         | 25.61                            | 33150.                                                                                             | 9.974                                                                      | -417.3                        | 101.7               | 19.07                | 13.16                                          | 19.54                                          | 1573                              |
| 33                         | 25.81                            | 32315.                                                                                             | 9.842                                                                      | -401.6                        | 121.4               | 19.67                | 13.27                                          | 19.94                                          | 1563                              |
| 34                         | 26.01                            | 31523.                                                                                             | 9.705                                                                      | -385.6                        | 141.5               | 20.27                | 13.36                                          | 20.33                                          | 1553                              |
| 35                         | 26.23                            | 30735.                                                                                             | 9.564                                                                      | -369.4                        | 162.1               | 20.87                | 13.45                                          | 20.71                                          | 1542                              |
| 36                         | 26.44                            | 29955.                                                                                             | 9.416                                                                      | -352.9                        | 183.0               | 21.46                | 13.54                                          | 21.08                                          | 1531                              |
| 37                         | 26.67                            | 29217.                                                                                             | 9.265                                                                      | -336.1                        | 204.2               | 22.04                | 13.61                                          | 21.44                                          | 1521                              |
| 38                         | 26.89                            | 28475.                                                                                             | 9.109                                                                      | -319.2                        | 225.8               | 22.62                | 13.67                                          | 21.78                                          | 1510                              |
| 39                         | 27.13                            | 27787.                                                                                             | 8.952                                                                      | -302.0                        | 247.8               | 23.19                | 13.71                                          | 22.10                                          | 1500                              |
| 40                         | 27.37                            | 27097.                                                                                             | 8.793                                                                      | -284.6                        | 270.0               | 23.75                | 13.75                                          | 22.42                                          | 1490                              |
| 41                         | 27.61                            | 26441.                                                                                             | 8.632                                                                      | -267.0                        | 292.6               | 24.31                | 13.79                                          | 22.72                                          | 1480                              |
| 42                         | 27.87                            | 25813.                                                                                             | 8.471                                                                      | -249.2                        | 315.5               | 24.86                | 13.82                                          | 23.01                                          | 1470                              |
| 43                         | 28.12                            | 25195.                                                                                             | 8.309                                                                      | -231.3                        | 338.6               | 25.40                | 13.86                                          | 23.30                                          | 1459                              |
| 44                         | 28.39                            | 24598.                                                                                             | 8.148                                                                      | -213.2                        | 362.0               | 25.94                | 13.89                                          | 23.59                                          | 1449                              |
| 45                         | 28.66                            | 24036.                                                                                             | 7.987                                                                      | -195.0                        | 385.8               | 26.47                | 13.92                                          | 23.86                                          | 1439                              |
| 46                         | 28.93                            | 23496.                                                                                             | 7.826                                                                      | -176.5                        | 409.8               | 27.01                | 13.97                                          | 24.14                                          | 1429                              |
| 47                         | 29.21                            | 22964.                                                                                             | 7.667                                                                      | -158.0                        | 434.1               | 27.53                | 14.01                                          | 24.42                                          | 1418                              |
| 48                         | 29.50                            | 22455.                                                                                             | 7.509                                                                      | -139.3                        | 458.6               | 28.04                | 14.06                                          | 24.69                                          | 1408                              |
| 49                         | 29.80                            | 21973.                                                                                             | 7.352                                                                      | -120.4                        | 483.4               | 28.56                | 14.11                                          | 24.95                                          | 1398                              |
| 50                         | 30.10                            | 21516.                                                                                             | 7.198                                                                      | -101.4                        | 508.5               | 29.06                | 14.15                                          | 25.20                                          | 1388                              |
| 51                         | 30.40                            | 21071.                                                                                             | 7.045                                                                      | -82.3                         | 533.8               | 29.56                | 14.20                                          | 25.45                                          | 1378                              |
| 52                         | 30.71                            | 20646.                                                                                             | 6.894                                                                      | -63.1                         | 559.4               | 30.06                | 14.24                                          | 25.69                                          | 1368                              |
| 53                         | 31.03                            | 20247.                                                                                             | 6.746                                                                      | -43.7                         | 585.2               | 30.55                | 14.29                                          | 25.92                                          | 1358                              |
| 54                         | 31.36                            | 19859.                                                                                             | 6.600                                                                      | -24.2                         | 611.2               | 31.04                | 14.34                                          | 26.14                                          | 1349                              |
| 55                         | 31.69                            | 19494.                                                                                             | 6.457                                                                      | -4.7                          | 637.4               | 31.52                | 14.39                                          | 26.35                                          | 1340                              |
| 56                         | 32.02                            | 19144.                                                                                             | 6.316                                                                      | 15.5                          | 664.4               | 32.01                | 14.43                                          | 26.56                                          | 1331                              |
| 57                         | 32.36                            | 18811.                                                                                             | 6.179                                                                      | 35.2                          | 691.0               | 32.48                | 14.47                                          | 26.74                                          | 1322                              |
| 58                         | 32.71                            | 18500.                                                                                             | 6.044                                                                      | 55.1                          | 717.9               | 32.94                | 14.51                                          | 26.93                                          | 1313                              |
| 59                         | 33.06                            | 18207.                                                                                             | 5.912                                                                      | 74.9                          | 744.9               | 33.41                | 14.56                                          | 27.10                                          | 1305                              |
| 60                         | 33.42                            | 17933.                                                                                             | 5.783                                                                      | 94.9                          | 772.0               | 33.86                | 14.61                                          | 27.27                                          | 1297                              |
| 61                         | 33.78                            | 17669.                                                                                             | 5.658                                                                      | 114.9                         | 799.4               | 34.31                | 14.66                                          | 27.44                                          | 1289                              |
| 62                         | 34.15                            | 17421.                                                                                             | 5.536                                                                      | 134.9                         | 826.9               | 34.76                | 14.72                                          | 27.61                                          | 1281                              |
| 63                         | 34.52                            | 17190.                                                                                             | 5.416                                                                      | 155.1                         | 854.6               | 35.20                | 14.78                                          | 27.76                                          | 1274                              |
| 64                         | 34.90                            | 16979.                                                                                             | 5.300                                                                      | 175.2                         | 882.4               | 35.64                | 14.85                                          | 27.92                                          | 1267                              |
| 65                         | 35.28                            | 16780.                                                                                             | 5.187                                                                      | 195.5                         | 910.4               | 36.08                | 14.92                                          | 28.07                                          | 1259                              |
| 66                         | 35.67                            | 16589.                                                                                             | 5.076                                                                      | 215.8                         | 938.6               | 36.51                | 15.00                                          | 28.21                                          | 1252                              |
| 67                         | 36.06                            | 16411.                                                                                             | 4.969                                                                      | 236.1                         | 966.9               | 36.93                | 15.08                                          | 28.36                                          | 1246                              |
| 68                         | 36.46                            | 16249.                                                                                             | 4.864                                                                      | 256.5                         | 995.3               | 37.35                | 15.16                                          | 28.50                                          | 1239                              |
| 69                         | 36.85                            | 16099.                                                                                             | 4.763                                                                      | 277.0                         | 1023.9              | 37.77                | 15.25                                          | 28.64                                          | 1232                              |
| 70                         | 37.26                            | 15962.                                                                                             | 4.665                                                                      | 297.5                         | 1052.6              | 38.18                | 15.35                                          | 28.77                                          | 1226                              |
| 71                         | 37.67                            | 15834.                                                                                             | 4.569                                                                      | 318.1                         | 1081.4              | 38.59                | 15.45                                          | 28.90                                          | 1220                              |
| 72                         | 38.08                            | 15716.                                                                                             | 4.476                                                                      | 338.7                         | 1110.4              | 39.00                | 15.55                                          | 29.03                                          | 1214                              |
| 73                         | 38.49                            | 15608.                                                                                             | 4.385                                                                      | 359.4                         | 1139.5              | 39.40                | 15.66                                          | 29.16                                          | 1209                              |
| 74                         | 38.91                            | 15511.                                                                                             | 4.297                                                                      | 380.2                         | 1168.7              | 39.80                | 15.77                                          | 29.29                                          | 1203                              |
| 75                         | 39.33                            | 15423.                                                                                             | 4.212                                                                      | 401.0                         | 1198.1              | 40.19                | 15.89                                          | 29.41                                          | 1198                              |
| 76                         | 39.76                            | 15341.                                                                                             | 4.130                                                                      | 421.9                         | 1227.5              | 40.58                | 16.01                                          | 29.54                                          | 1193                              |
| 77                         | 40.18                            | 15268.                                                                                             | 4.049                                                                      | 442.8                         | 1257.1              | 40.97                | 16.13                                          | 29.66                                          | 1188                              |
| 78                         | 40.61                            | 15204.                                                                                             | 3.971                                                                      | 463.9                         | 1286.9              | 41.35                | 16.26                                          | 29.78                                          | 1183                              |
| 79                         | 41.04                            | 15148.                                                                                             | 3.896                                                                      | 484.9                         | 1316.7              | 41.73                | 16.39                                          | 29.90                                          | 1178                              |
| 80                         | 41.48                            | 15100.                                                                                             | 3.822                                                                      | 506.1                         | 1346.7              | 42.11                | 16.53                                          | 30.02                                          | 1174                              |
| 81                         | 41.91                            | 15055.                                                                                             | 3.751                                                                      | 527.3                         | 1376.7              | 42.48                | 16.67                                          | 30.15                                          | 1170                              |
| 82                         | 42.35                            | 15017.                                                                                             | 3.682                                                                      | 548.7                         | 1407.0              | 42.85                | 16.81                                          | 30.27                                          | 1166                              |
| 83                         | 42.79                            | 14987.                                                                                             | 3.615                                                                      | 570.0                         | 1437.3              | 43.22                | 16.96                                          | 30.39                                          | 1162                              |
| 84                         | 43.24                            | 14964.                                                                                             | 3.549                                                                      | 591.5                         | 1467.7              | 43.59                | 17.11                                          | 30.50                                          | 1158                              |
| 85                         | 43.68                            | 14948.                                                                                             | 3.486                                                                      | 613.1                         | 1498.3              | 43.95                | 17.26                                          | 30.62                                          | 1155                              |
| 86                         | 44.13                            | 14934.                                                                                             | 3.425                                                                      | 634.7                         | 1529.0              | 44.31                | 17.41                                          | 30.74                                          | 1151                              |
| 87                         | 44.57                            | 14926.                                                                                             | 3.365                                                                      | 656.5                         | 1559.8              | 44.66                | 17.57                                          | 30.86                                          | 1148                              |
| 88                         | 45.02                            | 14921.                                                                                             | 3.308                                                                      | 678.3                         | 1590.7              | 45.02                | 17.73                                          | 30.98                                          | 1145                              |
| 89                         | 45.47                            | 14925.                                                                                             | 3.252                                                                      | 700.2                         | 1621.7              | 45.37                | 17.89                                          | 31.10                                          | 1142                              |
| 90                         | 45.92                            | 14937.                                                                                             | 3.198                                                                      | 722.2                         | 1652.9              | 45.71                | 18.05                                          | 31.22                                          | 1139                              |
| 91                         | 46.38                            | 14939.                                                                                             | 3.145                                                                      | 744.4                         | 1684.2              | 46.06                | 18.22                                          | 31.34                                          | 1137                              |
| 92                         | 46.83                            | 14948.                                                                                             | 3.094                                                                      | 766.6                         | 1715.6              | 46.40                | 18.38                                          | 31.47                                          | 1134                              |
| 93                         | 47.28                            | 14962.                                                                                             | 3.044                                                                      | 788.9                         | 1747.1              | 46.74                | 18.55                                          | 31.59                                          | 1132                              |
| 94                         | 47.74                            | 14978.                                                                                             | 2.996                                                                      | 811.3                         | 1778.7              | 47.08                | 18.71                                          | 31.72                                          | 1130                              |
| 95                         | 48.20                            | 14998.                                                                                             | 2.949                                                                      | 833.9                         | 1810.5              | 47.42                | 18.88                                          | 31.85                                          | 1128                              |
| 96                         | 48.65                            | 15021.                                                                                             | 2.903                                                                      | 856.5                         | 1842.4              | 47.75                | 19.05                                          | 31.97                                          | 1126                              |
| 97                         | 49.11                            | 15048.                                                                                             | 2.859                                                                      | 879.3                         | 1874.5              | 48.08                | 19.22                                          | 32.10                                          | 1124                              |
| 98                         | 49.57                            | 15078.                                                                                             | 2.816                                                                      | 902.1                         | 1906.6              | 48.41                | 19.39                                          | 32.23                                          | 1122                              |
| 99                         | 50.03                            | 15111.                                                                                             | 2.775                                                                      | 925.1                         | 1938.9              | 48.74                | 19.56                                          | 32.35                                          | 1121                              |
| 100                        | 50.49                            | 15147.                                                                                             | 2.734                                                                      | 948.2                         | 1971.3              | 49.07                | 19.73                                          | 32.48                                          | 1119                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, 1508ARS-CONTINUED

220.0 ATMOSPHERE ISO8AR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 19.903                     | 23.36                            | 47377.                                                                                             | 11.163                                                                      | -580.7                        | -60.0               | 10.90                | 10.89                                          | 13.79                                          | 1736                              |
| 20                         | 23.37                            | 47317.                                                                                             | 11.141                                                                      | -579.6                        | -58.6               | 10.96                | 10.92                                          | 13.82                                          | 1735                              |
| 21                         | 23.51                            | 45785.                                                                                             | 11.014                                                                      | -568.5                        | -44.5               | 11.65                | 11.19                                          | 14.30                                          | 1715                              |
| 22                         | 23.64                            | 44821.                                                                                             | 10.991                                                                      | -557.0                        | -29.9               | 12.33                | 11.45                                          | 14.81                                          | 1707                              |
| 23                         | 23.78                            | 43885.                                                                                             | 10.965                                                                      | -545.0                        | -14.9               | 13.00                | 11.69                                          | 15.30                                          | 1699                              |
| 24                         | 23.92                            | 42936.                                                                                             | 10.922                                                                      | -532.7                        | 0.7                 | 13.66                | 11.91                                          | 15.77                                          | 1691                              |
| 25                         | 24.07                            | 41976.                                                                                             | 10.866                                                                      | -520.0                        | 16.7                | 14.32                | 12.11                                          | 16.23                                          | 1682                              |
| 26                         | 24.23                            | 41012.                                                                                             | 10.798                                                                      | -506.9                        | 33.1                | 14.96                | 12.29                                          | 16.68                                          | 1673                              |
| 27                         | 24.38                            | 40070.                                                                                             | 10.720                                                                      | -493.5                        | 50.0                | 15.60                | 12.46                                          | 17.13                                          | 1664                              |
| 28                         | 24.54                            | 39176.                                                                                             | 10.628                                                                      | -479.7                        | 67.4                | 16.23                | 12.63                                          | 17.55                                          | 1655                              |
| 29                         | 24.71                            | 38266.                                                                                             | 10.529                                                                      | -465.7                        | 85.1                | 16.85                | 12.78                                          | 17.97                                          | 1645                              |
| 30                         | 24.88                            | 37396.                                                                                             | 10.428                                                                      | -451.3                        | 103.3               | 17.47                | 12.91                                          | 18.38                                          | 1636                              |
| 31                         | 25.05                            | 36508.                                                                                             | 10.320                                                                      | -436.6                        | 121.9               | 18.08                | 13.04                                          | 18.80                                          | 1626                              |
| 32                         | 25.23                            | 35646.                                                                                             | 10.206                                                                      | -421.6                        | 140.9               | 18.68                | 13.17                                          | 19.20                                          | 1616                              |
| 33                         | 25.42                            | 34819.                                                                                             | 10.084                                                                      | -406.3                        | 160.3               | 19.28                | 13.28                                          | 19.59                                          | 1607                              |
| 34                         | 25.61                            | 33996.                                                                                             | 9.956                                                                       | -390.8                        | 180.1               | 19.87                | 13.38                                          | 19.97                                          | 1597                              |
| 35                         | 25.80                            | 33211.                                                                                             | 9.823                                                                       | -375.0                        | 200.2               | 20.45                | 13.48                                          | 20.33                                          | 1587                              |
| 36                         | 26.00                            | 32425.                                                                                             | 9.685                                                                       | -358.9                        | 220.7               | 21.03                | 13.56                                          | 20.70                                          | 1577                              |
| 37                         | 26.21                            | 31677.                                                                                             | 9.543                                                                       | -342.6                        | 241.6               | 21.60                | 13.64                                          | 21.04                                          | 1567                              |
| 38                         | 26.42                            | 30938.                                                                                             | 9.397                                                                       | -326.0                        | 262.8               | 22.17                | 13.70                                          | 21.37                                          | 1557                              |
| 39                         | 26.63                            | 30241.                                                                                             | 9.247                                                                       | -309.3                        | 284.3               | 22.73                | 13.75                                          | 21.68                                          | 1548                              |
| 40                         | 26.85                            | 29534.                                                                                             | 9.095                                                                       | -292.4                        | 306.2               | 23.28                | 13.80                                          | 21.98                                          | 1538                              |
| 41                         | 27.07                            | 28877.                                                                                             | 8.942                                                                       | -275.2                        | 328.3               | 23.83                | 13.84                                          | 22.27                                          | 1528                              |
| 42                         | 27.30                            | 28241.                                                                                             | 8.787                                                                       | -258.0                        | 350.7               | 24.37                | 13.87                                          | 22.55                                          | 1519                              |
| 43                         | 27.54                            | 27625.                                                                                             | 8.632                                                                       | -240.5                        | 373.4               | 24.90                | 13.91                                          | 22.82                                          | 1509                              |
| 44                         | 27.78                            | 27024.                                                                                             | 8.477                                                                       | -222.9                        | 396.3               | 25.43                | 13.95                                          | 23.09                                          | 1500                              |
| 45                         | 28.02                            | 26451.                                                                                             | 8.321                                                                       | -205.1                        | 419.5               | 25.95                | 13.98                                          | 23.35                                          | 1490                              |
| 46                         | 28.27                            | 25902.                                                                                             | 8.167                                                                       | -187.2                        | 443.0               | 26.47                | 14.03                                          | 23.63                                          | 1480                              |
| 47                         | 28.53                            | 25360.                                                                                             | 8.013                                                                       | -169.1                        | 466.8               | 26.98                | 14.08                                          | 23.89                                          | 1471                              |
| 48                         | 28.78                            | 24838.                                                                                             | 7.860                                                                       | -150.8                        | 490.8               | 27.48                | 14.13                                          | 24.15                                          | 1461                              |
| 49                         | 29.05                            | 24343.                                                                                             | 7.708                                                                       | -132.5                        | 515.1               | 27.99                | 14.18                                          | 24.40                                          | 1451                              |
| 50                         | 29.32                            | 23868.                                                                                             | 7.558                                                                       | -114.0                        | 539.6               | 28.48                | 14.23                                          | 24.65                                          | 1442                              |
| 51                         | 29.59                            | 23409.                                                                                             | 7.409                                                                       | -95.3                         | 564.4               | 28.97                | 14.27                                          | 24.89                                          | 1432                              |
| 52                         | 29.87                            | 22971.                                                                                             | 7.262                                                                       | -76.6                         | 589.3               | 29.46                | 14.32                                          | 25.12                                          | 1423                              |
| 53                         | 30.16                            | 22551.                                                                                             | 7.117                                                                       | -57.7                         | 614.6               | 29.94                | 14.37                                          | 25.34                                          | 1414                              |
| 54                         | 30.45                            | 22150.                                                                                             | 6.974                                                                       | -38.7                         | 640.0               | 30.41                | 14.42                                          | 25.56                                          | 1405                              |
| 55                         | 30.74                            | 21767.                                                                                             | 6.833                                                                       | -19.6                         | 665.7               | 30.88                | 14.47                                          | 25.77                                          | 1396                              |
| 56                         | 31.04                            | 21396.                                                                                             | 6.694                                                                       | 0.2                           | 692.1               | 31.36                | 14.52                                          | 25.97                                          | 1387                              |
| 57                         | 31.34                            | 21043.                                                                                             | 6.558                                                                       | 19.4                          | 718.1               | 31.82                | 14.56                                          | 26.15                                          | 1378                              |
| 58                         | 31.65                            | 20708.                                                                                             | 6.424                                                                       | 38.8                          | 744.4               | 32.28                | 14.60                                          | 26.34                                          | 1370                              |
| 59                         | 31.96                            | 20392.                                                                                             | 6.294                                                                       | 58.3                          | 770.8               | 32.73                | 14.65                                          | 26.51                                          | 1362                              |
| 60                         | 32.28                            | 20092.                                                                                             | 6.165                                                                       | 77.8                          | 797.4               | 33.18                | 14.70                                          | 26.68                                          | 1354                              |
| 61                         | 32.60                            | 19802.                                                                                             | 6.040                                                                       | 97.4                          | 824.2               | 33.62                | 14.75                                          | 26.86                                          | 1346                              |
| 62                         | 32.93                            | 19529.                                                                                             | 5.918                                                                       | 117.0                         | 851.1               | 34.06                | 14.81                                          | 27.03                                          | 1338                              |
| 63                         | 33.26                            | 19273.                                                                                             | 5.798                                                                       | 136.8                         | 878.2               | 34.49                | 14.87                                          | 27.19                                          | 1331                              |
| 64                         | 33.59                            | 19036.                                                                                             | 5.682                                                                       | 156.6                         | 905.4               | 34.92                | 14.94                                          | 27.35                                          | 1323                              |
| 65                         | 33.93                            | 18810.                                                                                             | 5.567                                                                       | 176.4                         | 932.9               | 35.34                | 15.01                                          | 27.51                                          | 1316                              |
| 66                         | 34.28                            | 18591.                                                                                             | 5.455                                                                       | 196.4                         | 960.5               | 35.77                | 15.09                                          | 27.67                                          | 1309                              |
| 67                         | 34.62                            | 18388.                                                                                             | 5.347                                                                       | 216.4                         | 988.2               | 36.18                | 15.17                                          | 27.82                                          | 1302                              |
| 68                         | 34.97                            | 18198.                                                                                             | 5.241                                                                       | 236.5                         | 1016.1              | 36.60                | 15.26                                          | 27.97                                          | 1295                              |
| 69                         | 35.33                            | 18021.                                                                                             | 5.137                                                                       | 256.6                         | 1044.1              | 37.00                | 15.35                                          | 28.12                                          | 1288                              |
| 70                         | 35.68                            | 17858.                                                                                             | 5.036                                                                       | 276.9                         | 1072.3              | 37.41                | 15.44                                          | 28.27                                          | 1282                              |
| 71                         | 36.05                            | 17704.                                                                                             | 4.938                                                                       | 297.2                         | 1100.7              | 37.81                | 15.54                                          | 28.41                                          | 1276                              |
| 72                         | 36.41                            | 17562.                                                                                             | 4.842                                                                       | 317.5                         | 1129.1              | 38.21                | 15.64                                          | 28.55                                          | 1269                              |
| 73                         | 36.78                            | 17431.                                                                                             | 4.750                                                                       | 338.0                         | 1157.8              | 38.61                | 15.75                                          | 28.70                                          | 1263                              |
| 74                         | 37.15                            | 17309.                                                                                             | 4.659                                                                       | 358.5                         | 1186.5              | 39.00                | 15.86                                          | 28.84                                          | 1258                              |
| 75                         | 37.52                            | 17199.                                                                                             | 4.571                                                                       | 379.1                         | 1215.4              | 39.39                | 15.98                                          | 28.98                                          | 1252                              |
| 76                         | 37.89                            | 17091.                                                                                             | 4.485                                                                       | 399.8                         | 1244.5              | 39.77                | 16.10                                          | 29.12                                          | 1246                              |
| 77                         | 38.27                            | 16994.                                                                                             | 4.402                                                                       | 420.5                         | 1273.7              | 40.15                | 16.23                                          | 29.26                                          | 1241                              |
| 78                         | 38.65                            | 16905.                                                                                             | 4.321                                                                       | 441.4                         | 1303.0              | 40.53                | 16.35                                          | 29.39                                          | 1236                              |
| 79                         | 39.04                            | 16827.                                                                                             | 4.242                                                                       | 462.3                         | 1332.5              | 40.91                | 16.49                                          | 29.53                                          | 1231                              |
| 80                         | 39.42                            | 16756.                                                                                             | 4.165                                                                       | 483.3                         | 1362.1              | 41.28                | 16.62                                          | 29.67                                          | 1226                              |
| 81                         | 39.81                            | 16686.                                                                                             | 4.091                                                                       | 504.4                         | 1391.8              | 41.65                | 16.76                                          | 29.81                                          | 1221                              |
| 82                         | 40.20                            | 16625.                                                                                             | 4.018                                                                       | 525.6                         | 1421.7              | 42.01                | 16.90                                          | 29.94                                          | 1217                              |
| 83                         | 40.59                            | 16571.                                                                                             | 3.948                                                                       | 546.9                         | 1451.7              | 42.38                | 17.05                                          | 30.08                                          | 1212                              |
| 84                         | 40.98                            | 16526.                                                                                             | 3.879                                                                       | 568.3                         | 1481.8              | 42.74                | 17.20                                          | 30.22                                          | 1208                              |
| 85                         | 41.38                            | 16488.                                                                                             | 3.813                                                                       | 589.7                         | 1512.1              | 43.10                | 17.35                                          | 30.35                                          | 1204                              |
| 86                         | 41.78                            | 16455.                                                                                             | 3.748                                                                       | 611.3                         | 1542.5              | 43.45                | 17.50                                          | 30.48                                          | 1200                              |
| 87                         | 42.17                            | 16425.                                                                                             | 3.685                                                                       | 633.0                         | 1573.1              | 43.81                | 17.66                                          | 30.62                                          | 1196                              |
| 88                         | 42.57                            | 16404.                                                                                             | 3.623                                                                       | 654.7                         | 1603.8              | 44.16                | 17.82                                          | 30.75                                          | 1193                              |
| 89                         | 42.97                            | 16387.                                                                                             | 3.564                                                                       | 676.6                         | 1634.6              | 44.50                | 17.98                                          | 30.88                                          | 1190                              |
| 90                         | 43.38                            | 16377.                                                                                             | 3.506                                                                       | 698.6                         | 1665.5              | 44.85                | 18.14                                          | 31.01                                          | 1186                              |
| 91                         | 43.78                            | 16369.                                                                                             | 3.450                                                                       | 720.7                         | 1696.6              | 45.19                | 18.30                                          | 31.15                                          | 1183                              |
| 92                         | 44.18                            | 16366.                                                                                             | 3.395                                                                       | 742.9                         | 1727.8              | 45.53                | 18.46                                          | 31.28                                          | 1180                              |
| 93                         | 44.59                            | 16365.                                                                                             | 3.341                                                                       | 765.2                         | 1759.1              | 45.87                | 18.63                                          | 31.41                                          | 1178                              |
| 94                         | 45.00                            | 16365.                                                                                             | 3.290                                                                       | 787.6                         | 1790.6              | 46.21                | 18.80                                          | 31.55                                          | 1175                              |
| 95                         | 45.40                            | 16375.                                                                                             | 3.239                                                                       | 810.1                         | 1822.2              | 46.54                | 18.96                                          | 31.68                                          | 1173                              |
| 96                         | 45.81                            | 16387.                                                                                             | 3.190                                                                       | 832.8                         | 1854.0              | 46.88                | 19.13                                          | 31.81                                          | 1170                              |
| 97                         | 46.22                            | 16393.                                                                                             | 3.143                                                                       | 855.5                         | 1885.9              | 47.21                | 19.30                                          | 31.95                                          | 1168                              |
| 98                         | 46.63                            | 16408.                                                                                             | 3.096                                                                       | 878.4                         | 1917.9              | 47.54                | 19.47                                          | 32.08                                          | 1166                              |
| 99                         | 47.04                            | 16427.                                                                                             | 3.052                                                                       | 901.4                         | 1950.0              | 47.86                | 19.63                                          | 32.22                                          | 1164                              |
| 100                        | 47.45                            | 16449.                                                                                             | 3.008                                                                       | 924.5                         | 1982.3              | 48.19                | 19.80                                          | 32.35                                          | 1162                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISO8ARS-CONTINUED

240.0 ATMOSPHERE ISO8AR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM/GMOLE | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_p$<br>ISOTHERM<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 20.373                     | 23.19              | 49287.                                                                              | 11.284                                                         | -575.5                        | -11.5               | 10.96                | 11.04                                          | 13.90                                          | 1767                              |
| 21                         | 23.27              | 48094.                                                                              | 11.218                                                         | -568.6                        | -2.6                | 11.39                | 11.18                                          | 14.20                                          | 1752                              |
| 22                         | 23.40              | 47219.                                                                              | 11.138                                                         | -557.3                        | 11.8                | 12.06                | 11.42                                          | 14.63                                          | 1743                              |
| 23                         | 23.53              | 46208.                                                                              | 11.107                                                         | -545.6                        | 26.7                | 12.72                | 11.66                                          | 15.11                                          | 1735                              |
| 24                         | 23.67              | 45280.                                                                              | 11.074                                                         | -533.6                        | 42.0                | 13.38                | 11.88                                          | 15.57                                          | 1727                              |
| 25                         | 23.81              | 44333.                                                                              | 11.026                                                         | -521.1                        | 57.8                | 14.02                | 12.09                                          | 16.02                                          | 1719                              |
| 26                         | 23.95              | 43392.                                                                              | 10.966                                                         | -508.4                        | 74.1                | 14.66                | 12.27                                          | 16.46                                          | 1710                              |
| 27                         | 24.10              | 42452.                                                                              | 10.897                                                         | -495.3                        | 90.7                | 15.29                | 12.45                                          | 16.89                                          | 1702                              |
| 28                         | 24.25              | 41568.                                                                              | 10.816                                                         | -481.8                        | 107.8               | 15.91                | 12.62                                          | 17.31                                          | 1693                              |
| 29                         | 24.40              | 40661.                                                                              | 10.728                                                         | -468.1                        | 125.3               | 16.52                | 12.77                                          | 17.72                                          | 1684                              |
| 30                         | 24.56              | 39783.                                                                              | 10.629                                                         | -454.0                        | 143.3               | 17.13                | 12.91                                          | 18.12                                          | 1675                              |
| 31                         | 24.73              | 38935.                                                                              | 10.525                                                         | -439.7                        | 161.6               | 17.73                | 13.04                                          | 18.51                                          | 1666                              |
| 32                         | 24.89              | 38085.                                                                              | 10.419                                                         | -425.1                        | 180.3               | 18.33                | 13.17                                          | 18.90                                          | 1657                              |
| 33                         | 25.06              | 37259.                                                                              | 10.306                                                         | -410.1                        | 199.4               | 18.91                | 13.29                                          | 19.28                                          | 1648                              |
| 34                         | 25.24              | 36406.                                                                              | 10.186                                                         | -395.0                        | 218.8               | 19.49                | 13.39                                          | 19.65                                          | 1638                              |
| 35                         | 25.42              | 35620.                                                                              | 10.060                                                         | -379.5                        | 238.7               | 20.07                | 13.49                                          | 20.01                                          | 1629                              |
| 36                         | 25.61              | 34831.                                                                              | 9.930                                                          | -363.8                        | 258.9               | 20.64                | 13.58                                          | 20.35                                          | 1620                              |
| 37                         | 25.80              | 34074.                                                                              | 9.795                                                          | -347.9                        | 279.4               | 21.20                | 13.67                                          | 20.69                                          | 1610                              |
| 38                         | 25.99              | 33335.                                                                              | 9.658                                                          | -331.8                        | 300.2               | 21.76                | 13.74                                          | 21.01                                          | 1601                              |
| 39                         | 26.19              | 32632.                                                                              | 9.517                                                          | -315.4                        | 321.4               | 22.31                | 13.79                                          | 21.31                                          | 1592                              |
| 40                         | 26.39              | 31914.                                                                              | 9.372                                                          | -298.9                        | 342.9               | 22.85                | 13.84                                          | 21.60                                          | 1583                              |
| 41                         | 26.60              | 31244.                                                                              | 9.224                                                          | -282.2                        | 364.6               | 23.39                | 13.88                                          | 21.88                                          | 1573                              |
| 42                         | 26.81              | 30600.                                                                              | 9.076                                                          | -265.3                        | 386.6               | 23.92                | 13.92                                          | 22.15                                          | 1564                              |
| 43                         | 27.02              | 29985.                                                                              | 8.927                                                          | -248.2                        | 408.9               | 24.44                | 13.96                                          | 22.42                                          | 1555                              |
| 44                         | 27.24              | 29384.                                                                              | 8.777                                                          | -231.0                        | 431.4               | 24.96                | 14.00                                          | 22.68                                          | 1546                              |
| 45                         | 27.46              | 28800.                                                                              | 8.628                                                          | -213.7                        | 454.2               | 25.47                | 14.04                                          | 22.93                                          | 1537                              |
| 46                         | 27.69              | 28240.                                                                              | 8.478                                                          | -196.1                        | 477.3               | 25.98                | 14.09                                          | 23.19                                          | 1528                              |
| 47                         | 27.92              | 27692.                                                                              | 8.329                                                          | -178.5                        | 500.6               | 26.48                | 14.14                                          | 23.45                                          | 1519                              |
| 48                         | 28.16              | 27162.                                                                              | 8.181                                                          | -160.6                        | 524.2               | 26.98                | 14.19                                          | 23.70                                          | 1510                              |
| 49                         | 28.40              | 26651.                                                                              | 8.033                                                          | -142.7                        | 548.0               | 27.47                | 14.24                                          | 23.94                                          | 1500                              |
| 50                         | 28.65              | 26163.                                                                              | 7.887                                                          | -124.6                        | 572.1               | 27.96                | 14.29                                          | 24.18                                          | 1491                              |
| 51                         | 28.90              | 25691.                                                                              | 7.742                                                          | -106.4                        | 596.3               | 28.44                | 14.34                                          | 24.41                                          | 1482                              |
| 52                         | 29.15              | 25240.                                                                              | 7.599                                                          | -88.0                         | 620.9               | 28.91                | 14.39                                          | 24.64                                          | 1474                              |
| 53                         | 29.41              | 24807.                                                                              | 7.457                                                          | -69.5                         | 645.6               | 29.38                | 14.45                                          | 24.86                                          | 1465                              |
| 54                         | 29.67              | 24393.                                                                              | 7.317                                                          | -50.9                         | 670.6               | 29.85                | 14.50                                          | 25.07                                          | 1456                              |
| 55                         | 29.94              | 23997.                                                                              | 7.179                                                          | -32.2                         | 695.7               | 30.31                | 14.55                                          | 25.28                                          | 1448                              |
| 56                         | 30.21              | 23609.                                                                              | 7.043                                                          | -12.9                         | 721.6               | 30.78                | 14.60                                          | 25.47                                          | 1439                              |
| 57                         | 30.48              | 23239.                                                                              | 6.908                                                          | 6.0                           | 747.2               | 31.23                | 14.64                                          | 25.66                                          | 1431                              |
| 58                         | 30.76              | 22887.                                                                              | 6.776                                                          | 25.0                          | 772.9               | 31.68                | 14.68                                          | 25.84                                          | 1423                              |
| 59                         | 31.04              | 22557.                                                                              | 6.646                                                          | 44.0                          | 798.9               | 32.12                | 14.73                                          | 26.01                                          | 1415                              |
| 60                         | 31.33              | 22237.                                                                              | 6.518                                                          | 63.2                          | 825.0               | 32.56                | 14.78                                          | 26.18                                          | 1407                              |
| 61                         | 31.62              | 21921.                                                                              | 6.393                                                          | 82.4                          | 851.2               | 33.00                | 14.84                                          | 26.36                                          | 1399                              |
| 62                         | 31.91              | 21626.                                                                              | 6.271                                                          | 101.7                         | 877.7               | 33.43                | 14.90                                          | 26.53                                          | 1391                              |
| 63                         | 32.21              | 21347.                                                                              | 6.151                                                          | 121.1                         | 904.3               | 33.85                | 14.96                                          | 26.69                                          | 1384                              |
| 64                         | 32.51              | 21085.                                                                              | 6.034                                                          | 140.6                         | 931.0               | 34.27                | 15.03                                          | 26.86                                          | 1376                              |
| 65                         | 32.81              | 20839.                                                                              | 5.919                                                          | 160.1                         | 958.0               | 34.69                | 15.10                                          | 27.02                                          | 1369                              |
| 66                         | 33.12              | 20594.                                                                              | 5.808                                                          | 179.7                         | 985.1               | 35.10                | 15.17                                          | 27.19                                          | 1362                              |
| 67                         | 33.43              | 20360.                                                                              | 5.699                                                          | 199.4                         | 1012.3              | 35.51                | 15.26                                          | 27.35                                          | 1355                              |
| 68                         | 33.74              | 20135.                                                                              | 5.592                                                          | 219.2                         | 1039.7              | 35.92                | 15.34                                          | 27.51                                          | 1348                              |
| 69                         | 34.06              | 19954.                                                                              | 5.487                                                          | 239.1                         | 1067.3              | 36.32                | 15.43                                          | 27.67                                          | 1341                              |
| 70                         | 34.38              | 19767.                                                                              | 5.385                                                          | 259.0                         | 1095.1              | 36.72                | 15.53                                          | 27.83                                          | 1334                              |
| 71                         | 34.70              | 19591.                                                                              | 5.286                                                          | 279.1                         | 1123.0              | 37.12                | 15.63                                          | 27.98                                          | 1328                              |
| 72                         | 35.03              | 19426.                                                                              | 5.188                                                          | 299.2                         | 1151.0              | 37.51                | 15.73                                          | 28.13                                          | 1321                              |
| 73                         | 35.36              | 19277.                                                                              | 5.093                                                          | 319.4                         | 1179.2              | 37.90                | 15.84                                          | 28.28                                          | 1315                              |
| 74                         | 35.69              | 19139.                                                                              | 5.000                                                          | 339.7                         | 1207.6              | 38.28                | 15.95                                          | 28.43                                          | 1309                              |
| 75                         | 36.02              | 18998.                                                                              | 4.910                                                          | 360.1                         | 1236.1              | 38.67                | 16.07                                          | 28.58                                          | 1303                              |
| 76                         | 36.36              | 18868.                                                                              | 4.821                                                          | 380.5                         | 1264.7              | 39.05                | 16.19                                          | 28.73                                          | 1297                              |
| 77                         | 36.70              | 18748.                                                                              | 4.736                                                          | 401.1                         | 1293.5              | 39.42                | 16.31                                          | 28.88                                          | 1292                              |
| 78                         | 37.04              | 18637.                                                                              | 4.652                                                          | 421.8                         | 1322.5              | 39.80                | 16.44                                          | 29.03                                          | 1286                              |
| 79                         | 37.38              | 18537.                                                                              | 4.571                                                          | 442.5                         | 1351.6              | 40.17                | 16.57                                          | 29.18                                          | 1281                              |
| 80                         | 37.73              | 18445.                                                                              | 4.491                                                          | 463.4                         | 1380.9              | 40.54                | 16.71                                          | 29.33                                          | 1276                              |
| 81                         | 38.08              | 18357.                                                                              | 4.414                                                          | 484.3                         | 1410.3              | 40.90                | 16.85                                          | 29.48                                          | 1270                              |
| 82                         | 38.43              | 18270.                                                                              | 4.338                                                          | 505.4                         | 1439.9              | 41.26                | 16.99                                          | 29.63                                          | 1265                              |
| 83                         | 38.78              | 18195.                                                                              | 4.265                                                          | 526.5                         | 1469.6              | 41.62                | 17.14                                          | 29.78                                          | 1261                              |
| 84                         | 39.13              | 18128.                                                                              | 4.194                                                          | 547.8                         | 1499.4              | 41.98                | 17.28                                          | 29.93                                          | 1256                              |
| 85                         | 39.49              | 18068.                                                                              | 4.124                                                          | 569.2                         | 1529.4              | 42.34                | 17.44                                          | 30.08                                          | 1252                              |
| 86                         | 39.84              | 18014.                                                                              | 4.057                                                          | 590.6                         | 1559.6              | 42.69                | 17.59                                          | 30.23                                          | 1247                              |
| 87                         | 40.20              | 17967.                                                                              | 3.991                                                          | 612.2                         | 1589.8              | 43.04                | 17.74                                          | 30.37                                          | 1243                              |
| 88                         | 40.56              | 17926.                                                                              | 3.926                                                          | 633.9                         | 1620.3              | 43.39                | 17.90                                          | 30.52                                          | 1239                              |
| 89                         | 40.92              | 17891.                                                                              | 3.864                                                          | 655.7                         | 1650.8              | 43.73                | 18.06                                          | 30.66                                          | 1236                              |
| 90                         | 41.28              | 17863.                                                                              | 3.803                                                          | 677.6                         | 1681.6              | 44.08                | 18.22                                          | 30.80                                          | 1232                              |
| 91                         | 41.65              | 17842.                                                                              | 3.743                                                          | 699.7                         | 1712.4              | 44.42                | 18.38                                          | 30.94                                          | 1229                              |
| 92                         | 42.01              | 17825.                                                                              | 3.686                                                          | 721.8                         | 1743.4              | 44.76                | 18.55                                          | 31.08                                          | 1225                              |
| 93                         | 42.38              | 17812.                                                                              | 3.629                                                          | 744.1                         | 1774.6              | 45.09                | 18.71                                          | 31.22                                          | 1222                              |
| 94                         | 42.74              | 17803.                                                                              | 3.574                                                          | 766.5                         | 1805.9              | 45.43                | 18.88                                          | 31.36                                          | 1219                              |
| 95                         | 43.11              | 17797.                                                                              | 3.521                                                          | 789.0                         | 1837.3              | 45.76                | 19.04                                          | 31.50                                          | 1216                              |
| 96                         | 43.48              | 17789.                                                                              | 3.469                                                          | 811.6                         | 1868.9              | 46.09                | 19.21                                          | 31.65                                          | 1214                              |
| 97                         | 43.85              | 17785.                                                                              | 3.418                                                          | 834.3                         | 1900.6              | 46.42                | 19.38                                          | 31.79                                          | 1211                              |
| 98                         | 44.22              | 17786.                                                                              | 3.368                                                          | 857.2                         | 1932.5              | 46.75                | 19.54                                          | 31.93                                          | 1208                              |
| 99                         | 44.59              | 17790.                                                                              | 3.320                                                          | 880.2                         | 1964.5              | 47.07                | 19.71                                          | 32.07                                          | 1206                              |
| 100                        | 44.96              | 17790.                                                                              | 3.273                                                          | 903.3                         | 1996.6              | 47.39                | 19.88                                          | 32.21                                          | 1204                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

260.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 20.834                   | 23.04                            | 50716.                                                                                             | 11.337                                                                     | -570.1                        | 36.8                | 11.03                | 11.14                                          | 13.98                                          | 1788                              |
| 21                         | 23.06                            | 50341.                                                                                             | 11.332                                                                     | -568.3                        | 39.1                | 11.14                | 11.18                                          | 14.07                                          | 1784                              |
| 22                         | 23.18                            | 49599.                                                                                             | 11.285                                                                     | -557.2                        | 53.3                | 11.81                | 11.41                                          | 14.48                                          | 1779                              |
| 23                         | 23.30                            | 48451.                                                                                             | 11.243                                                                     | -545.8                        | 68.1                | 12.46                | 11.64                                          | 14.94                                          | 1768                              |
| 24                         | 23.43                            | 47543.                                                                                             | 11.216                                                                     | -534.0                        | 83.3                | 13.11                | 11.86                                          | 15.39                                          | 1761                              |
| 25                         | 23.56                            | 46620.                                                                                             | 11.176                                                                     | -521.8                        | 98.9                | 13.74                | 12.07                                          | 15.83                                          | 1753                              |
| 26                         | 23.70                            | 45713.                                                                                             | 11.122                                                                     | -509.3                        | 114.9               | 14.37                | 12.26                                          | 16.26                                          | 1746                              |
| 27                         | 23.83                            | 44775.                                                                                             | 11.058                                                                     | -496.5                        | 131.4               | 14.99                | 12.44                                          | 16.68                                          | 1737                              |
| 28                         | 23.98                            | 43897.                                                                                             | 10.987                                                                     | -483.4                        | 148.3               | 15.61                | 12.61                                          | 17.09                                          | 1729                              |
| 29                         | 24.12                            | 42995.                                                                                             | 10.907                                                                     | -469.9                        | 165.6               | 16.22                | 12.72                                          | 17.49                                          | 1721                              |
| 30                         | 24.27                            | 42103.                                                                                             | 10.818                                                                     | -456.2                        | 183.3               | 16.82                | 12.91                                          | 17.88                                          | 1712                              |
| 31                         | 24.42                            | 41295.                                                                                             | 10.722                                                                     | -442.1                        | 201.3               | 17.41                | 13.04                                          | 18.26                                          | 1705                              |
| 32                         | 24.58                            | 40461.                                                                                             | 10.619                                                                     | -427.8                        | 219.8               | 17.99                | 13.17                                          | 18.63                                          | 1696                              |
| 33                         | 24.74                            | 39630.                                                                                             | 10.513                                                                     | -413.2                        | 238.6               | 18.57                | 13.29                                          | 19.00                                          | 1687                              |
| 34                         | 24.91                            | 38760.                                                                                             | 10.401                                                                     | -398.4                        | 257.8               | 19.15                | 13.40                                          | 19.37                                          | 1678                              |
| 35                         | 25.07                            | 37970.                                                                                             | 10.282                                                                     | -383.2                        | 277.3               | 19.71                | 13.51                                          | 19.72                                          | 1669                              |
| 36                         | 25.25                            | 37183.                                                                                             | 10.158                                                                     | -367.9                        | 297.2               | 20.27                | 13.60                                          | 20.06                                          | 1660                              |
| 37                         | 25.42                            | 36416.                                                                                             | 10.029                                                                     | -352.3                        | 317.4               | 20.83                | 13.69                                          | 20.38                                          | 1651                              |
| 38                         | 25.60                            | 35677.                                                                                             | 9.896                                                                      | -336.5                        | 338.0               | 21.37                | 13.77                                          | 20.69                                          | 1642                              |
| 39                         | 25.79                            | 34963.                                                                                             | 9.761                                                                      | -320.5                        | 358.8               | 21.92                | 13.82                                          | 20.98                                          | 1633                              |
| 40                         | 25.97                            | 34249.                                                                                             | 9.625                                                                      | -304.3                        | 379.9               | 22.45                | 13.87                                          | 21.27                                          | 1624                              |
| 41                         | 26.17                            | 33564.                                                                                             | 9.484                                                                      | -288.0                        | 401.4               | 22.98                | 13.92                                          | 21.54                                          | 1616                              |
| 42                         | 26.36                            | 32905.                                                                                             | 9.341                                                                      | -271.4                        | 423.0               | 23.50                | 13.97                                          | 21.81                                          | 1607                              |
| 43                         | 26.56                            | 32287.                                                                                             | 9.197                                                                      | -254.8                        | 445.0               | 24.02                | 14.01                                          | 22.06                                          | 1599                              |
| 44                         | 26.76                            | 31685.                                                                                             | 9.052                                                                      | -237.9                        | 467.1               | 24.53                | 14.05                                          | 22.31                                          | 1590                              |
| 45                         | 26.97                            | 31085.                                                                                             | 8.908                                                                      | -220.9                        | 489.6               | 25.03                | 14.10                                          | 22.56                                          | 1581                              |
| 46                         | 27.18                            | 30514.                                                                                             | 8.763                                                                      | -203.7                        | 512.3               | 25.53                | 14.15                                          | 22.82                                          | 1572                              |
| 47                         | 27.39                            | 29963.                                                                                             | 8.619                                                                      | -186.4                        | 535.2               | 26.03                | 14.20                                          | 23.06                                          | 1564                              |
| 48                         | 27.61                            | 29428.                                                                                             | 8.474                                                                      | -169.0                        | 558.4               | 26.51                | 14.26                                          | 23.30                                          | 1555                              |
| 49                         | 27.83                            | 28904.                                                                                             | 8.331                                                                      | -151.4                        | 581.8               | 27.00                | 14.31                                          | 23.54                                          | 1546                              |
| 50                         | 28.06                            | 28403.                                                                                             | 8.189                                                                      | -133.7                        | 605.5               | 27.48                | 14.36                                          | 23.78                                          | 1537                              |
| 51                         | 28.29                            | 27918.                                                                                             | 8.048                                                                      | -115.8                        | 629.4               | 27.95                | 14.41                                          | 24.01                                          | 1529                              |
| 52                         | 28.52                            | 27454.                                                                                             | 7.908                                                                      | -97.8                         | 653.5               | 28.42                | 14.46                                          | 24.23                                          | 1520                              |
| 53                         | 28.75                            | 27011.                                                                                             | 7.770                                                                      | -79.7                         | 677.8               | 28.88                | 14.52                                          | 24.44                                          | 1512                              |
| 54                         | 28.99                            | 26586.                                                                                             | 7.634                                                                      | -61.5                         | 702.4               | 29.34                | 14.57                                          | 24.65                                          | 1504                              |
| 55                         | 29.24                            | 26179.                                                                                             | 7.498                                                                      | -43.1                         | 727.1               | 29.79                | 14.62                                          | 24.85                                          | 1495                              |
| 56                         | 29.48                            | 25778.                                                                                             | 7.363                                                                      | -24.1                         | 752.6               | 30.25                | 14.67                                          | 25.05                                          | 1487                              |
| 57                         | 29.73                            | 25394.                                                                                             | 7.232                                                                      | -5.6                          | 777.8               | 30.70                | 14.71                                          | 25.23                                          | 1479                              |
| 58                         | 29.99                            | 25028.                                                                                             | 7.103                                                                      | 13.1                          | 803.1               | 31.14                | 14.76                                          | 25.41                                          | 1472                              |
| 59                         | 30.24                            | 24678.                                                                                             | 6.974                                                                      | 31.8                          | 828.6               | 31.57                | 14.81                                          | 25.59                                          | 1464                              |
| 60                         | 30.50                            | 24345.                                                                                             | 6.847                                                                      | 50.6                          | 854.2               | 32.01                | 14.86                                          | 25.76                                          | 1456                              |
| 61                         | 30.77                            | 24015.                                                                                             | 6.722                                                                      | 69.5                          | 880.1               | 32.43                | 14.92                                          | 25.93                                          | 1448                              |
| 62                         | 31.03                            | 23701.                                                                                             | 6.600                                                                      | 88.5                          | 906.1               | 32.86                | 14.98                                          | 26.10                                          | 1441                              |
| 63                         | 31.30                            | 23404.                                                                                             | 6.480                                                                      | 107.6                         | 932.3               | 33.27                | 15.04                                          | 26.27                                          | 1433                              |
| 64                         | 31.58                            | 23122.                                                                                             | 6.363                                                                      | 126.7                         | 958.6               | 33.69                | 15.11                                          | 26.43                                          | 1426                              |
| 65                         | 31.85                            | 22855.                                                                                             | 6.248                                                                      | 146.0                         | 985.1               | 34.10                | 15.18                                          | 26.60                                          | 1419                              |
| 66                         | 32.13                            | 22594.                                                                                             | 6.136                                                                      | 165.3                         | 1011.8              | 34.51                | 15.26                                          | 26.76                                          | 1411                              |
| 67                         | 32.41                            | 22347.                                                                                             | 6.026                                                                      | 184.7                         | 1038.7              | 34.91                | 15.34                                          | 26.93                                          | 1404                              |
| 68                         | 32.70                            | 22112.                                                                                             | 5.918                                                                      | 204.3                         | 1065.7              | 35.31                | 15.43                                          | 27.09                                          | 1397                              |
| 69                         | 32.99                            | 21891.                                                                                             | 5.814                                                                      | 223.9                         | 1092.8              | 35.71                | 15.52                                          | 27.26                                          | 1390                              |
| 70                         | 33.28                            | 21682.                                                                                             | 5.713                                                                      | 243.5                         | 1120.2              | 36.10                | 15.61                                          | 27.43                                          | 1384                              |
| 71                         | 33.57                            | 21483.                                                                                             | 5.612                                                                      | 263.3                         | 1147.7              | 36.49                | 15.71                                          | 27.60                                          | 1377                              |
| 72                         | 33.86                            | 21296.                                                                                             | 5.512                                                                      | 283.2                         | 1175.3              | 36.88                | 15.81                                          | 27.75                                          | 1371                              |
| 73                         | 34.16                            | 21122.                                                                                             | 5.417                                                                      | 303.2                         | 1203.2              | 37.26                | 15.92                                          | 27.91                                          | 1364                              |
| 74                         | 34.46                            | 20959.                                                                                             | 5.323                                                                      | 323.3                         | 1231.2              | 37.64                | 16.04                                          | 28.07                                          | 1358                              |
| 75                         | 34.76                            | 20809.                                                                                             | 5.231                                                                      | 343.4                         | 1259.3              | 38.02                | 16.15                                          | 28.23                                          | 1352                              |
| 76                         | 35.07                            | 20658.                                                                                             | 5.140                                                                      | 363.7                         | 1287.6              | 38.40                | 16.27                                          | 28.39                                          | 1346                              |
| 77                         | 35.38                            | 20518.                                                                                             | 5.053                                                                      | 384.1                         | 1316.1              | 38.77                | 16.40                                          | 28.55                                          | 1340                              |
| 78                         | 35.69                            | 20387.                                                                                             | 4.966                                                                      | 404.6                         | 1344.7              | 39.14                | 16.53                                          | 28.70                                          | 1334                              |
| 79                         | 36.00                            | 20267.                                                                                             | 4.883                                                                      | 425.2                         | 1373.5              | 39.50                | 16.66                                          | 28.86                                          | 1328                              |
| 80                         | 36.31                            | 20156.                                                                                             | 4.802                                                                      | 445.8                         | 1402.4              | 39.87                | 16.80                                          | 29.02                                          | 1323                              |
| 81                         | 36.62                            | 20047.                                                                                             | 4.722                                                                      | 466.6                         | 1431.5              | 40.23                | 16.93                                          | 29.18                                          | 1318                              |
| 82                         | 36.94                            | 19946.                                                                                             | 4.644                                                                      | 487.6                         | 1460.7              | 40.59                | 17.08                                          | 29.34                                          | 1312                              |
| 83                         | 37.26                            | 19851.                                                                                             | 4.568                                                                      | 508.6                         | 1490.2              | 40.94                | 17.22                                          | 29.50                                          | 1307                              |
| 84                         | 37.58                            | 19764.                                                                                             | 4.494                                                                      | 529.7                         | 1519.7              | 41.30                | 17.37                                          | 29.65                                          | 1302                              |
| 85                         | 37.90                            | 19684.                                                                                             | 4.422                                                                      | 551.0                         | 1549.4              | 41.65                | 17.52                                          | 29.81                                          | 1297                              |
| 86                         | 38.22                            | 19611.                                                                                             | 4.352                                                                      | 572.3                         | 1579.3              | 42.00                | 17.67                                          | 29.97                                          | 1293                              |
| 87                         | 38.55                            | 19544.                                                                                             | 4.284                                                                      | 593.8                         | 1609.4              | 42.35                | 17.83                                          | 30.13                                          | 1288                              |
| 88                         | 38.88                            | 19484.                                                                                             | 4.217                                                                      | 615.4                         | 1639.6              | 42.69                | 17.99                                          | 30.28                                          | 1284                              |
| 89                         | 39.20                            | 19433.                                                                                             | 4.151                                                                      | 637.1                         | 1669.9              | 43.04                | 18.14                                          | 30.44                                          | 1280                              |
| 90                         | 39.53                            | 19387.                                                                                             | 4.088                                                                      | 659.0                         | 1700.4              | 43.38                | 18.31                                          | 30.59                                          | 1276                              |
| 91                         | 39.86                            | 19350.                                                                                             | 4.026                                                                      | 680.9                         | 1731.1              | 43.71                | 18.47                                          | 30.74                                          | 1272                              |
| 92                         | 40.19                            | 19310.                                                                                             | 3.966                                                                      | 703.0                         | 1761.9              | 44.05                | 18.63                                          | 30.89                                          | 1269                              |
| 93                         | 40.52                            | 19293.                                                                                             | 3.907                                                                      | 725.2                         | 1792.8              | 44.39                | 18.79                                          | 31.04                                          | 1265                              |
| 94                         | 40.86                            | 19272.                                                                                             | 3.849                                                                      | 747.6                         | 1823.9              | 44.72                | 18.96                                          | 31.18                                          | 1262                              |
| 95                         | 41.19                            | 19255.                                                                                             | 3.793                                                                      | 770.0                         | 1855.2              | 45.05                | 19.13                                          | 31.33                                          | 1259                              |
| 96                         | 41.53                            | 19232.                                                                                             | 3.738                                                                      | 792.6                         | 1886.6              | 45.38                | 19.29                                          | 31.48                                          | 1256                              |
| 97                         | 41.86                            | 19213.                                                                                             | 3.685                                                                      | 815.3                         | 1918.1              | 45.71                | 19.46                                          | 31.63                                          | 1253                              |
| 98                         | 42.20                            | 19200.                                                                                             | 3.633                                                                      | 838.2                         | 1949.8              | 46.03                | 19.62                                          | 31.78                                          | 1250                              |
| 99                         | 42.53                            | 19191.                                                                                             | 3.581                                                                      | 861.1                         | 1981.7              | 46.35                | 19.79                                          | 31.92                                          | 1247                              |
| 100                        | 42.87                            | 19185.                                                                                             | 3.532                                                                      | 884.2                         | 2013.7              | 46.68                | 19.96                                          | 32.07                                          | 1245                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

280.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial p$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>p</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 21.287                     | 22.89                            | 52362.                                                                                          | 11.376                                                                      | -564.6                        | 84.7                | 11.10                | 11.23                                          | 14.02                                          | 1813                              |
| 22                         | 22.97                            | 51956.                                                                                          | 11.408                                                                      | -556.8                        | 94.8                | 11.56                | 11.39                                          | 14.34                                          | 1813                              |
| 23                         | 23.08                            | 50617.                                                                                          | 11.383                                                                      | -545.6                        | 109.4               | 12.21                | 11.61                                          | 14.79                                          | 1800                              |
| 24                         | 23.21                            | 49718.                                                                                          | 11.351                                                                      | -534.0                        | 124.4               | 12.85                | 11.83                                          | 15.23                                          | 1793                              |
| 25                         | 23.33                            | 48831.                                                                                          | 11.322                                                                      | -522.1                        | 139.8               | 13.48                | 12.04                                          | 15.66                                          | 1787                              |
| 26                         | 23.46                            | 47978.                                                                                          | 11.274                                                                      | -509.8                        | 155.7               | 14.10                | 12.24                                          | 16.08                                          | 1780                              |
| 27                         | 23.59                            | 47046.                                                                                          | 11.213                                                                      | -497.3                        | 172.0               | 14.72                | 12.42                                          | 16.49                                          | 1772                              |
| 28                         | 23.72                            | 46165.                                                                                          | 11.146                                                                      | -484.4                        | 188.7               | 15.33                | 12.59                                          | 16.89                                          | 1764                              |
| 29                         | 23.86                            | 45273.                                                                                          | 11.074                                                                      | -471.2                        | 205.8               | 15.92                | 12.76                                          | 17.29                                          | 1756                              |
| 30                         | 24.00                            | 44360.                                                                                          | 10.993                                                                      | -457.7                        | 223.2               | 16.52                | 12.90                                          | 17.67                                          | 1748                              |
| 31                         | 24.15                            | 43585.                                                                                          | 10.905                                                                      | -444.0                        | 241.1               | 17.10                | 13.04                                          | 18.04                                          | 1741                              |
| 32                         | 24.29                            | 42765.                                                                                          | 10.809                                                                      | -429.9                        | 259.3               | 17.68                | 13.17                                          | 18.40                                          | 1733                              |
| 33                         | 24.44                            | 41922.                                                                                          | 10.706                                                                      | -415.6                        | 277.9               | 18.25                | 13.30                                          | 18.76                                          | 1724                              |
| 34                         | 24.60                            | 41064.                                                                                          | 10.601                                                                      | -401.1                        | 296.8               | 18.82                | 13.41                                          | 19.12                                          | 1715                              |
| 35                         | 24.76                            | 40268.                                                                                          | 10.493                                                                      | -386.3                        | 316.1               | 19.38                | 13.52                                          | 19.46                                          | 1707                              |
| 36                         | 24.92                            | 39491.                                                                                          | 10.375                                                                      | -371.2                        | 335.7               | 19.93                | 13.62                                          | 19.79                                          | 1698                              |
| 37                         | 25.08                            | 38711.                                                                                          | 10.251                                                                      | -355.9                        | 355.7               | 20.48                | 13.71                                          | 20.11                                          | 1689                              |
| 38                         | 25.25                            | 37971.                                                                                          | 10.123                                                                      | -340.4                        | 376.0               | 21.02                | 13.79                                          | 20.42                                          | 1681                              |
| 39                         | 25.42                            | 37242.                                                                                          | 9.991                                                                       | -324.8                        | 396.5               | 21.55                | 13.85                                          | 20.70                                          | 1672                              |
| 40                         | 25.60                            | 36561.                                                                                          | 9.856                                                                       | -308.9                        | 417.4               | 22.08                | 13.91                                          | 20.97                                          | 1664                              |
| 41                         | 25.78                            | 35852.                                                                                          | 9.721                                                                       | -292.8                        | 438.5               | 22.60                | 13.96                                          | 21.24                                          | 1656                              |
| 42                         | 25.96                            | 35178.                                                                                          | 9.586                                                                       | -276.6                        | 459.8               | 23.12                | 14.01                                          | 21.50                                          | 1647                              |
| 43                         | 26.14                            | 34541.                                                                                          | 9.447                                                                       | -260.3                        | 481.5               | 23.62                | 14.06                                          | 21.75                                          | 1639                              |
| 44                         | 26.33                            | 33933.                                                                                          | 9.306                                                                       | -243.7                        | 503.3               | 24.13                | 14.10                                          | 22.00                                          | 1631                              |
| 45                         | 26.52                            | 33314.                                                                                          | 9.165                                                                       | -227.1                        | 525.5               | 24.62                | 14.15                                          | 22.24                                          | 1622                              |
| 46                         | 26.72                            | 32727.                                                                                          | 9.024                                                                       | -210.2                        | 547.9               | 25.12                | 14.21                                          | 22.49                                          | 1614                              |
| 47                         | 26.92                            | 32178.                                                                                          | 8.885                                                                       | -193.2                        | 570.5               | 25.61                | 14.26                                          | 22.73                                          | 1605                              |
| 48                         | 27.12                            | 31640.                                                                                          | 8.746                                                                       | -176.1                        | 593.3               | 26.09                | 14.32                                          | 22.96                                          | 1597                              |
| 49                         | 27.33                            | 31102.                                                                                          | 8.606                                                                       | -158.9                        | 616.4               | 26.56                | 14.37                                          | 23.20                                          | 1589                              |
| 50                         | 27.53                            | 30587.                                                                                          | 8.467                                                                       | -141.4                        | 639.7               | 27.03                | 14.42                                          | 23.43                                          | 1580                              |
| 51                         | 27.75                            | 30087.                                                                                          | 8.329                                                                       | -123.9                        | 663.3               | 27.50                | 14.48                                          | 23.65                                          | 1572                              |
| 52                         | 27.96                            | 29613.                                                                                          | 8.193                                                                       | -106.2                        | 687.0               | 27.96                | 14.53                                          | 23.87                                          | 1564                              |
| 53                         | 28.18                            | 29159.                                                                                          | 8.059                                                                       | -88.4                         | 711.0               | 28.42                | 14.58                                          | 24.08                                          | 1556                              |
| 54                         | 28.40                            | 28725.                                                                                          | 7.924                                                                       | -70.5                         | 735.2               | 28.87                | 14.64                                          | 24.28                                          | 1548                              |
| 55                         | 28.62                            | 28309.                                                                                          | 7.791                                                                       | -52.5                         | 759.6               | 29.32                | 14.69                                          | 24.48                                          | 1540                              |
| 56                         | 28.85                            | 27897.                                                                                          | 7.661                                                                       | -33.8                         | 784.7               | 29.77                | 14.74                                          | 24.68                                          | 1532                              |
| 57                         | 29.08                            | 27502.                                                                                          | 7.532                                                                       | -15.6                         | 809.5               | 30.21                | 14.79                                          | 24.86                                          | 1524                              |
| 58                         | 29.31                            | 27124.                                                                                          | 7.403                                                                       | 2.8                           | 834.4               | 30.64                | 14.84                                          | 25.04                                          | 1517                              |
| 59                         | 29.55                            | 26764.                                                                                          | 7.277                                                                       | 21.2                          | 859.5               | 31.07                | 14.89                                          | 25.21                                          | 1509                              |
| 60                         | 29.79                            | 26418.                                                                                          | 7.154                                                                       | 39.7                          | 884.8               | 31.50                | 14.94                                          | 25.39                                          | 1502                              |
| 61                         | 30.03                            | 26076.                                                                                          | 7.031                                                                       | 58.3                          | 910.3               | 31.92                | 15.00                                          | 25.57                                          | 1495                              |
| 62                         | 30.27                            | 25748.                                                                                          | 6.909                                                                       | 77.1                          | 936.0               | 32.34                | 15.06                                          | 25.73                                          | 1487                              |
| 63                         | 30.52                            | 25436.                                                                                          | 6.790                                                                       | 95.8                          | 961.8               | 32.75                | 15.12                                          | 25.90                                          | 1480                              |
| 64                         | 30.77                            | 25138.                                                                                          | 6.672                                                                       | 114.7                         | 987.7               | 33.16                | 15.19                                          | 26.07                                          | 1472                              |
| 65                         | 31.02                            | 24854.                                                                                          | 6.557                                                                       | 133.7                         | 1013.9              | 33.56                | 15.26                                          | 26.23                                          | 1465                              |
| 66                         | 31.28                            | 24580.                                                                                          | 6.443                                                                       | 152.8                         | 1040.2              | 33.96                | 15.34                                          | 26.39                                          | 1458                              |
| 67                         | 31.54                            | 24317.                                                                                          | 6.333                                                                       | 171.9                         | 1066.7              | 34.36                | 15.42                                          | 26.56                                          | 1451                              |
| 68                         | 31.80                            | 24066.                                                                                          | 6.225                                                                       | 191.2                         | 1093.3              | 34.76                | 15.51                                          | 26.73                                          | 1444                              |
| 69                         | 32.06                            | 23826.                                                                                          | 6.120                                                                       | 210.6                         | 1120.1              | 35.15                | 15.60                                          | 26.89                                          | 1437                              |
| 70                         | 32.32                            | 23599.                                                                                          | 6.017                                                                       | 230.0                         | 1147.1              | 35.54                | 15.69                                          | 27.06                                          | 1430                              |
| 71                         | 32.59                            | 23376.                                                                                          | 5.915                                                                       | 249.6                         | 1174.2              | 35.92                | 15.79                                          | 27.23                                          | 1423                              |
| 72                         | 32.86                            | 23168.                                                                                          | 5.816                                                                       | 269.2                         | 1201.6              | 36.30                | 15.89                                          | 27.40                                          | 1417                              |
| 73                         | 33.13                            | 22973.                                                                                          | 5.722                                                                       | 289.0                         | 1229.0              | 36.68                | 16.00                                          | 27.58                                          | 1411                              |
| 74                         | 33.41                            | 22791.                                                                                          | 5.629                                                                       | 308.9                         | 1256.7              | 37.06                | 16.12                                          | 27.75                                          | 1404                              |
| 75                         | 33.69                            | 22621.                                                                                          | 5.534                                                                       | 328.8                         | 1284.5              | 37.43                | 16.23                                          | 27.91                                          | 1398                              |
| 76                         | 33.96                            | 22454.                                                                                          | 5.442                                                                       | 348.9                         | 1312.5              | 37.80                | 16.35                                          | 28.07                                          | 1392                              |
| 77                         | 34.24                            | 22296.                                                                                          | 5.354                                                                       | 369.1                         | 1340.7              | 38.17                | 16.48                                          | 28.24                                          | 1386                              |
| 78                         | 34.53                            | 22148.                                                                                          | 5.268                                                                       | 389.4                         | 1369.0              | 38.54                | 16.61                                          | 28.41                                          | 1380                              |
| 79                         | 34.81                            | 22008.                                                                                          | 5.182                                                                       | 409.8                         | 1397.5              | 38.90                | 16.74                                          | 28.58                                          | 1374                              |
| 80                         | 35.10                            | 21880.                                                                                          | 5.097                                                                       | 430.4                         | 1426.1              | 39.26                | 16.88                                          | 28.73                                          | 1368                              |
| 81                         | 35.38                            | 21760.                                                                                          | 5.016                                                                       | 451.0                         | 1454.9              | 39.62                | 17.02                                          | 28.90                                          | 1363                              |
| 82                         | 35.67                            | 21646.                                                                                          | 4.936                                                                       | 471.8                         | 1483.9              | 39.97                | 17.16                                          | 29.06                                          | 1357                              |
| 83                         | 35.96                            | 21536.                                                                                          | 4.859                                                                       | 492.7                         | 1513.0              | 40.33                | 17.30                                          | 29.23                                          | 1352                              |
| 84                         | 36.26                            | 21437.                                                                                          | 4.783                                                                       | 513.7                         | 1542.3              | 40.68                | 17.45                                          | 29.39                                          | 1347                              |
| 85                         | 36.55                            | 21335.                                                                                          | 4.708                                                                       | 534.8                         | 1571.8              | 41.03                | 17.60                                          | 29.56                                          | 1342                              |
| 86                         | 36.85                            | 21245.                                                                                          | 4.635                                                                       | 556.1                         | 1601.4              | 41.37                | 17.76                                          | 29.72                                          | 1337                              |
| 87                         | 37.14                            | 21167.                                                                                          | 4.564                                                                       | 577.4                         | 1631.2              | 41.72                | 17.91                                          | 29.88                                          | 1332                              |
| 88                         | 37.44                            | 21084.                                                                                          | 4.495                                                                       | 598.9                         | 1661.1              | 42.06                | 18.07                                          | 30.05                                          | 1328                              |
| 89                         | 37.74                            | 21014.                                                                                          | 4.428                                                                       | 620.6                         | 1691.3              | 42.40                | 18.23                                          | 30.21                                          | 1323                              |
| 90                         | 38.04                            | 20949.                                                                                          | 4.362                                                                       | 642.3                         | 1721.6              | 42.74                | 18.39                                          | 30.37                                          | 1319                              |
| 91                         | 38.34                            | 20893.                                                                                          | 4.298                                                                       | 664.2                         | 1752.0              | 43.07                | 18.55                                          | 30.53                                          | 1315                              |
| 92                         | 38.64                            | 20844.                                                                                          | 4.235                                                                       | 686.2                         | 1782.6              | 43.41                | 18.71                                          | 30.69                                          | 1311                              |
| 93                         | 38.95                            | 20803.                                                                                          | 4.174                                                                       | 708.4                         | 1813.4              | 43.74                | 18.88                                          | 30.85                                          | 1307                              |
| 94                         | 39.25                            | 20768.                                                                                          | 4.114                                                                       | 730.6                         | 1844.3              | 44.07                | 19.04                                          | 31.00                                          | 1304                              |
| 95                         | 39.56                            | 20738.                                                                                          | 4.056                                                                       | 753.0                         | 1875.4              | 44.40                | 19.21                                          | 31.15                                          | 1300                              |
| 96                         | 39.87                            | 20701.                                                                                          | 3.998                                                                       | 775.6                         | 1906.6              | 44.73                | 19.37                                          | 31.31                                          | 1297                              |
| 97                         | 40.17                            | 20669.                                                                                          | 3.943                                                                       | 798.3                         | 1938.0              | 45.05                | 19.54                                          | 31.47                                          | 1293                              |
| 98                         | 40.48                            | 20641.                                                                                          | 3.888                                                                       | 821.1                         | 1969.5              | 45.38                | 19.70                                          | 31.62                                          | 1290                              |
| 99                         | 40.79                            | 20619.                                                                                          | 3.835                                                                       | 844.0                         | 2001.2              | 45.70                | 19.87                                          | 31.77                                          | 1287                              |
| 100                        | 41.10                            | 20601.                                                                                          | 3.783                                                                       | 867.0                         | 2033.1              | 46.02                | 20.04                                          | 31.92                                          | 1284                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

300.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ·ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 21.732                   | 22.74                            | 54403.                                                                                              | 11.412                                                                     | -558.9                        | 132.3               | 11.16                | 11.30                                          | 14.03                                          | 1842                              |
| 22                         | 22.77                            | 54286.                                                                                              | 11.430                                                                     | -556.0                        | 136.1               | 11.34                | 11.37                                          | 14.15                                          | 1843                              |
| 23                         | 22.88                            | 52702.                                                                                              | 11.475                                                                     | -545.0                        | 150.5               | 11.98                | 11.59                                          | 14.64                                          | 1829                              |
| 24                         | 23.00                            | 51818.                                                                                              | 11.483                                                                     | -533.7                        | 165.4               | 12.61                | 11.81                                          | 15.08                                          | 1824                              |
| 25                         | 23.11                            | 50964.                                                                                              | 11.453                                                                     | -522.0                        | 180.7               | 13.23                | 12.02                                          | 15.50                                          | 1818                              |
| 26                         | 23.24                            | 50194.                                                                                              | 11.421                                                                     | -510.0                        | 196.3               | 13.85                | 12.22                                          | 15.92                                          | 1813                              |
| 27                         | 23.36                            | 49266.                                                                                              | 11.363                                                                     | -497.6                        | 212.5               | 14.46                | 12.41                                          | 16.32                                          | 1805                              |
| 28                         | 23.49                            | 48372.                                                                                              | 11.294                                                                     | -485.0                        | 229.0               | 15.06                | 12.58                                          | 16.71                                          | 1797                              |
| 29                         | 23.62                            | 47497.                                                                                              | 11.226                                                                     | -472.0                        | 245.9               | 15.65                | 12.75                                          | 17.10                                          | 1789                              |
| 30                         | 23.75                            | 46567.                                                                                              | 11.155                                                                     | -458.8                        | 263.2               | 16.24                | 12.89                                          | 17.47                                          | 1781                              |
| 31                         | 23.89                            | 45783.                                                                                              | 11.079                                                                     | -445.3                        | 280.8               | 16.82                | 13.04                                          | 17.84                                          | 1775                              |
| 32                         | 24.03                            | 44968.                                                                                              | 10.990                                                                     | -431.5                        | 298.9               | 17.39                | 13.17                                          | 18.20                                          | 1767                              |
| 33                         | 24.17                            | 44133.                                                                                              | 10.893                                                                     | -417.5                        | 317.2               | 17.95                | 13.30                                          | 18.55                                          | 1759                              |
| 34                         | 24.32                            | 43329.                                                                                              | 10.789                                                                     | -403.2                        | 336.0               | 18.51                | 13.42                                          | 18.89                                          | 1751                              |
| 35                         | 24.46                            | 42517.                                                                                              | 10.682                                                                     | -388.6                        | 355.0               | 19.06                | 13.52                                          | 19.22                                          | 1743                              |
| 36                         | 24.62                            | 41766.                                                                                              | 10.579                                                                     | -373.9                        | 374.4               | 19.61                | 13.63                                          | 19.55                                          | 1735                              |
| 37                         | 24.77                            | 40969.                                                                                              | 10.468                                                                     | -358.9                        | 394.1               | 20.15                | 13.73                                          | 19.88                                          | 1727                              |
| 38                         | 24.93                            | 40226.                                                                                              | 10.344                                                                     | -343.7                        | 414.1               | 20.68                | 13.81                                          | 20.18                                          | 1719                              |
| 39                         | 25.09                            | 39474.                                                                                              | 10.215                                                                     | -328.3                        | 434.4               | 21.21                | 13.88                                          | 20.46                                          | 1710                              |
| 40                         | 25.25                            | 38856.                                                                                              | 10.083                                                                     | -312.7                        | 455.0               | 21.73                | 13.94                                          | 20.70                                          | 1703                              |
| 41                         | 25.42                            | 38127.                                                                                              | 9.948                                                                      | -296.9                        | 475.8               | 22.25                | 14.00                                          | 20.97                                          | 1694                              |
| 42                         | 25.59                            | 37424.                                                                                              | 9.811                                                                      | -281.0                        | 496.9               | 22.76                | 14.05                                          | 21.22                                          | 1685                              |
| 43                         | 25.77                            | 36760.                                                                                              | 9.676                                                                      | -264.9                        | 518.3               | 23.26                | 14.10                                          | 21.47                                          | 1677                              |
| 44                         | 25.94                            | 36139.                                                                                              | 9.543                                                                      | -248.7                        | 539.9               | 23.75                | 14.15                                          | 21.71                                          | 1669                              |
| 45                         | 26.12                            | 35490.                                                                                              | 9.405                                                                      | -232.3                        | 561.7               | 24.25                | 14.20                                          | 21.95                                          | 1661                              |
| 46                         | 26.30                            | 34881.                                                                                              | 9.267                                                                      | -215.7                        | 583.9               | 24.73                | 14.26                                          | 22.20                                          | 1652                              |
| 47                         | 26.49                            | 34336.                                                                                              | 9.129                                                                      | -199.0                        | 606.2               | 25.21                | 14.32                                          | 22.43                                          | 1644                              |
| 48                         | 26.68                            | 33801.                                                                                              | 8.993                                                                      | -182.2                        | 628.7               | 25.69                | 14.37                                          | 22.66                                          | 1636                              |
| 49                         | 26.87                            | 33248.                                                                                              | 8.858                                                                      | -165.2                        | 651.5               | 26.16                | 14.43                                          | 22.89                                          | 1628                              |
| 50                         | 27.06                            | 32719.                                                                                              | 8.724                                                                      | -148.1                        | 674.5               | 26.62                | 14.49                                          | 23.12                                          | 1620                              |
| 51                         | 27.26                            | 32201.                                                                                              | 8.590                                                                      | -130.9                        | 697.7               | 27.08                | 14.54                                          | 23.34                                          | 1612                              |
| 52                         | 27.46                            | 31713.                                                                                              | 8.456                                                                      | -113.5                        | 721.2               | 27.54                | 14.60                                          | 23.55                                          | 1604                              |
| 53                         | 27.66                            | 31248.                                                                                              | 8.323                                                                      | -96.0                         | 744.8               | 27.99                | 14.65                                          | 23.76                                          | 1596                              |
| 54                         | 27.87                            | 30806.                                                                                              | 8.192                                                                      | -78.4                         | 768.7               | 28.43                | 14.71                                          | 23.96                                          | 1588                              |
| 55                         | 28.07                            | 30383.                                                                                              | 8.064                                                                      | -60.6                         | 792.8               | 28.88                | 14.76                                          | 24.16                                          | 1581                              |
| 56                         | 28.29                            | 29950.                                                                                              | 7.936                                                                      | -42.2                         | 817.6               | 29.32                | 14.81                                          | 24.36                                          | 1573                              |
| 57                         | 28.50                            | 29555.                                                                                              | 7.808                                                                      | -24.3                         | 842.0               | 29.76                | 14.86                                          | 24.53                                          | 1566                              |
| 58                         | 28.71                            | 29171.                                                                                              | 7.683                                                                      | -6.2                          | 866.6               | 30.19                | 14.91                                          | 24.71                                          | 1559                              |
| 59                         | 28.93                            | 28801.                                                                                              | 7.561                                                                      | 12.0                          | 891.4               | 30.61                | 14.96                                          | 24.89                                          | 1552                              |
| 60                         | 29.15                            | 28446.                                                                                              | 7.437                                                                      | 30.2                          | 916.5               | 31.03                | 15.01                                          | 25.06                                          | 1545                              |
| 61                         | 29.38                            | 28098.                                                                                              | 7.315                                                                      | 48.6                          | 941.6               | 31.44                | 15.07                                          | 25.23                                          | 1538                              |
| 62                         | 29.60                            | 27767.                                                                                              | 7.197                                                                      | 67.0                          | 966.9               | 31.86                | 15.13                                          | 25.40                                          | 1530                              |
| 63                         | 29.83                            | 27438.                                                                                              | 7.082                                                                      | 85.6                          | 992.4               | 32.26                | 15.20                                          | 25.58                                          | 1524                              |
| 64                         | 30.06                            | 27125.                                                                                              | 6.964                                                                      | 104.2                         | 1018.1              | 32.67                | 15.27                                          | 25.75                                          | 1516                              |
| 65                         | 30.30                            | 26828.                                                                                              | 6.849                                                                      | 123.0                         | 1043.9              | 33.07                | 15.34                                          | 25.91                                          | 1509                              |
| 66                         | 30.53                            | 26546.                                                                                              | 6.736                                                                      | 141.8                         | 1069.9              | 33.47                | 15.42                                          | 26.08                                          | 1502                              |
| 67                         | 30.77                            | 26273.                                                                                              | 6.625                                                                      | 160.7                         | 1096.0              | 33.86                | 15.50                                          | 26.24                                          | 1495                              |
| 68                         | 31.01                            | 26000.                                                                                              | 6.515                                                                      | 179.8                         | 1122.4              | 34.25                | 15.59                                          | 26.40                                          | 1488                              |
| 69                         | 31.25                            | 25756.                                                                                              | 6.408                                                                      | 198.9                         | 1148.8              | 34.64                | 15.68                                          | 26.56                                          | 1481                              |
| 70                         | 31.49                            | 25513.                                                                                              | 6.304                                                                      | 218.1                         | 1175.5              | 35.02                | 15.77                                          | 26.73                                          | 1474                              |
| 71                         | 31.74                            | 25267.                                                                                              | 6.202                                                                      | 237.5                         | 1202.3              | 35.40                | 15.87                                          | 26.91                                          | 1467                              |
| 72                         | 31.99                            | 25036.                                                                                              | 6.103                                                                      | 256.9                         | 1229.3              | 35.78                | 15.98                                          | 27.08                                          | 1461                              |
| 73                         | 32.24                            | 24821.                                                                                              | 6.006                                                                      | 276.5                         | 1256.5              | 36.15                | 16.08                                          | 27.26                                          | 1454                              |
| 74                         | 32.49                            | 24619.                                                                                              | 5.910                                                                      | 296.1                         | 1283.8              | 36.52                | 16.20                                          | 27.43                                          | 1448                              |
| 75                         | 32.75                            | 24437.                                                                                              | 5.815                                                                      | 315.9                         | 1311.3              | 36.89                | 16.31                                          | 27.59                                          | 1441                              |
| 76                         | 33.00                            | 24250.                                                                                              | 5.727                                                                      | 335.8                         | 1339.0              | 37.26                | 16.43                                          | 27.78                                          | 1435                              |
| 77                         | 33.26                            | 24078.                                                                                              | 5.641                                                                      | 355.8                         | 1366.9              | 37.62                | 16.56                                          | 27.96                                          | 1430                              |
| 78                         | 33.52                            | 23911.                                                                                              | 5.552                                                                      | 376.0                         | 1395.0              | 37.99                | 16.69                                          | 28.14                                          | 1423                              |
| 79                         | 33.78                            | 23755.                                                                                              | 5.464                                                                      | 396.3                         | 1423.2              | 38.35                | 16.82                                          | 28.30                                          | 1417                              |
| 80                         | 34.05                            | 23617.                                                                                              | 5.379                                                                      | 416.6                         | 1451.5              | 38.70                | 16.96                                          | 28.47                                          | 1412                              |
| 81                         | 34.31                            | 23490.                                                                                              | 5.298                                                                      | 437.1                         | 1480.1              | 39.06                | 17.10                                          | 28.64                                          | 1406                              |
| 82                         | 34.58                            | 23366.                                                                                              | 5.218                                                                      | 457.8                         | 1508.8              | 39.41                | 17.24                                          | 28.81                                          | 1401                              |
| 83                         | 34.85                            | 23247.                                                                                              | 5.137                                                                      | 478.5                         | 1537.7              | 39.76                | 17.38                                          | 28.98                                          | 1396                              |
| 84                         | 35.11                            | 23131.                                                                                              | 5.058                                                                      | 499.4                         | 1566.7              | 40.11                | 17.53                                          | 29.14                                          | 1390                              |
| 85                         | 35.38                            | 23010.                                                                                              | 4.982                                                                      | 520.4                         | 1596.0              | 40.45                | 17.68                                          | 29.31                                          | 1385                              |
| 86                         | 35.66                            | 22916.                                                                                              | 4.907                                                                      | 541.5                         | 1625.4              | 40.80                | 17.84                                          | 29.48                                          | 1380                              |
| 87                         | 35.93                            | 22816.                                                                                              | 4.835                                                                      | 562.8                         | 1654.9              | 41.14                | 17.99                                          | 29.65                                          | 1375                              |
| 88                         | 36.20                            | 22723.                                                                                              | 4.764                                                                      | 584.2                         | 1684.6              | 41.48                | 18.15                                          | 29.82                                          | 1370                              |
| 89                         | 36.48                            | 22634.                                                                                              | 4.695                                                                      | 605.7                         | 1714.6              | 41.82                | 18.31                                          | 29.99                                          | 1365                              |
| 90                         | 36.75                            | 22557.                                                                                              | 4.626                                                                      | 627.4                         | 1744.6              | 42.15                | 18.47                                          | 30.16                                          | 1361                              |
| 91                         | 37.03                            | 22469.                                                                                              | 4.559                                                                      | 649.2                         | 1774.9              | 42.49                | 18.63                                          | 30.32                                          | 1356                              |
| 92                         | 37.31                            | 22390.                                                                                              | 4.495                                                                      | 671.1                         | 1805.3              | 42.82                | 18.79                                          | 30.50                                          | 1352                              |
| 93                         | 37.59                            | 22330.                                                                                              | 4.431                                                                      | 693.2                         | 1835.9              | 43.15                | 18.96                                          | 30.66                                          | 1348                              |
| 94                         | 37.87                            | 22285.                                                                                              | 4.369                                                                      | 715.4                         | 1866.6              | 43.48                | 19.12                                          | 30.82                                          | 1344                              |
| 95                         | 38.15                            | 22240.                                                                                              | 4.309                                                                      | 737.8                         | 1897.5              | 43.81                | 19.29                                          | 30.98                                          | 1340                              |
| 96                         | 38.43                            | 22190.                                                                                              | 4.250                                                                      | 760.2                         | 1928.6              | 44.13                | 19.45                                          | 31.15                                          | 1336                              |
| 97                         | 38.72                            | 22144.                                                                                              | 4.192                                                                      | 782.9                         | 1959.8              | 44.45                | 19.62                                          | 31.31                                          | 1333                              |
| 98                         | 39.00                            | 22104.                                                                                              | 4.135                                                                      | 805.6                         | 1991.2              | 44.78                | 19.78                                          | 31.47                                          | 1329                              |
| 99                         | 39.29                            | 22068.                                                                                              | 4.080                                                                      | 828.5                         | 2022.7              | 45.10                | 19.95                                          | 31.63                                          | 1326                              |
| 100                        | 39.57                            | 22038.                                                                                              | 4.026                                                                      | 851.5                         | 2054.4              | 45.42                | 20.11                                          | 31.78                                          | 1323                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOBARS-CONTINUED

320.0 ATMOSPHERE ISOBAR

| TEMPERATURE<br>OEG. KELVIN | VOLUME<br>CM/GMOLE | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_p$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|--------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| * 22.169                   | 22.60              | 56275.                                                                              | 11.441                                                        | -553.1                        | 179.7               | 11.23                | 11.37                                 | 14.04                                 | 1869                              |
| 23                         | 22.69              | 54699.                                                                              | 11.522                                                        | -544.1                        | 191.6               | 11.75                | 11.56                                 | 14.47                                 | 1855                              |
| 24                         | 22.80              | 53818.                                                                              | 11.569                                                        | -533.0                        | 206.2               | 12.38                | 11.78                                 | 14.93                                 | 1851                              |
| 25                         | 22.91              | 53031.                                                                              | 11.574                                                        | -521.5                        | 221.3               | 12.99                | 12.00                                 | 15.35                                 | 1847                              |
| 26                         | 23.03              | 52357.                                                                              | 11.546                                                        | -509.7                        | 236.9               | 13.60                | 12.20                                 | 15.76                                 | 1844                              |
| 27                         | 23.14              | 51446.                                                                              | 11.506                                                        | -497.6                        | 252.9               | 14.21                | 12.40                                 | 16.17                                 | 1836                              |
| 28                         | 23.27              | 50527.                                                                              | 11.429                                                        | -485.1                        | 269.2               | 14.80                | 12.58                                 | 16.55                                 | 1828                              |
| 29                         | 23.39              | 49669.                                                                              | 11.350                                                        | -472.4                        | 286.0               | 15.39                | 12.74                                 | 16.91                                 | 1820                              |
| 30                         | 23.52              | 48717.                                                                              | 11.291                                                        | -459.4                        | 303.1               | 15.97                | 12.89                                 | 17.29                                 | 1812                              |
| 31                         | 23.65              | 47867.                                                                              | 11.222                                                        | -446.2                        | 320.5               | 16.54                | 13.03                                 | 17.65                                 | 1805                              |
| 32                         | 23.78              | 47039.                                                                              | 11.159                                                        | -432.6                        | 338.4               | 17.11                | 13.17                                 | 18.02                                 | 1799                              |
| 33                         | 23.91              | 46260.                                                                              | 11.077                                                        | -418.8                        | 356.6               | 17.67                | 13.29                                 | 18.37                                 | 1792                              |
| 34                         | 24.05              | 45557.                                                                              | 10.979                                                        | -404.8                        | 375.1               | 18.22                | 13.42                                 | 18.69                                 | 1786                              |
| 35                         | 24.19              | 44726.                                                                              | 10.874                                                        | -390.5                        | 393.9               | 18.77                | 13.53                                 | 19.02                                 | 1778                              |
| 36                         | 24.34              | 44014.                                                                              | 10.763                                                        | -376.0                        | 413.1               | 19.31                | 13.64                                 | 19.32                                 | 1770                              |
| 37                         | 24.48              | 43204.                                                                              | 10.655                                                        | -361.2                        | 432.6               | 19.84                | 13.73                                 | 19.64                                 | 1762                              |
| 38                         | 24.63              | 42459.                                                                              | 10.554                                                        | -346.3                        | 452.4               | 20.37                | 13.82                                 | 19.95                                 | 1755                              |
| 39                         | 24.79              | 41664.                                                                              | 10.439                                                        | -331.1                        | 472.5               | 20.89                | 13.90                                 | 20.25                                 | 1747                              |
| 40                         | 24.94              | 41158.                                                                              | 10.308                                                        | -315.8                        | 492.8               | 21.41                | 13.96                                 | 20.47                                 | 1741                              |
| 41                         | 25.10              | 40392.                                                                              | 10.174                                                        | -300.3                        | 513.4               | 21.92                | 14.03                                 | 20.73                                 | 1732                              |
| 42                         | 25.26              | 39664.                                                                              | 10.038                                                        | -284.6                        | 534.3               | 22.42                | 14.08                                 | 20.98                                 | 1723                              |
| 43                         | 25.42              | 38946.                                                                              | 9.900                                                         | -268.8                        | 555.4               | 22.91                | 14.14                                 | 21.23                                 | 1714                              |
| 44                         | 25.59              | 38291.                                                                              | 9.761                                                         | -252.8                        | 576.8               | 23.41                | 14.20                                 | 21.46                                 | 1706                              |
| 45                         | 25.75              | 37618.                                                                              | 9.627                                                         | -236.7                        | 598.3               | 23.89                | 14.25                                 | 21.70                                 | 1697                              |
| 46                         | 25.92              | 36983.                                                                              | 9.495                                                         | -220.4                        | 620.2               | 24.37                | 14.31                                 | 21.95                                 | 1688                              |
| 47                         | 26.10              | 36444.                                                                              | 9.361                                                         | -204.0                        | 642.2               | 24.85                | 14.37                                 | 22.17                                 | 1681                              |
| 48                         | 26.27              | 35914.                                                                              | 9.225                                                         | -187.4                        | 664.5               | 25.32                | 14.43                                 | 22.39                                 | 1673                              |
| 49                         | 26.45              | 35347.                                                                              | 9.091                                                         | -170.7                        | 687.0               | 25.78                | 14.49                                 | 22.62                                 | 1665                              |
| 50                         | 26.63              | 34800.                                                                              | 8.958                                                         | -153.8                        | 709.8               | 26.24                | 14.55                                 | 22.84                                 | 1657                              |
| 51                         | 26.82              | 34261.                                                                              | 8.828                                                         | -136.9                        | 732.7               | 26.69                | 14.60                                 | 23.06                                 | 1649                              |
| 52                         | 27.01              | 33754.                                                                              | 8.700                                                         | -119.7                        | 755.9               | 27.14                | 14.66                                 | 23.28                                 | 1641                              |
| 53                         | 27.20              | 33276.                                                                              | 8.570                                                         | -102.5                        | 779.3               | 27.59                | 14.72                                 | 23.48                                 | 1634                              |
| 54                         | 27.39              | 32827.                                                                              | 8.442                                                         | -85.1                         | 802.9               | 28.03                | 14.77                                 | 23.68                                 | 1626                              |
| 55                         | 27.58              | 32391.                                                                              | 8.314                                                         | -67.6                         | 826.6               | 28.47                | 14.83                                 | 23.88                                 | 1619                              |
| 56                         | 27.78              | 31961.                                                                              | 8.187                                                         | -49.5                         | 851.1               | 28.91                | 14.88                                 | 24.06                                 | 1612                              |
| 57                         | 27.98              | 31557.                                                                              | 8.065                                                         | -31.8                         | 875.3               | 29.34                | 14.93                                 | 24.25                                 | 1605                              |
| 58                         | 28.18              | 31157.                                                                              | 7.944                                                         | -14.0                         | 899.7               | 29.76                | 14.98                                 | 24.43                                 | 1598                              |
| 59                         | 28.38              | 30781.                                                                              | 7.820                                                         | 3.9                           | 924.2               | 30.18                | 15.03                                 | 24.60                                 | 1591                              |
| 60                         | 28.59              | 30423.                                                                              | 7.699                                                         | 21.9                          | 948.8               | 30.59                | 15.09                                 | 24.76                                 | 1584                              |
| 61                         | 28.80              | 30074.                                                                              | 7.582                                                         | 40.0                          | 973.7               | 31.00                | 15.14                                 | 24.94                                 | 1578                              |
| 62                         | 29.01              | 29737.                                                                              | 7.466                                                         | 58.3                          | 998.8               | 31.41                | 15.21                                 | 25.12                                 | 1571                              |
| 63                         | 29.22              | 29403.                                                                              | 7.348                                                         | 76.6                          | 1024.0              | 31.82                | 15.27                                 | 25.28                                 | 1564                              |
| 64                         | 29.43              | 29085.                                                                              | 7.232                                                         | 95.0                          | 1049.3              | 32.22                | 15.34                                 | 25.45                                 | 1557                              |
| 65                         | 29.65              | 28778.                                                                              | 7.122                                                         | 113.5                         | 1074.9              | 32.61                | 15.42                                 | 25.62                                 | 1550                              |
| 66                         | 29.87              | 28489.                                                                              | 7.013                                                         | 132.2                         | 1100.6              | 33.00                | 15.50                                 | 25.80                                 | 1544                              |
| 67                         | 30.09              | 28210.                                                                              | 6.902                                                         | 150.9                         | 1126.5              | 33.39                | 15.58                                 | 25.96                                 | 1537                              |
| 68                         | 30.31              | 27939.                                                                              | 6.792                                                         | 169.7                         | 1152.5              | 33.78                | 15.67                                 | 26.12                                 | 1530                              |
| 69                         | 30.54              | 27675.                                                                              | 6.685                                                         | 188.6                         | 1178.7              | 34.16                | 15.76                                 | 26.29                                 | 1523                              |
| 70                         | 30.76              | 27421.                                                                              | 6.579                                                         | 207.7                         | 1205.1              | 34.54                | 15.85                                 | 26.45                                 | 1516                              |
| 71                         | 30.99              | 27174.                                                                              | 6.476                                                         | 226.8                         | 1231.7              | 34.92                | 15.95                                 | 26.63                                 | 1509                              |
| 72                         | 31.22              | 26894.                                                                              | 6.373                                                         | 246.1                         | 1258.4              | 35.29                | 16.06                                 | 26.80                                 | 1502                              |
| 73                         | 31.45              | 26659.                                                                              | 6.276                                                         | 265.4                         | 1285.2              | 35.66                | 16.17                                 | 26.97                                 | 1495                              |
| 74                         | 31.69              | 26438.                                                                              | 6.179                                                         | 284.9                         | 1312.3              | 36.03                | 16.28                                 | 27.15                                 | 1489                              |
| 75                         | 31.92              | 26237.                                                                              | 6.086                                                         | 304.5                         | 1339.5              | 36.40                | 16.39                                 | 27.33                                 | 1482                              |
| 76                         | 32.16              | 26040.                                                                              | 5.994                                                         | 324.2                         | 1366.9              | 36.76                | 16.51                                 | 27.50                                 | 1476                              |
| 77                         | 32.40              | 25855.                                                                              | 5.903                                                         | 344.1                         | 1394.5              | 37.12                | 16.64                                 | 27.67                                 | 1470                              |
| 78                         | 32.64              | 25679.                                                                              | 5.813                                                         | 364.0                         | 1422.3              | 37.48                | 16.77                                 | 27.85                                 | 1464                              |
| 79                         | 32.88              | 25511.                                                                              | 5.728                                                         | 384.1                         | 1450.2              | 37.83                | 16.90                                 | 28.02                                 | 1458                              |
| 80                         | 33.12              | 25357.                                                                              | 5.647                                                         | 404.3                         | 1478.3              | 38.19                | 17.03                                 | 28.22                                 | 1453                              |
| 81                         | 33.37              | 25229.                                                                              | 5.567                                                         | 424.7                         | 1506.8              | 38.54                | 17.17                                 | 28.40                                 | 1448                              |
| 82                         | 33.62              | 25109.                                                                              | 5.483                                                         | 445.2                         | 1535.2              | 38.89                | 17.31                                 | 28.56                                 | 1443                              |
| 83                         | 33.86              | 24988.                                                                              | 5.400                                                         | 465.9                         | 1563.9              | 39.24                | 17.46                                 | 28.71                                 | 1437                              |
| 84                         | 34.11              | 24865.                                                                              | 5.323                                                         | 486.6                         | 1592.7              | 39.58                | 17.61                                 | 28.89                                 | 1432                              |
| 85                         | 34.36              | 24745.                                                                              | 5.248                                                         | 507.5                         | 1621.6              | 39.92                | 17.76                                 | 29.08                                 | 1427                              |
| 86                         | 34.62              | 24622.                                                                              | 5.172                                                         | 528.5                         | 1650.9              | 40.27                | 17.91                                 | 29.26                                 | 1422                              |
| 87                         | 34.87              | 24510.                                                                              | 5.096                                                         | 549.7                         | 1680.3              | 40.61                | 18.07                                 | 29.43                                 | 1416                              |
| 88                         | 35.12              | 24402.                                                                              | 5.022                                                         | 571.0                         | 1709.8              | 40.94                | 18.23                                 | 29.59                                 | 1411                              |
| 89                         | 35.38              | 24300.                                                                              | 4.951                                                         | 592.4                         | 1739.5              | 41.28                | 18.38                                 | 29.77                                 | 1406                              |
| 90                         | 35.63              | 24203.                                                                              | 4.881                                                         | 614.0                         | 1769.3              | 41.61                | 18.54                                 | 29.94                                 | 1401                              |
| 91                         | 35.89              | 24083.                                                                              | 4.813                                                         | 635.7                         | 1799.4              | 41.94                | 18.71                                 | 30.13                                 | 1396                              |
| 92                         | 36.15              | 23981.                                                                              | 4.747                                                         | 657.6                         | 1829.6              | 42.28                | 18.87                                 | 30.31                                 | 1391                              |
| 93                         | 36.41              | 23893.                                                                              | 4.681                                                         | 679.6                         | 1860.0              | 42.60                | 19.03                                 | 30.49                                 | 1387                              |
| 94                         | 36.67              | 23818.                                                                              | 4.617                                                         | 701.7                         | 1890.6              | 42.93                | 19.20                                 | 30.66                                 | 1383                              |
| 95                         | 36.93              | 23753.                                                                              | 4.553                                                         | 724.0                         | 1921.3              | 43.26                | 19.36                                 | 30.82                                 | 1378                              |
| 96                         | 37.19              | 23692.                                                                              | 4.492                                                         | 746.4                         | 1952.2              | 43.58                | 19.53                                 | 30.99                                 | 1375                              |
| 97                         | 37.45              | 23634.                                                                              | 4.433                                                         | 768.9                         | 1983.2              | 43.90                | 19.69                                 | 31.15                                 | 1371                              |
| 98                         | 37.71              | 23582.                                                                              | 4.374                                                         | 791.6                         | 2014.5              | 44.22                | 19.86                                 | 31.32                                 | 1367                              |
| 99                         | 37.98              | 23534.                                                                              | 4.317                                                         | 814.5                         | 2045.9              | 44.54                | 20.02                                 | 31.48                                 | 1364                              |
| 100                        | 38.24              | 23492.                                                                              | 4.261                                                         | 837.4                         | 2077.4              | 44.86                | 20.19                                 | 31.64                                 | 1360                              |

\* TWO-PHASE BOUNDARY

TABLE X. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, 1508ARS-CONTINUED

340.0 ATMOSPHERE 1508AR

| TEMPERATURE<br>DEG. KELVIN | VOLUME<br>CM <sup>3</sup> /GMOLE | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------|----------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| * 22.600                   | 22.47                            | 57415.                                                                                             | 11.496                                                                      | -547.3                        | 227.0               | 11.30                | 11.42                                          | 14.09                                          | 1886                              |
| 23                         | 22.51                            | 56651.                                                                                             | 11.543                                                                      | -542.9                        | 232.4               | 11.54                | 11.51                                          | 14.29                                          | 1880                              |
| 24                         | 22.61                            | 55708.                                                                                             | 11.638                                                                      | -532.0                        | 247.0               | 12.16                | 11.74                                          | 14.77                                          | 1876                              |
| 25                         | 22.72                            | 55008.                                                                                             | 11.687                                                                      | -520.8                        | 261.9               | 12.77                | 11.96                                          | 15.21                                          | 1875                              |
| 26                         | 22.83                            | 54482.                                                                                             | 11.688                                                                      | -509.1                        | 277.3               | 13.37                | 12.17                                          | 15.62                                          | 1874                              |
| 27                         | 22.94                            | 53586.                                                                                             | 11.652                                                                      | -497.2                        | 293.1               | 13.97                | 12.38                                          | 16.03                                          | 1867                              |
| 28                         | 23.06                            | 52625.                                                                                             | 11.594                                                                      | -485.0                        | 309.4               | 14.56                | 12.58                                          | 16.43                                          | 1859                              |
| 29                         | 23.18                            | 51783.                                                                                             | 11.497                                                                      | -472.4                        | 326.0               | 15.14                | 12.76                                          | 16.79                                          | 1851                              |
| 30                         | 23.30                            | 50823.                                                                                             | 11.362                                                                      | -459.7                        | 342.9               | 15.72                | 12.90                                          | 17.09                                          | 1840                              |
| 31                         | 23.42                            | 49807.                                                                                             | 11.296                                                                      | -446.6                        | 360.2               | 16.28                | 13.03                                          | 17.45                                          | 1831                              |
| 32                         | 23.55                            | 48972.                                                                                             | 11.275                                                                      | -433.3                        | 377.9               | 16.84                | 13.17                                          | 17.83                                          | 1826                              |
| 33                         | 23.67                            | 48329.                                                                                             | 11.211                                                                      | -419.8                        | 395.8               | 17.40                | 13.29                                          | 18.16                                          | 1822                              |
| 34                         | 23.80                            | 47787.                                                                                             | 11.166                                                                      | -406.0                        | 414.1               | 17.94                | 13.41                                          | 18.50                                          | 1820                              |
| 35                         | 23.94                            | 46897.                                                                                             | 11.069                                                                      | -391.9                        | 432.9               | 18.49                | 13.53                                          | 18.84                                          | 1812                              |
| 36                         | 24.08                            | 46247.                                                                                             | 10.962                                                                      | -377.6                        | 451.9               | 19.02                | 13.64                                          | 19.13                                          | 1806                              |
| 37                         | 24.22                            | 45415.                                                                                             | 10.850                                                                      | -363.1                        | 471.2               | 19.55                | 13.74                                          | 19.44                                          | 1797                              |
| 38                         | 24.36                            | 44660.                                                                                             | 10.729                                                                      | -348.4                        | 490.8               | 20.07                | 13.83                                          | 19.72                                          | 1789                              |
| 39                         | 24.50                            | 43833.                                                                                             | 10.624                                                                      | -333.5                        | 510.6               | 20.59                | 13.91                                          | 20.02                                          | 1781                              |
| 40                         | 24.64                            | 43511.                                                                                             | 10.528                                                                      | -318.4                        | 530.6               | 21.10                | 13.98                                          | 20.25                                          | 1780                              |
| 41                         | 24.80                            | 42677.                                                                                             | 10.406                                                                      | -303.1                        | 551.2               | 21.60                | 14.05                                          | 20.53                                          | 1771                              |
| 42                         | 24.95                            | 41913.                                                                                             | 10.268                                                                      | -287.6                        | 571.9               | 22.10                | 14.11                                          | 20.77                                          | 1761                              |
| 43                         | 25.10                            | 41109.                                                                                             | 10.130                                                                      | -272.0                        | 592.7               | 22.59                | 14.18                                          | 21.03                                          | 1751                              |
| 44                         | 25.26                            | 40392.                                                                                             | 9.988                                                                       | -256.3                        | 613.9               | 23.08                | 14.24                                          | 21.26                                          | 1741                              |
| 45                         | 25.42                            | 39688.                                                                                             | 9.849                                                                       | -240.4                        | 635.2               | 23.56                | 14.29                                          | 21.49                                          | 1732                              |
| 46                         | 25.58                            | 39018.                                                                                             | 9.708                                                                       | -224.3                        | 656.8               | 24.04                | 14.36                                          | 21.73                                          | 1722                              |
| 47                         | 25.74                            | 38504.                                                                                             | 9.575                                                                       | -208.2                        | 678.6               | 24.50                | 14.43                                          | 21.94                                          | 1716                              |
| 48                         | 25.90                            | 37981.                                                                                             | 9.446                                                                       | -191.8                        | 700.6               | 24.97                | 14.49                                          | 22.16                                          | 1709                              |
| 49                         | 26.07                            | 37386.                                                                                             | 9.313                                                                       | -175.3                        | 722.9               | 25.43                | 14.55                                          | 22.38                                          | 1700                              |
| 50                         | 26.24                            | 36826.                                                                                             | 9.180                                                                       | -158.7                        | 745.4               | 25.88                | 14.61                                          | 22.60                                          | 1692                              |
| 51                         | 26.42                            | 36261.                                                                                             | 9.048                                                                       | -142.0                        | 768.1               | 26.33                | 14.67                                          | 22.81                                          | 1683                              |
| 52                         | 26.59                            | 35732.                                                                                             | 8.919                                                                       | -125.1                        | 791.0               | 26.78                | 14.73                                          | 23.02                                          | 1676                              |
| 53                         | 26.77                            | 35242.                                                                                             | 8.794                                                                       | -108.1                        | 814.1               | 27.22                | 14.78                                          | 23.23                                          | 1668                              |
| 54                         | 26.95                            | 34777.                                                                                             | 8.671                                                                       | -91.0                         | 837.5               | 27.65                | 14.84                                          | 23.43                                          | 1661                              |
| 55                         | 27.13                            | 34337.                                                                                             | 8.547                                                                       | -73.7                         | 861.0               | 28.08                | 14.90                                          | 23.63                                          | 1654                              |
| 56                         | 27.32                            | 33895.                                                                                             | 8.424                                                                       | -55.8                         | 885.3               | 28.52                | 14.95                                          | 23.81                                          | 1647                              |
| 57                         | 27.50                            | 33479.                                                                                             | 8.301                                                                       | -38.3                         | 909.1               | 28.94                | 15.00                                          | 23.99                                          | 1641                              |
| 58                         | 27.69                            | 33080.                                                                                             | 8.179                                                                       | -20.8                         | 933.2               | 29.36                | 15.05                                          | 24.16                                          | 1634                              |
| 59                         | 27.88                            | 32702.                                                                                             | 8.061                                                                       | -3.1                          | 957.5               | 29.78                | 15.10                                          | 24.33                                          | 1627                              |
| 60                         | 28.07                            | 32339.                                                                                             | 7.945                                                                       | 14.7                          | 981.9               | 30.19                | 15.16                                          | 24.51                                          | 1621                              |
| 61                         | 28.27                            | 31996.                                                                                             | 7.829                                                                       | 32.6                          | 1006.5              | 30.60                | 15.22                                          | 24.68                                          | 1615                              |
| 62                         | 28.47                            | 31661.                                                                                             | 7.711                                                                       | 50.6                          | 1031.3              | 31.00                | 15.28                                          | 24.84                                          | 1608                              |
| 63                         | 28.67                            | 31332.                                                                                             | 7.598                                                                       | 68.7                          | 1056.2              | 31.40                | 15.35                                          | 25.01                                          | 1602                              |
| 64                         | 28.87                            | 31011.                                                                                             | 7.488                                                                       | 86.9                          | 1081.3              | 31.79                | 15.42                                          | 25.19                                          | 1596                              |
| 65                         | 29.07                            | 30692.                                                                                             | 7.377                                                                       | 105.2                         | 1106.7              | 32.19                | 15.49                                          | 25.36                                          | 1589                              |
| 66                         | 29.27                            | 30413.                                                                                             | 7.265                                                                       | 123.6                         | 1132.1              | 32.57                | 15.57                                          | 25.51                                          | 1583                              |
| 67                         | 29.48                            | 30134.                                                                                             | 7.155                                                                       | 142.2                         | 1157.7              | 32.96                | 15.65                                          | 25.68                                          | 1576                              |
| 68                         | 29.69                            | 29861.                                                                                             | 7.052                                                                       | 160.8                         | 1183.5              | 33.34                | 15.74                                          | 25.85                                          | 1570                              |
| 69                         | 29.90                            | 29587.                                                                                             | 6.948                                                                       | 179.6                         | 1209.6              | 33.72                | 15.83                                          | 26.03                                          | 1563                              |
| 70                         | 30.11                            | 29320.                                                                                             | 6.842                                                                       | 198.4                         | 1235.7              | 34.10                | 15.93                                          | 26.20                                          | 1557                              |
| 71                         | 30.32                            | 29019.                                                                                             | 6.738                                                                       | 217.4                         | 1262.0              | 34.47                | 16.03                                          | 26.38                                          | 1549                              |
| 72                         | 30.54                            | 28740.                                                                                             | 6.636                                                                       | 236.5                         | 1288.4              | 34.84                | 16.14                                          | 26.56                                          | 1542                              |
| 73                         | 30.75                            | 28480.                                                                                             | 6.536                                                                       | 255.7                         | 1315.1              | 35.21                | 16.24                                          | 26.74                                          | 1535                              |
| 74                         | 30.97                            | 28241.                                                                                             | 6.437                                                                       | 275.0                         | 1341.9              | 35.57                | 16.36                                          | 26.91                                          | 1528                              |
| 75                         | 31.19                            | 28015.                                                                                             | 6.340                                                                       | 294.4                         | 1368.9              | 35.93                | 16.47                                          | 27.08                                          | 1521                              |
| 76                         | 31.41                            | 27820.                                                                                             | 6.247                                                                       | 313.9                         | 1396.0              | 36.29                | 16.59                                          | 27.25                                          | 1515                              |
| 77                         | 31.63                            | 27627.                                                                                             | 6.156                                                                       | 333.6                         | 1423.3              | 36.65                | 16.72                                          | 27.43                                          | 1509                              |
| 78                         | 31.85                            | 27441.                                                                                             | 6.067                                                                       | 353.4                         | 1450.8              | 37.01                | 16.85                                          | 27.60                                          | 1503                              |
| 79                         | 32.08                            | 27261.                                                                                             | 5.980                                                                       | 373.4                         | 1478.5              | 37.36                | 16.98                                          | 27.78                                          | 1497                              |
| 80                         | 32.31                            | 27089.                                                                                             | 5.894                                                                       | 393.5                         | 1506.4              | 37.71                | 17.11                                          | 27.96                                          | 1492                              |
| 81                         | 32.53                            | 26992.                                                                                             | 5.810                                                                       | 413.7                         | 1534.4              | 38.06                | 17.25                                          | 28.11                                          | 1487                              |
| 82                         | 32.76                            | 26887.                                                                                             | 5.727                                                                       | 434.0                         | 1562.6              | 38.40                | 17.39                                          | 28.27                                          | 1482                              |
| 83                         | 32.99                            | 26765.                                                                                             | 5.650                                                                       | 454.5                         | 1591.1              | 38.75                | 17.54                                          | 28.45                                          | 1477                              |
| 84                         | 33.22                            | 26647.                                                                                             | 5.578                                                                       | 475.1                         | 1619.6              | 39.09                | 17.68                                          | 28.65                                          | 1473                              |
| 85                         | 33.46                            | 26503.                                                                                             | 5.499                                                                       | 495.9                         | 1648.8              | 39.44                | 17.83                                          | 28.84                                          | 1468                              |
| 86                         | 33.70                            | 26380.                                                                                             | 5.420                                                                       | 516.8                         | 1677.7              | 39.77                | 17.99                                          | 29.00                                          | 1462                              |
| 87                         | 33.93                            | 26255.                                                                                             | 5.342                                                                       | 537.9                         | 1706.8              | 40.11                | 18.14                                          | 29.17                                          | 1457                              |
| 88                         | 34.17                            | 26137.                                                                                             | 5.272                                                                       | 559.1                         | 1736.1              | 40.44                | 18.30                                          | 29.37                                          | 1452                              |
| 89                         | 34.40                            | 26023.                                                                                             | 5.202                                                                       | 580.4                         | 1765.5              | 40.78                | 18.46                                          | 29.56                                          | 1447                              |
| 90                         | 34.64                            | 25898.                                                                                             | 5.130                                                                       | 602.0                         | 1795.5              | 41.11                | 18.62                                          | 29.74                                          | 1442                              |
| 91                         | 34.88                            | 25733.                                                                                             | 5.058                                                                       | 623.6                         | 1825.3              | 41.44                | 18.78                                          | 29.94                                          | 1436                              |
| 92                         | 35.12                            | 25597.                                                                                             | 4.988                                                                       | 645.3                         | 1855.3              | 41.77                | 18.94                                          | 30.13                                          | 1430                              |
| 93                         | 35.36                            | 25470.                                                                                             | 4.921                                                                       | 667.3                         | 1885.6              | 42.10                | 19.11                                          | 30.31                                          | 1425                              |
| 94                         | 35.61                            | 25361.                                                                                             | 4.855                                                                       | 689.3                         | 1916.0              | 42.42                | 19.27                                          | 30.50                                          | 1420                              |
| 95                         | 35.85                            | 25277.                                                                                             | 4.791                                                                       | 711.5                         | 1946.5              | 42.75                | 19.44                                          | 30.67                                          | 1416                              |
| 96                         | 36.09                            | 25201.                                                                                             | 4.729                                                                       | 733.9                         | 1977.3              | 43.07                | 19.60                                          | 30.85                                          | 1412                              |
| 97                         | 36.34                            | 25131.                                                                                             | 4.668                                                                       | 756.4                         | 2008.2              | 43.39                | 19.77                                          | 31.02                                          | 1408                              |
| 98                         | 36.58                            | 25066.                                                                                             | 4.607                                                                       | 779.0                         | 2039.3              | 43.71                | 19.94                                          | 31.19                                          | 1404                              |
| 99                         | 36.83                            | 25007.                                                                                             | 4.547                                                                       | 801.8                         | 2070.6              | 44.02                | 20.10                                          | 31.35                                          | 1400                              |
| 100                        | 37.07                            | 24957.                                                                                             | 4.488                                                                       | 824.7                         | 2101.9              | 44.34                | 20.27                                          | 31.51                                          | 1396                              |

\* TWO-PHASE BOUNDARY

TABLE X1. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES

| TEMPERATURE<br>DEG. KELVIN             | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.00002 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| 14                                     | 0.023           | 1138.                                                                                 | 0.002                                                            | 173.9                         | 289.7               | 85.28                | 12.48                                 | 20.90                                 | 309                               |
| 15                                     | 0.025           | 1227.                                                                                 | 0.002                                                            | 186.4                         | 310.5               | 86.14                | 12.48                                 | 20.89                                 | 320                               |
| 16                                     | 0.026           | 1307.                                                                                 | 0.002                                                            | 198.8                         | 331.3               | 86.95                | 12.48                                 | 20.88                                 | 331                               |
| 17                                     | 0.028           | 1385.                                                                                 | 0.002                                                            | 211.3                         | 352.2               | 87.70                | 12.48                                 | 20.88                                 | 341                               |
| 18                                     | 0.029           | 1467.                                                                                 | 0.002                                                            | 223.8                         | 373.0               | 88.42                | 12.48                                 | 20.87                                 | 351                               |
| 19                                     | 0.031           | 1549.                                                                                 | 0.002                                                            | 236.3                         | 393.8               | 89.09                | 12.48                                 | 20.87                                 | 361                               |
| 20                                     | 0.033           | 1637.                                                                                 | 0.002                                                            | 248.8                         | 414.6               | 89.73                | 12.48                                 | 20.86                                 | 370                               |
| 21                                     | 0.034           | 1714.                                                                                 | 0.002                                                            | 261.2                         | 435.4               | 90.34                | 12.48                                 | 20.86                                 | 379                               |
| 22                                     | 0.036           | 1796.                                                                                 | 0.002                                                            | 273.7                         | 456.2               | 90.92                | 12.48                                 | 20.85                                 | 388                               |
| 23                                     | 0.038           | 1878.                                                                                 | 0.002                                                            | 286.2                         | 477.0               | 91.47                | 12.48                                 | 20.85                                 | 397                               |
| 24                                     | 0.039           | 1961.                                                                                 | 0.002                                                            | 298.7                         | 497.8               | 92.01                | 12.48                                 | 20.85                                 | 406                               |
| 25                                     | 0.041           | 2043.                                                                                 | 0.002                                                            | 311.2                         | 518.6               | 92.51                | 12.48                                 | 20.84                                 | 414                               |
| 26                                     | 0.043           | 2125.                                                                                 | 0.002                                                            | 323.6                         | 539.4               | 93.00                | 12.48                                 | 20.84                                 | 422                               |
| 27                                     | 0.044           | 2207.                                                                                 | 0.002                                                            | 336.1                         | 560.2               | 93.48                | 12.48                                 | 20.84                                 | 430                               |
| 28                                     | 0.046           | 2289.                                                                                 | 0.002                                                            | 348.6                         | 581.0               | 93.93                | 12.48                                 | 20.84                                 | 438                               |
| 29                                     | 0.048           | 2372.                                                                                 | 0.002                                                            | 361.1                         | 601.8               | 94.37                | 12.48                                 | 20.84                                 | 446                               |
| 30                                     | 0.049           | 2454.                                                                                 | 0.002                                                            | 373.5                         | 622.6               | 94.79                | 12.48                                 | 20.83                                 | 454                               |
| 31                                     | 0.051           | 2536.                                                                                 | 0.002                                                            | 386.0                         | 643.4               | 95.20                | 12.48                                 | 20.83                                 | 461                               |
| 32                                     | 0.052           | 2618.                                                                                 | 0.002                                                            | 398.5                         | 664.2               | 95.60                | 12.48                                 | 20.83                                 | 469                               |
| 33                                     | 0.054           | 2700.                                                                                 | 0.002                                                            | 411.0                         | 685.0               | 95.98                | 12.48                                 | 20.83                                 | 476                               |
| 34                                     | 0.056           | 2782.                                                                                 | 0.002                                                            | 423.5                         | 705.8               | 96.35                | 12.48                                 | 20.83                                 | 483                               |
| 35                                     | 0.057           | 2865.                                                                                 | 0.002                                                            | 435.9                         | 726.6               | 96.71                | 12.48                                 | 20.83                                 | 490                               |
| 36                                     | 0.059           | 2947.                                                                                 | 0.002                                                            | 448.4                         | 747.4               | 97.06                | 12.48                                 | 20.83                                 | 497                               |
| 37                                     | 0.061           | 3029.                                                                                 | 0.002                                                            | 460.9                         | 768.2               | 97.41                | 12.48                                 | 20.83                                 | 504                               |
| 38                                     | 0.062           | 3111.                                                                                 | 0.002                                                            | 473.4                         | 789.0               | 97.74                | 12.49                                 | 20.83                                 | 511                               |
| 39                                     | 0.064           | 3194.                                                                                 | 0.002                                                            | 485.9                         | 809.8               | 98.06                | 12.49                                 | 20.83                                 | 517                               |
| 40                                     | 0.066           | 3276.                                                                                 | 0.002                                                            | 498.4                         | 830.6               | 98.38                | 12.50                                 | 20.84                                 | 524                               |
| 42                                     | 0.069           | 3440.                                                                                 | 0.002                                                            | 523.4                         | 872.3               | 98.99                | 12.51                                 | 20.85                                 | 537                               |
| 44                                     | 0.072           | 3604.                                                                                 | 0.002                                                            | 548.4                         | 914.0               | 99.57                | 12.53                                 | 20.87                                 | 549                               |
| 46                                     | 0.075           | 3769.                                                                                 | 0.002                                                            | 573.5                         | 955.7               | 100.13               | 12.55                                 | 20.89                                 | 561                               |
| 48                                     | 0.079           | 3933.                                                                                 | 0.002                                                            | 598.6                         | 997.5               | 100.67               | 12.59                                 | 20.93                                 | 573                               |
| 50                                     | 0.082           | 4098.                                                                                 | 0.002                                                            | 623.9                         | 1039.3              | 101.18               | 12.64                                 | 20.97                                 | 585                               |
| 55                                     | 0.090           | 4508.                                                                                 | 0.002                                                            | 687.4                         | 1144.5              | 102.39               | 12.81                                 | 21.14                                 | 612                               |
| 60                                     | 0.098           | 4919.                                                                                 | 0.002                                                            | 752.1                         | 1250.8              | 103.52               | 13.09                                 | 21.42                                 | 636                               |
| 65                                     | 0.107           | 5330.                                                                                 | 0.002                                                            | 818.5                         | 1358.8              | 104.58               | 13.47                                 | 21.80                                 | 658                               |
| 70                                     | 0.115           | 5741.                                                                                 | 0.002                                                            | 887.1                         | 1468.9              | 105.60               | 13.98                                 | 22.31                                 | 679                               |
| 75                                     | 0.123           | 6151.                                                                                 | 0.002                                                            | 958.5                         | 1581.9              | 106.58               | 14.60                                 | 22.92                                 | 697                               |
| 80                                     | 0.131           | 6562.                                                                                 | 0.002                                                            | 1033.2                        | 1698.3              | 107.55               | 15.31                                 | 23.64                                 | 714                               |
| 85                                     | 0.139           | 6973.                                                                                 | 0.002                                                            | 1111.7                        | 1818.4              | 108.50               | 16.10                                 | 24.43                                 | 729                               |
| 90                                     | 0.148           | 7384.                                                                                 | 0.002                                                            | 1194.3                        | 1942.6              | 109.44               | 16.94                                 | 25.27                                 | 744                               |
| 95                                     | 0.156           | 7794.                                                                                 | 0.002                                                            | 1281.2                        | 2071.1              | 110.38               | 17.82                                 | 26.14                                 | 758                               |
| 100                                    | 0.164           | 8205.                                                                                 | 0.002                                                            | 1372.5                        | 2203.9              | 111.32               | 18.69                                 | 27.02                                 | 772                               |
| 0.00003 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| 14                                     | 0.034           | 1132.                                                                                 | 0.002                                                            | 173.5                         | 289.1               | 81.90                | 12.48                                 | 20.96                                 | 309                               |
| 15                                     | 0.037           | 1215.                                                                                 | 0.002                                                            | 186.0                         | 309.9               | 82.76                | 12.48                                 | 20.94                                 | 320                               |
| 16                                     | 0.039           | 1297.                                                                                 | 0.002                                                            | 198.5                         | 330.7               | 83.57                | 12.48                                 | 20.93                                 | 331                               |
| 17                                     | 0.042           | 1380.                                                                                 | 0.002                                                            | 211.0                         | 351.5               | 84.33                | 12.48                                 | 20.92                                 | 341                               |
| 18                                     | 0.044           | 1462.                                                                                 | 0.002                                                            | 223.5                         | 372.4               | 85.04                | 12.48                                 | 20.92                                 | 351                               |
| 19                                     | 0.047           | 1544.                                                                                 | 0.002                                                            | 235.9                         | 393.2               | 85.71                | 12.48                                 | 20.91                                 | 361                               |
| 20                                     | 0.049           | 1627.                                                                                 | 0.002                                                            | 248.4                         | 414.0               | 86.35                | 12.48                                 | 20.90                                 | 370                               |
| 21                                     | 0.051           | 1709.                                                                                 | 0.002                                                            | 260.9                         | 434.8               | 86.96                | 12.48                                 | 20.89                                 | 379                               |
| 22                                     | 0.054           | 1791.                                                                                 | 0.002                                                            | 273.4                         | 455.6               | 87.54                | 12.48                                 | 20.89                                 | 388                               |
| 23                                     | 0.056           | 1874.                                                                                 | 0.002                                                            | 285.9                         | 476.4               | 88.10                | 12.48                                 | 20.88                                 | 397                               |
| 24                                     | 0.059           | 1956.                                                                                 | 0.002                                                            | 298.3                         | 497.2               | 88.63                | 12.48                                 | 20.88                                 | 406                               |
| 25                                     | 0.061           | 2038.                                                                                 | 0.002                                                            | 310.8                         | 518.0               | 89.14                | 12.48                                 | 20.87                                 | 414                               |
| 26                                     | 0.064           | 2121.                                                                                 | 0.002                                                            | 323.3                         | 538.8               | 89.63                | 12.48                                 | 20.87                                 | 422                               |
| 27                                     | 0.066           | 2203.                                                                                 | 0.002                                                            | 335.8                         | 559.6               | 90.10                | 12.48                                 | 20.87                                 | 430                               |
| 28                                     | 0.069           | 2285.                                                                                 | 0.002                                                            | 348.3                         | 580.5               | 90.55                | 12.48                                 | 20.86                                 | 438                               |
| 29                                     | 0.071           | 2368.                                                                                 | 0.002                                                            | 360.8                         | 601.3               | 90.99                | 12.48                                 | 20.86                                 | 446                               |
| 30                                     | 0.074           | 2450.                                                                                 | 0.002                                                            | 373.2                         | 622.1               | 91.41                | 12.48                                 | 20.86                                 | 454                               |
| 31                                     | 0.076           | 2532.                                                                                 | 0.002                                                            | 385.7                         | 642.9               | 91.82                | 12.48                                 | 20.85                                 | 461                               |
| 32                                     | 0.079           | 2614.                                                                                 | 0.002                                                            | 398.2                         | 663.7               | 92.22                | 12.48                                 | 20.85                                 | 469                               |
| 33                                     | 0.081           | 2697.                                                                                 | 0.002                                                            | 410.7                         | 684.5               | 92.60                | 12.48                                 | 20.85                                 | 476                               |
| 34                                     | 0.084           | 2779.                                                                                 | 0.002                                                            | 423.2                         | 705.3               | 92.98                | 12.48                                 | 20.85                                 | 483                               |
| 35                                     | 0.086           | 2861.                                                                                 | 0.002                                                            | 435.6                         | 726.1               | 93.34                | 12.48                                 | 20.85                                 | 490                               |
| 36                                     | 0.088           | 2943.                                                                                 | 0.002                                                            | 448.1                         | 746.9               | 93.69                | 12.48                                 | 20.85                                 | 497                               |
| 37                                     | 0.091           | 3026.                                                                                 | 0.002                                                            | 460.6                         | 767.7               | 94.03                | 12.49                                 | 20.85                                 | 504                               |
| 38                                     | 0.093           | 3108.                                                                                 | 0.002                                                            | 473.1                         | 788.5               | 94.37                | 12.49                                 | 20.85                                 | 511                               |
| 39                                     | 0.096           | 3190.                                                                                 | 0.002                                                            | 485.6                         | 809.4               | 94.69                | 12.49                                 | 20.85                                 | 517                               |
| 40                                     | 0.098           | 3272.                                                                                 | 0.002                                                            | 498.1                         | 830.2               | 95.01                | 12.50                                 | 20.86                                 | 524                               |
| 42                                     | 0.103           | 3437.                                                                                 | 0.002                                                            | 523.1                         | 871.8               | 95.62                | 12.51                                 | 20.87                                 | 537                               |
| 44                                     | 0.108           | 3601.                                                                                 | 0.002                                                            | 548.1                         | 913.5               | 96.20                | 12.53                                 | 20.88                                 | 549                               |
| 46                                     | 0.113           | 3766.                                                                                 | 0.002                                                            | 573.2                         | 955.2               | 96.76                | 12.56                                 | 20.91                                 | 561                               |
| 48                                     | 0.118           | 3930.                                                                                 | 0.002                                                            | 598.4                         | 997.0               | 97.29                | 12.59                                 | 20.94                                 | 573                               |
| 50                                     | 0.123           | 4095.                                                                                 | 0.002                                                            | 623.6                         | 1038.9              | 97.81                | 12.64                                 | 20.98                                 | 585                               |
| 55                                     | 0.135           | 4506.                                                                                 | 0.002                                                            | 687.2                         | 1144.1              | 99.02                | 12.81                                 | 21.16                                 | 612                               |
| 60                                     | 0.148           | 4917.                                                                                 | 0.002                                                            | 751.9                         | 1250.4              | 100.14               | 13.09                                 | 21.43                                 | 636                               |
| 65                                     | 0.160           | 5329.                                                                                 | 0.002                                                            | 818.2                         | 1358.4              | 101.21               | 13.48                                 | 21.81                                 | 658                               |
| 70                                     | 0.172           | 5739.                                                                                 | 0.002                                                            | 886.8                         | 1468.6              | 102.22               | 13.98                                 | 22.32                                 | 679                               |
| 75                                     | 0.185           | 6150.                                                                                 | 0.002                                                            | 958.2                         | 1581.6              | 103.21               | 14.60                                 | 22.93                                 | 697                               |
| 80                                     | 0.197           | 6561.                                                                                 | 0.002                                                            | 1033.0                        | 1698.0              | 104.17               | 15.31                                 | 23.64                                 | 714                               |
| 85                                     | 0.209           | 6972.                                                                                 | 0.002                                                            | 1111.5                        | 1818.1              | 105.12               | 16.10                                 | 24.43                                 | 729                               |
| 90                                     | 0.222           | 7383.                                                                                 | 0.002                                                            | 1194.1                        | 1942.3              | 106.07               | 16.95                                 | 25.28                                 | 744                               |
| 95                                     | 0.234           | 7794.                                                                                 | 0.002                                                            | 1281.0                        | 2070.8              | 107.01               | 17.82                                 | 26.15                                 | 758                               |
| 100                                    | 0.246           | 8205.                                                                                 | 0.002                                                            | 1372.3                        | 2203.7              | 107.94               | 18.69                                 | 27.02                                 | 772                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN            | PRESSURE<br>ATM | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_p$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|---------------------------------------|-----------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.00004 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                     |                                                               |                               |                     |                      |                                                |                                                |                                   |
| 14                                    | 0.046           | 1127.                                                                               | 0.003                                                         | 173.1                         | 288.4               | 79.50                | 12.49                                          | 21.02                                          | 309                               |
| 15                                    | 0.049           | 1209.                                                                               | 0.003                                                         | 185.6                         | 309.3               | 80.36                | 12.49                                          | 21.00                                          | 320                               |
| 16                                    | 0.052           | 1297.                                                                               | 0.003                                                         | 198.1                         | 330.1               | 81.17                | 12.49                                          | 20.99                                          | 330                               |
| 17                                    | 0.055           | 1374.                                                                               | 0.003                                                         | 210.6                         | 350.9               | 81.93                | 12.49                                          | 20.97                                          | 341                               |
| 18                                    | 0.059           | 1457.                                                                               | 0.003                                                         | 223.1                         | 371.7               | 82.64                | 12.49                                          | 20.96                                          | 351                               |
| 19                                    | 0.062           | 1539.                                                                               | 0.003                                                         | 235.6                         | 392.6               | 83.32                | 12.49                                          | 20.95                                          | 360                               |
| 20                                    | 0.065           | 1627.                                                                               | 0.003                                                         | 248.1                         | 413.4               | 83.96                | 12.49                                          | 20.94                                          | 370                               |
| 21                                    | 0.069           | 1704.                                                                               | 0.003                                                         | 260.6                         | 434.2               | 84.57                | 12.49                                          | 20.93                                          | 379                               |
| 22                                    | 0.072           | 1787.                                                                               | 0.003                                                         | 273.0                         | 455.0               | 85.15                | 12.49                                          | 20.92                                          | 388                               |
| 23                                    | 0.075           | 1869.                                                                               | 0.003                                                         | 285.5                         | 475.8               | 85.70                | 12.49                                          | 20.92                                          | 397                               |
| 24                                    | 0.078           | 1957.                                                                               | 0.003                                                         | 298.0                         | 496.7               | 86.23                | 12.49                                          | 20.91                                          | 405                               |
| 25                                    | 0.082           | 2034.                                                                               | 0.003                                                         | 310.5                         | 517.5               | 86.74                | 12.48                                          | 20.90                                          | 414                               |
| 26                                    | 0.085           | 2116.                                                                               | 0.003                                                         | 323.0                         | 538.3               | 87.23                | 12.48                                          | 20.90                                          | 422                               |
| 27                                    | 0.088           | 2199.                                                                               | 0.003                                                         | 335.5                         | 559.1               | 87.70                | 12.48                                          | 20.89                                          | 430                               |
| 28                                    | 0.092           | 2281.                                                                               | 0.003                                                         | 348.0                         | 579.9               | 88.16                | 12.48                                          | 20.89                                          | 438                               |
| 29                                    | 0.095           | 2364.                                                                               | 0.003                                                         | 360.4                         | 600.7               | 88.60                | 12.48                                          | 20.89                                          | 446                               |
| 30                                    | 0.098           | 2446.                                                                               | 0.003                                                         | 372.9                         | 621.6               | 89.02                | 12.48                                          | 20.88                                          | 453                               |
| 31                                    | 0.101           | 2528.                                                                               | 0.003                                                         | 385.4                         | 642.4               | 89.43                | 12.48                                          | 20.88                                          | 461                               |
| 32                                    | 0.105           | 2611.                                                                               | 0.003                                                         | 397.9                         | 663.2               | 89.82                | 12.48                                          | 20.87                                          | 468                               |
| 33                                    | 0.108           | 2693.                                                                               | 0.003                                                         | 410.4                         | 684.0               | 90.21                | 12.48                                          | 20.87                                          | 476                               |
| 34                                    | 0.111           | 2775.                                                                               | 0.003                                                         | 422.9                         | 704.8               | 90.58                | 12.48                                          | 20.87                                          | 483                               |
| 35                                    | 0.115           | 2858.                                                                               | 0.003                                                         | 435.3                         | 725.6               | 90.94                | 12.49                                          | 20.87                                          | 490                               |
| 36                                    | 0.118           | 2940.                                                                               | 0.003                                                         | 447.8                         | 746.4               | 91.30                | 12.49                                          | 20.87                                          | 497                               |
| 37                                    | 0.121           | 3022.                                                                               | 0.003                                                         | 460.3                         | 767.3               | 91.64                | 12.49                                          | 20.87                                          | 504                               |
| 38                                    | 0.124           | 3105.                                                                               | 0.003                                                         | 472.8                         | 788.1               | 91.97                | 12.49                                          | 20.87                                          | 511                               |
| 39                                    | 0.128           | 3187.                                                                               | 0.003                                                         | 485.3                         | 808.9               | 92.30                | 12.49                                          | 20.87                                          | 517                               |
| 40                                    | 0.131           | 3269.                                                                               | 0.003                                                         | 497.8                         | 829.7               | 92.61                | 12.50                                          | 20.87                                          | 524                               |
| 42                                    | 0.138           | 3434.                                                                               | 0.003                                                         | 522.8                         | 871.4               | 93.22                | 12.51                                          | 20.88                                          | 537                               |
| 44                                    | 0.144           | 3598.                                                                               | 0.003                                                         | 547.8                         | 913.1               | 93.80                | 12.53                                          | 20.90                                          | 549                               |
| 46                                    | 0.151           | 3763.                                                                               | 0.003                                                         | 572.9                         | 954.8               | 94.36                | 12.56                                          | 20.92                                          | 561                               |
| 48                                    | 0.157           | 3927.                                                                               | 0.003                                                         | 598.1                         | 996.6               | 94.90                | 12.59                                          | 20.95                                          | 573                               |
| 50                                    | 0.164           | 4092.                                                                               | 0.003                                                         | 623.3                         | 1038.5              | 95.41                | 12.64                                          | 21.00                                          | 585                               |
| 55                                    | 0.180           | 4503.                                                                               | 0.003                                                         | 686.9                         | 1143.7              | 96.62                | 12.81                                          | 21.17                                          | 611                               |
| 60                                    | 0.197           | 4915.                                                                               | 0.003                                                         | 751.6                         | 1250.1              | 97.75                | 13.09                                          | 21.44                                          | 636                               |
| 65                                    | 0.213           | 5326.                                                                               | 0.003                                                         | 818.0                         | 1358.0              | 98.81                | 13.48                                          | 21.82                                          | 658                               |
| 70                                    | 0.230           | 5737.                                                                               | 0.003                                                         | 886.6                         | 1468.3              | 99.83                | 13.98                                          | 22.32                                          | 679                               |
| 75                                    | 0.246           | 6148.                                                                               | 0.003                                                         | 958.0                         | 1581.3              | 100.81               | 14.60                                          | 22.94                                          | 697                               |
| 80                                    | 0.262           | 6560.                                                                               | 0.003                                                         | 1032.7                        | 1697.7              | 101.78               | 15.31                                          | 23.65                                          | 714                               |
| 85                                    | 0.279           | 6971.                                                                               | 0.003                                                         | 1111.2                        | 1817.8              | 102.73               | 16.10                                          | 24.44                                          | 729                               |
| 90                                    | 0.295           | 7382.                                                                               | 0.003                                                         | 1193.8                        | 1942.0              | 103.67               | 16.95                                          | 25.28                                          | 744                               |
| 95                                    | 0.312           | 7793.                                                                               | 0.003                                                         | 1280.8                        | 2070.5              | 104.61               | 17.82                                          | 26.15                                          | 758                               |
| 100                                   | 0.328           | 8204.                                                                               | 0.003                                                         | 1372.0                        | 2203.4              | 105.55               | 18.69                                          | 27.03                                          | 772                               |
| 0.00005 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                     |                                                               |                               |                     |                      |                                                |                                                |                                   |
| 14                                    | 0.057           | 1121.                                                                               | 0.004                                                         | 172.8                         | 287.8               | 77.64                | 12.50                                          | 21.09                                          | 308                               |
| 15                                    | 0.061           | 1204.                                                                               | 0.004                                                         | 185.3                         | 308.6               | 78.50                | 12.50                                          | 21.07                                          | 319                               |
| 16                                    | 0.065           | 1287.                                                                               | 0.004                                                         | 197.8                         | 329.5               | 79.31                | 12.49                                          | 21.04                                          | 330                               |
| 17                                    | 0.069           | 1369.                                                                               | 0.004                                                         | 210.3                         | 350.3               | 80.07                | 12.49                                          | 21.02                                          | 340                               |
| 18                                    | 0.073           | 1452.                                                                               | 0.004                                                         | 222.7                         | 371.1               | 80.78                | 12.49                                          | 21.01                                          | 350                               |
| 19                                    | 0.077           | 1535.                                                                               | 0.004                                                         | 235.2                         | 392.0               | 81.46                | 12.49                                          | 20.99                                          | 360                               |
| 20                                    | 0.081           | 1617.                                                                               | 0.004                                                         | 247.7                         | 412.8               | 82.10                | 12.49                                          | 20.98                                          | 369                               |
| 21                                    | 0.086           | 1700.                                                                               | 0.004                                                         | 260.2                         | 433.6               | 82.71                | 12.49                                          | 20.97                                          | 379                               |
| 22                                    | 0.090           | 1782.                                                                               | 0.004                                                         | 272.7                         | 454.5               | 83.29                | 12.49                                          | 20.96                                          | 388                               |
| 23                                    | 0.094           | 1865.                                                                               | 0.004                                                         | 285.2                         | 475.3               | 83.84                | 12.49                                          | 20.95                                          | 397                               |
| 24                                    | 0.098           | 1947.                                                                               | 0.004                                                         | 297.7                         | 496.1               | 84.37                | 12.49                                          | 20.94                                          | 405                               |
| 25                                    | 0.102           | 2030.                                                                               | 0.004                                                         | 310.2                         | 516.9               | 84.88                | 12.49                                          | 20.93                                          | 414                               |
| 26                                    | 0.106           | 2112.                                                                               | 0.004                                                         | 322.7                         | 537.8               | 85.37                | 12.49                                          | 20.93                                          | 422                               |
| 27                                    | 0.110           | 2195.                                                                               | 0.004                                                         | 335.1                         | 558.6               | 85.84                | 12.49                                          | 20.92                                          | 430                               |
| 28                                    | 0.114           | 2277.                                                                               | 0.004                                                         | 347.6                         | 579.4               | 86.30                | 12.49                                          | 20.92                                          | 438                               |
| 29                                    | 0.118           | 2360.                                                                               | 0.004                                                         | 360.1                         | 600.2               | 86.74                | 12.49                                          | 20.91                                          | 446                               |
| 30                                    | 0.123           | 2442.                                                                               | 0.004                                                         | 372.6                         | 621.0               | 87.16                | 12.49                                          | 20.90                                          | 453                               |
| 31                                    | 0.127           | 2524.                                                                               | 0.004                                                         | 385.1                         | 641.9               | 87.57                | 12.49                                          | 20.90                                          | 461                               |
| 32                                    | 0.131           | 2607.                                                                               | 0.004                                                         | 397.6                         | 662.7               | 87.97                | 12.49                                          | 20.90                                          | 468                               |
| 33                                    | 0.135           | 2689.                                                                               | 0.004                                                         | 410.1                         | 683.5               | 88.35                | 12.49                                          | 20.89                                          | 476                               |
| 34                                    | 0.139           | 2772.                                                                               | 0.004                                                         | 422.6                         | 704.3               | 88.72                | 12.49                                          | 20.89                                          | 483                               |
| 35                                    | 0.143           | 2854.                                                                               | 0.004                                                         | 435.0                         | 725.1               | 89.08                | 12.49                                          | 20.89                                          | 490                               |
| 36                                    | 0.147           | 2936.                                                                               | 0.004                                                         | 447.5                         | 746.0               | 89.44                | 12.49                                          | 20.89                                          | 497                               |
| 37                                    | 0.151           | 3019.                                                                               | 0.004                                                         | 460.0                         | 766.8               | 89.78                | 12.49                                          | 20.89                                          | 504                               |
| 38                                    | 0.155           | 3101.                                                                               | 0.004                                                         | 472.5                         | 787.6               | 90.11                | 12.49                                          | 20.88                                          | 510                               |
| 39                                    | 0.160           | 3184.                                                                               | 0.004                                                         | 485.0                         | 808.4               | 90.44                | 12.50                                          | 20.89                                          | 517                               |
| 40                                    | 0.164           | 3266.                                                                               | 0.004                                                         | 497.5                         | 829.3               | 90.75                | 12.50                                          | 20.89                                          | 524                               |
| 42                                    | 0.172           | 3431.                                                                               | 0.004                                                         | 522.5                         | 870.9               | 91.36                | 12.51                                          | 20.90                                          | 537                               |
| 44                                    | 0.180           | 3595.                                                                               | 0.004                                                         | 547.6                         | 912.6               | 91.95                | 12.53                                          | 20.91                                          | 549                               |
| 46                                    | 0.188           | 3760.                                                                               | 0.004                                                         | 572.7                         | 954.4               | 92.50                | 12.56                                          | 20.93                                          | 561                               |
| 48                                    | 0.197           | 3925.                                                                               | 0.004                                                         | 597.8                         | 996.2               | 93.04                | 12.59                                          | 20.97                                          | 573                               |
| 50                                    | 0.205           | 4089.                                                                               | 0.004                                                         | 623.0                         | 1038.1              | 93.55                | 12.64                                          | 21.01                                          | 584                               |
| 55                                    | 0.225           | 4501.                                                                               | 0.004                                                         | 686.6                         | 1143.3              | 94.77                | 12.81                                          | 21.18                                          | 611                               |
| 60                                    | 0.246           | 4917.                                                                               | 0.004                                                         | 751.4                         | 1249.7              | 95.89                | 13.09                                          | 21.45                                          | 636                               |
| 65                                    | 0.266           | 5324.                                                                               | 0.004                                                         | 817.7                         | 1357.7              | 96.95                | 13.48                                          | 21.83                                          | 658                               |
| 70                                    | 0.287           | 5735.                                                                               | 0.004                                                         | 886.3                         | 1467.9              | 97.97                | 13.98                                          | 22.33                                          | 679                               |
| 75                                    | 0.308           | 6147.                                                                               | 0.004                                                         | 957.7                         | 1581.0              | 98.96                | 14.60                                          | 22.95                                          | 697                               |
| 80                                    | 0.328           | 6558.                                                                               | 0.004                                                         | 1032.5                        | 1697.3              | 99.92                | 15.31                                          | 23.66                                          | 714                               |
| 85                                    | 0.349           | 6970.                                                                               | 0.004                                                         | 1111.0                        | 1817.5              | 100.87               | 16.10                                          | 24.45                                          | 729                               |
| 90                                    | 0.369           | 7381.                                                                               | 0.004                                                         | 1193.6                        | 1941.7              | 101.82               | 16.95                                          | 25.29                                          | 744                               |
| 95                                    | 0.390           | 7793.                                                                               | 0.004                                                         | 1280.5                        | 2070.2              | 102.76               | 17.82                                          | 26.16                                          | 758                               |
| 100                                   | 0.410           | 8204.                                                                               | 0.004                                                         | 1371.8                        | 2203.2              | 103.69               | 18.69                                          | 27.03                                          | 772                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN             | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|----------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.000075 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 14.170                               | 0.086           | 1121.                                                                                  | 0.006                                                            | 173.9                         | 289.6               | 74.40                | 12.53                                 | 21.28                                 | 309                               |
| 15                                     | 0.091           | 1190.                                                                                  | 0.006                                                            | 184.3                         | 307.0               | 75.11                | 12.52                                 | 21.24                                 | 318                               |
| 16                                     | 0.097           | 1277.                                                                                  | 0.006                                                            | 196.8                         | 327.9               | 75.92                | 12.51                                 | 21.19                                 | 329                               |
| 17                                     | 0.103           | 1354.                                                                                  | 0.006                                                            | 209.3                         | 348.7               | 76.68                | 12.51                                 | 21.16                                 | 340                               |
| 18                                     | 0.109           | 1439.                                                                                  | 0.006                                                            | 221.9                         | 369.6               | 77.40                | 12.51                                 | 21.13                                 | 350                               |
| 19                                     | 0.116           | 1527.                                                                                  | 0.006                                                            | 234.4                         | 390.5               | 78.07                | 12.50                                 | 21.10                                 | 359                               |
| 20                                     | 0.122           | 1605.                                                                                  | 0.006                                                            | 246.9                         | 411.3               | 78.71                | 12.50                                 | 21.08                                 | 369                               |
| 21                                     | 0.128           | 1688.                                                                                  | 0.006                                                            | 259.4                         | 432.2               | 79.32                | 12.50                                 | 21.06                                 | 378                               |
| 22                                     | 0.134           | 1771.                                                                                  | 0.006                                                            | 271.9                         | 453.0               | 79.90                | 12.50                                 | 21.05                                 | 387                               |
| 23                                     | 0.140           | 1853.                                                                                  | 0.006                                                            | 284.4                         | 473.9               | 80.46                | 12.50                                 | 21.03                                 | 396                               |
| 24                                     | 0.146           | 1936.                                                                                  | 0.006                                                            | 296.9                         | 494.7               | 80.99                | 12.50                                 | 21.02                                 | 405                               |
| 25                                     | 0.153           | 2019.                                                                                  | 0.006                                                            | 309.4                         | 515.6               | 81.50                | 12.50                                 | 21.01                                 | 413                               |
| 26                                     | 0.159           | 2107.                                                                                  | 0.006                                                            | 321.9                         | 536.4               | 81.99                | 12.50                                 | 21.00                                 | 421                               |
| 27                                     | 0.165           | 2184.                                                                                  | 0.006                                                            | 334.3                         | 557.2               | 82.46                | 12.49                                 | 20.99                                 | 429                               |
| 28                                     | 0.171           | 2267.                                                                                  | 0.006                                                            | 346.8                         | 578.1               | 82.92                | 12.49                                 | 20.98                                 | 437                               |
| 29                                     | 0.177           | 2349.                                                                                  | 0.006                                                            | 359.3                         | 598.9               | 83.36                | 12.49                                 | 20.97                                 | 445                               |
| 30                                     | 0.184           | 2437.                                                                                  | 0.006                                                            | 371.8                         | 619.8               | 83.78                | 12.49                                 | 20.96                                 | 453                               |
| 31                                     | 0.190           | 2515.                                                                                  | 0.006                                                            | 384.3                         | 640.6               | 84.19                | 12.49                                 | 20.96                                 | 460                               |
| 32                                     | 0.196           | 2597.                                                                                  | 0.006                                                            | 396.8                         | 661.4               | 84.59                | 12.49                                 | 20.95                                 | 468                               |
| 33                                     | 0.202           | 2680.                                                                                  | 0.006                                                            | 409.3                         | 682.3               | 84.97                | 12.49                                 | 20.95                                 | 475                               |
| 34                                     | 0.208           | 2762.                                                                                  | 0.006                                                            | 421.8                         | 703.1               | 85.34                | 12.49                                 | 20.94                                 | 482                               |
| 35                                     | 0.214           | 2845.                                                                                  | 0.006                                                            | 434.3                         | 723.9               | 85.71                | 12.49                                 | 20.94                                 | 490                               |
| 36                                     | 0.221           | 2928.                                                                                  | 0.006                                                            | 446.8                         | 744.8               | 86.06                | 12.49                                 | 20.93                                 | 497                               |
| 37                                     | 0.227           | 3010.                                                                                  | 0.006                                                            | 459.3                         | 765.6               | 86.40                | 12.50                                 | 20.93                                 | 503                               |
| 38                                     | 0.233           | 3093.                                                                                  | 0.006                                                            | 471.8                         | 786.4               | 86.73                | 12.50                                 | 20.93                                 | 510                               |
| 39                                     | 0.239           | 3175.                                                                                  | 0.006                                                            | 484.3                         | 807.3               | 87.06                | 12.50                                 | 20.93                                 | 517                               |
| 40                                     | 0.245           | 3258.                                                                                  | 0.006                                                            | 496.8                         | 828.1               | 87.37                | 12.51                                 | 20.93                                 | 523                               |
| 42                                     | 0.258           | 3423.                                                                                  | 0.006                                                            | 521.8                         | 869.8               | 87.98                | 12.52                                 | 20.93                                 | 536                               |
| 44                                     | 0.270           | 3588.                                                                                  | 0.006                                                            | 546.9                         | 911.5               | 88.57                | 12.54                                 | 20.95                                 | 549                               |
| 46                                     | 0.282           | 3753.                                                                                  | 0.006                                                            | 572.0                         | 953.3               | 89.13                | 12.56                                 | 20.97                                 | 561                               |
| 48                                     | 0.295           | 3918.                                                                                  | 0.006                                                            | 597.1                         | 995.1               | 89.66                | 12.60                                 | 21.00                                 | 573                               |
| 50                                     | 0.307           | 4082.                                                                                  | 0.006                                                            | 622.4                         | 1037.0              | 90.18                | 12.64                                 | 21.04                                 | 584                               |
| 55                                     | 0.338           | 4495.                                                                                  | 0.006                                                            | 686.0                         | 1142.3              | 91.39                | 12.82                                 | 21.20                                 | 611                               |
| 60                                     | 0.369           | 4907.                                                                                  | 0.006                                                            | 750.7                         | 1248.7              | 92.51                | 13.09                                 | 21.47                                 | 636                               |
| 65                                     | 0.399           | 5319.                                                                                  | 0.006                                                            | 817.1                         | 1356.8              | 93.58                | 13.48                                 | 21.85                                 | 658                               |
| 70                                     | 0.430           | 5731.                                                                                  | 0.006                                                            | 885.7                         | 1467.1              | 94.59                | 13.98                                 | 22.35                                 | 679                               |
| 75                                     | 0.461           | 6143.                                                                                  | 0.006                                                            | 957.1                         | 1580.1              | 95.58                | 14.60                                 | 22.96                                 | 697                               |
| 80                                     | 0.492           | 6555.                                                                                  | 0.006                                                            | 1031.9                        | 1696.6              | 96.54                | 15.31                                 | 23.67                                 | 714                               |
| 85                                     | 0.523           | 6967.                                                                                  | 0.006                                                            | 1110.4                        | 1816.7              | 97.50                | 16.10                                 | 24.46                                 | 729                               |
| 90                                     | 0.554           | 7379.                                                                                  | 0.006                                                            | 1193.0                        | 1941.0              | 98.44                | 16.95                                 | 25.30                                 | 744                               |
| 95                                     | 0.585           | 7791.                                                                                  | 0.006                                                            | 1279.9                        | 2069.6              | 99.38                | 17.82                                 | 26.17                                 | 758                               |
| 100                                    | 0.615           | 8203.                                                                                  | 0.006                                                            | 1371.2                        | 2202.5              | 100.32               | 18.69                                 | 27.04                                 | 772                               |
| 0.0001 GMOLE/CM <sup>3</sup> ISOCORE   |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 14.777                               | 0.118           | 1157.                                                                                  | 0.008                                                            | 180.5                         | 300.6               | 72.51                | 12.56                                 | 21.45                                 | 315                               |
| 15                                     | 0.120           | 1176.                                                                                  | 0.008                                                            | 183.3                         | 305.3               | 72.70                | 12.56                                 | 21.43                                 | 318                               |
| 16                                     | 0.129           | 1260.                                                                                  | 0.008                                                            | 195.9                         | 326.2               | 73.51                | 12.54                                 | 21.35                                 | 328                               |
| 17                                     | 0.137           | 1343.                                                                                  | 0.008                                                            | 208.4                         | 347.2               | 74.27                | 12.53                                 | 21.30                                 | 339                               |
| 18                                     | 0.145           | 1427.                                                                                  | 0.008                                                            | 221.0                         | 368.1               | 74.99                | 12.52                                 | 21.25                                 | 349                               |
| 19                                     | 0.153           | 1510.                                                                                  | 0.008                                                            | 233.5                         | 389.0               | 75.67                | 12.52                                 | 21.22                                 | 359                               |
| 20                                     | 0.162           | 1593.                                                                                  | 0.008                                                            | 246.0                         | 409.8               | 76.31                | 12.51                                 | 21.19                                 | 368                               |
| 21                                     | 0.170           | 1676.                                                                                  | 0.008                                                            | 258.5                         | 430.7               | 76.92                | 12.51                                 | 21.16                                 | 377                               |
| 22                                     | 0.178           | 1759.                                                                                  | 0.008                                                            | 271.0                         | 451.6               | 77.50                | 12.51                                 | 21.14                                 | 387                               |
| 23                                     | 0.186           | 1842.                                                                                  | 0.008                                                            | 283.5                         | 472.5               | 78.06                | 12.51                                 | 21.12                                 | 395                               |
| 24                                     | 0.195           | 1925.                                                                                  | 0.008                                                            | 296.0                         | 493.3               | 78.59                | 12.51                                 | 21.10                                 | 404                               |
| 25                                     | 0.203           | 2008.                                                                                  | 0.008                                                            | 308.5                         | 514.2               | 79.10                | 12.50                                 | 21.09                                 | 413                               |
| 26                                     | 0.211           | 2091.                                                                                  | 0.008                                                            | 321.0                         | 535.1               | 79.59                | 12.50                                 | 21.07                                 | 421                               |
| 27                                     | 0.219           | 2174.                                                                                  | 0.008                                                            | 333.5                         | 555.9               | 80.06                | 12.50                                 | 21.06                                 | 429                               |
| 28                                     | 0.228           | 2257.                                                                                  | 0.008                                                            | 346.0                         | 576.8               | 80.52                | 12.50                                 | 21.05                                 | 437                               |
| 29                                     | 0.236           | 2339.                                                                                  | 0.008                                                            | 358.5                         | 597.6               | 80.95                | 12.50                                 | 21.04                                 | 445                               |
| 30                                     | 0.244           | 2427.                                                                                  | 0.008                                                            | 371.0                         | 618.5               | 81.38                | 12.50                                 | 21.03                                 | 453                               |
| 31                                     | 0.252           | 2504.                                                                                  | 0.008                                                            | 383.5                         | 639.3               | 81.79                | 12.50                                 | 21.02                                 | 460                               |
| 32                                     | 0.261           | 2589.                                                                                  | 0.008                                                            | 396.0                         | 660.2               | 82.19                | 12.50                                 | 21.01                                 | 468                               |
| 33                                     | 0.269           | 2671.                                                                                  | 0.008                                                            | 408.5                         | 681.0               | 82.57                | 12.50                                 | 21.00                                 | 475                               |
| 34                                     | 0.277           | 2753.                                                                                  | 0.008                                                            | 421.0                         | 701.9               | 82.94                | 12.50                                 | 20.99                                 | 482                               |
| 35                                     | 0.285           | 2834.                                                                                  | 0.008                                                            | 433.5                         | 722.7               | 83.31                | 12.50                                 | 20.99                                 | 489                               |
| 36                                     | 0.294           | 2919.                                                                                  | 0.008                                                            | 446.0                         | 743.6               | 83.66                | 12.50                                 | 20.98                                 | 496                               |
| 37                                     | 0.302           | 3001.                                                                                  | 0.008                                                            | 458.5                         | 764.4               | 84.00                | 12.50                                 | 20.98                                 | 503                               |
| 38                                     | 0.310           | 3084.                                                                                  | 0.008                                                            | 471.0                         | 785.3               | 84.33                | 12.50                                 | 20.97                                 | 510                               |
| 39                                     | 0.318           | 3167.                                                                                  | 0.008                                                            | 483.5                         | 806.1               | 84.66                | 12.51                                 | 20.97                                 | 517                               |
| 40                                     | 0.327           | 3249.                                                                                  | 0.008                                                            | 496.1                         | 827.0               | 84.97                | 12.51                                 | 20.97                                 | 523                               |
| 42                                     | 0.343           | 3415.                                                                                  | 0.008                                                            | 521.1                         | 868.7               | 85.59                | 12.52                                 | 20.97                                 | 536                               |
| 44                                     | 0.360           | 3589.                                                                                  | 0.008                                                            | 546.2                         | 910.4               | 86.17                | 12.54                                 | 20.98                                 | 549                               |
| 46                                     | 0.376           | 3745.                                                                                  | 0.008                                                            | 571.3                         | 952.2               | 86.73                | 12.57                                 | 21.00                                 | 561                               |
| 48                                     | 0.392           | 3919.                                                                                  | 0.008                                                            | 596.4                         | 994.1               | 87.26                | 12.60                                 | 21.03                                 | 573                               |
| 50                                     | 0.409           | 4074.                                                                                  | 0.008                                                            | 621.7                         | 1036.0              | 87.78                | 12.65                                 | 21.07                                 | 584                               |
| 55                                     | 0.450           | 4489.                                                                                  | 0.008                                                            | 685.3                         | 1141.4              | 88.99                | 12.82                                 | 21.23                                 | 611                               |
| 60                                     | 0.491           | 4901.                                                                                  | 0.008                                                            | 750.0                         | 1247.8              | 90.12                | 13.09                                 | 21.50                                 | 636                               |
| 65                                     | 0.532           | 5314.                                                                                  | 0.008                                                            | 816.4                         | 1355.9              | 91.18                | 13.48                                 | 21.88                                 | 658                               |
| 70                                     | 0.574           | 5727.                                                                                  | 0.008                                                            | 885.1                         | 1466.2              | 92.20                | 13.99                                 | 22.37                                 | 679                               |
| 75                                     | 0.615           | 6139.                                                                                  | 0.008                                                            | 956.5                         | 1579.3              | 93.18                | 14.60                                 | 22.98                                 | 697                               |
| 80                                     | 0.656           | 6557.                                                                                  | 0.008                                                            | 1031.2                        | 1695.8              | 94.15                | 15.32                                 | 23.69                                 | 714                               |
| 85                                     | 0.697           | 6965.                                                                                  | 0.008                                                            | 1109.8                        | 1816.0              | 95.10                | 16.11                                 | 24.48                                 | 729                               |
| 90                                     | 0.738           | 7377.                                                                                  | 0.008                                                            | 1192.4                        | 1940.3              | 96.04                | 16.95                                 | 25.32                                 | 744                               |
| 95                                     | 0.779           | 7799.                                                                                  | 0.008                                                            | 1279.3                        | 2068.9              | 96.98                | 17.82                                 | 26.18                                 | 758                               |
| 100                                    | 0.820           | 8207.                                                                                  | 0.008                                                            | 1370.6                        | 2201.9              | 97.92                | 18.70                                 | 27.06                                 | 772                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMOODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0002 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 16.454                             | 0.259           | 1244.                                                                                  | 0.017                                                            | 197.7                         | 329.2               | 68.03                | 12.69                                 | 22.06                                 | 330                               |
| 17                                   | 0.269           | 1290.                                                                                  | 0.017                                                            | 204.6                         | 340.7               | 68.44                | 12.66                                 | 21.97                                 | 335                               |
| 18                                   | 0.285           | 1375.                                                                                  | 0.017                                                            | 217.3                         | 361.8               | 69.16                | 12.62                                 | 21.83                                 | 346                               |
| 19                                   | 0.302           | 1467.                                                                                  | 0.017                                                            | 229.9                         | 382.9               | 69.85                | 12.60                                 | 21.73                                 | 356                               |
| 20                                   | 0.319           | 1545.                                                                                  | 0.017                                                            | 242.5                         | 403.9               | 70.49                | 12.58                                 | 21.65                                 | 366                               |
| 21                                   | 0.335           | 1629.                                                                                  | 0.017                                                            | 255.1                         | 424.9               | 71.10                | 12.57                                 | 21.58                                 | 375                               |
| 22                                   | 0.352           | 1713.                                                                                  | 0.017                                                            | 267.6                         | 445.9               | 71.69                | 12.56                                 | 21.53                                 | 384                               |
| 23                                   | 0.368           | 1797.                                                                                  | 0.017                                                            | 280.2                         | 466.8               | 72.25                | 12.55                                 | 21.48                                 | 393                               |
| 24                                   | 0.385           | 1881.                                                                                  | 0.017                                                            | 292.7                         | 487.8               | 72.78                | 12.54                                 | 21.44                                 | 402                               |
| 25                                   | 0.402           | 1965.                                                                                  | 0.017                                                            | 305.3                         | 508.7               | 73.29                | 12.54                                 | 21.40                                 | 411                               |
| 26                                   | 0.418           | 2049.                                                                                  | 0.017                                                            | 317.8                         | 529.7               | 73.78                | 12.54                                 | 21.37                                 | 419                               |
| 27                                   | 0.435           | 2137.                                                                                  | 0.017                                                            | 330.3                         | 550.6               | 74.26                | 12.53                                 | 21.34                                 | 427                               |
| 28                                   | 0.451           | 2218.                                                                                  | 0.017                                                            | 342.9                         | 571.5               | 74.71                | 12.53                                 | 21.32                                 | 435                               |
| 29                                   | 0.468           | 2299.                                                                                  | 0.017                                                            | 355.4                         | 592.4               | 75.15                | 12.53                                 | 21.29                                 | 443                               |
| 30                                   | 0.484           | 2387.                                                                                  | 0.017                                                            | 367.9                         | 613.4               | 75.58                | 12.53                                 | 21.27                                 | 451                               |
| 31                                   | 0.501           | 2466.                                                                                  | 0.017                                                            | 380.5                         | 634.3               | 75.99                | 12.53                                 | 21.25                                 | 459                               |
| 32                                   | 0.518           | 2550.                                                                                  | 0.017                                                            | 393.0                         | 655.2               | 76.39                | 12.52                                 | 21.23                                 | 466                               |
| 33                                   | 0.534           | 2633.                                                                                  | 0.017                                                            | 405.5                         | 676.1               | 76.77                | 12.52                                 | 21.22                                 | 474                               |
| 34                                   | 0.551           | 2717.                                                                                  | 0.017                                                            | 418.0                         | 697.0               | 77.15                | 12.52                                 | 21.20                                 | 481                               |
| 35                                   | 0.567           | 2800.                                                                                  | 0.017                                                            | 430.5                         | 717.9               | 77.51                | 12.52                                 | 21.19                                 | 488                               |
| 36                                   | 0.584           | 2883.                                                                                  | 0.017                                                            | 443.1                         | 738.8               | 77.86                | 12.52                                 | 21.17                                 | 495                               |
| 37                                   | 0.600           | 2967.                                                                                  | 0.017                                                            | 455.6                         | 759.7               | 78.20                | 12.52                                 | 21.16                                 | 502                               |
| 38                                   | 0.617           | 3050.                                                                                  | 0.017                                                            | 468.1                         | 780.6               | 78.54                | 12.52                                 | 21.15                                 | 509                               |
| 39                                   | 0.633           | 3133.                                                                                  | 0.017                                                            | 480.6                         | 801.5               | 78.86                | 12.53                                 | 21.14                                 | 516                               |
| 40                                   | 0.650           | 3217.                                                                                  | 0.017                                                            | 493.2                         | 822.4               | 79.18                | 12.53                                 | 21.14                                 | 522                               |
| 42                                   | 0.683           | 3383.                                                                                  | 0.017                                                            | 518.2                         | 864.2               | 79.79                | 12.54                                 | 21.13                                 | 535                               |
| 44                                   | 0.716           | 3550.                                                                                  | 0.017                                                            | 543.3                         | 906.1               | 80.38                | 12.56                                 | 21.13                                 | 548                               |
| 46                                   | 0.749           | 3716.                                                                                  | 0.017                                                            | 568.5                         | 947.9               | 80.93                | 12.58                                 | 21.14                                 | 560                               |
| 48                                   | 0.782           | 3882.                                                                                  | 0.017                                                            | 593.7                         | 989.9               | 81.47                | 12.61                                 | 21.16                                 | 572                               |
| 50                                   | 0.815           | 4049.                                                                                  | 0.017                                                            | 618.9                         | 1031.9              | 81.99                | 12.66                                 | 21.20                                 | 584                               |
| 55                                   | 0.898           | 4464.                                                                                  | 0.017                                                            | 682.6                         | 1137.4              | 83.20                | 12.83                                 | 21.34                                 | 611                               |
| 60                                   | 0.980           | 4879.                                                                                  | 0.017                                                            | 747.4                         | 1244.1              | 84.33                | 13.10                                 | 21.59                                 | 636                               |
| 65                                   | 1.063           | 5295.                                                                                  | 0.017                                                            | 813.9                         | 1352.3              | 85.39                | 13.49                                 | 21.96                                 | 658                               |
| 70                                   | 1.145           | 5710.                                                                                  | 0.017                                                            | 882.5                         | 1462.8              | 86.41                | 13.99                                 | 22.45                                 | 679                               |
| 75                                   | 1.228           | 6125.                                                                                  | 0.017                                                            | 954.0                         | 1576.1              | 87.39                | 14.61                                 | 23.06                                 | 697                               |
| 80                                   | 1.310           | 6540.                                                                                  | 0.017                                                            | 1028.8                        | 1692.7              | 88.36                | 15.32                                 | 23.76                                 | 714                               |
| 85                                   | 1.393           | 6954.                                                                                  | 0.017                                                            | 1107.3                        | 1813.0              | 89.31                | 16.11                                 | 24.54                                 | 730                               |
| 90                                   | 1.475           | 7369.                                                                                  | 0.016                                                            | 1190.0                        | 1937.5              | 90.26                | 16.95                                 | 25.38                                 | 745                               |
| 95                                   | 1.558           | 7784.                                                                                  | 0.016                                                            | 1276.9                        | 2066.2              | 91.20                | 17.82                                 | 26.24                                 | 759                               |
| 100                                  | 1.640           | 8198.                                                                                  | 0.016                                                            | 1368.2                        | 2199.3              | 92.13                | 18.70                                 | 27.11                                 | 773                               |
| 0.0003 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 17.598                             | 0.410           | 1289.                                                                                  | 0.025                                                            | 208.4                         | 346.9               | 65.44                | 12.80                                 | 22.63                                 | 338                               |
| 18                                   | 0.420           | 1324.                                                                                  | 0.025                                                            | 213.5                         | 355.4               | 65.72                | 12.77                                 | 22.53                                 | 343                               |
| 19                                   | 0.445           | 1410.                                                                                  | 0.025                                                            | 226.2                         | 376.7               | 66.41                | 12.71                                 | 22.32                                 | 353                               |
| 20                                   | 0.471           | 1496.                                                                                  | 0.025                                                            | 238.9                         | 397.9               | 67.06                | 12.66                                 | 22.17                                 | 363                               |
| 21                                   | 0.496           | 1582.                                                                                  | 0.025                                                            | 251.6                         | 419.0               | 67.68                | 12.64                                 | 22.04                                 | 372                               |
| 22                                   | 0.521           | 1667.                                                                                  | 0.025                                                            | 264.2                         | 440.1               | 68.27                | 12.61                                 | 21.95                                 | 382                               |
| 23                                   | 0.546           | 1752.                                                                                  | 0.025                                                            | 276.8                         | 461.2               | 68.83                | 12.60                                 | 21.87                                 | 391                               |
| 24                                   | 0.571           | 1837.                                                                                  | 0.025                                                            | 289.4                         | 482.2               | 69.36                | 12.59                                 | 21.80                                 | 400                               |
| 25                                   | 0.596           | 1921.                                                                                  | 0.025                                                            | 302.0                         | 503.2               | 69.88                | 12.58                                 | 21.74                                 | 409                               |
| 26                                   | 0.621           | 2006.                                                                                  | 0.025                                                            | 314.5                         | 524.3               | 70.37                | 12.57                                 | 21.69                                 | 417                               |
| 27                                   | 0.646           | 2091.                                                                                  | 0.025                                                            | 327.1                         | 545.3               | 70.85                | 12.57                                 | 21.64                                 | 425                               |
| 28                                   | 0.671           | 2175.                                                                                  | 0.025                                                            | 339.7                         | 566.3               | 71.30                | 12.56                                 | 21.60                                 | 434                               |
| 29                                   | 0.696           | 2259.                                                                                  | 0.025                                                            | 352.2                         | 587.3               | 71.74                | 12.56                                 | 21.56                                 | 442                               |
| 30                                   | 0.721           | 2344.                                                                                  | 0.025                                                            | 364.8                         | 608.2               | 72.17                | 12.56                                 | 21.53                                 | 449                               |
| 31                                   | 0.746           | 2428.                                                                                  | 0.025                                                            | 377.4                         | 629.2               | 72.58                | 12.55                                 | 21.49                                 | 457                               |
| 32                                   | 0.771           | 2512.                                                                                  | 0.025                                                            | 389.9                         | 650.2               | 72.98                | 12.55                                 | 21.46                                 | 465                               |
| 33                                   | 0.796           | 2596.                                                                                  | 0.025                                                            | 402.5                         | 671.2               | 73.37                | 12.55                                 | 21.44                                 | 472                               |
| 34                                   | 0.821           | 2680.                                                                                  | 0.025                                                            | 415.0                         | 692.1               | 73.74                | 12.55                                 | 21.41                                 | 480                               |
| 35                                   | 0.845           | 2764.                                                                                  | 0.025                                                            | 427.6                         | 713.1               | 74.10                | 12.54                                 | 21.39                                 | 487                               |
| 36                                   | 0.870           | 2848.                                                                                  | 0.025                                                            | 440.1                         | 734.1               | 74.46                | 12.54                                 | 21.37                                 | 494                               |
| 37                                   | 0.895           | 2932.                                                                                  | 0.025                                                            | 452.6                         | 755.0               | 74.80                | 12.54                                 | 21.35                                 | 501                               |
| 38                                   | 0.920           | 3016.                                                                                  | 0.025                                                            | 465.2                         | 776.0               | 75.14                | 12.54                                 | 21.33                                 | 508                               |
| 39                                   | 0.945           | 3100.                                                                                  | 0.025                                                            | 477.7                         | 796.9               | 75.46                | 12.54                                 | 21.32                                 | 515                               |
| 40                                   | 0.970           | 3184.                                                                                  | 0.025                                                            | 490.3                         | 817.9               | 75.78                | 12.55                                 | 21.31                                 | 521                               |
| 42                                   | 1.020           | 3352.                                                                                  | 0.025                                                            | 515.4                         | 859.8               | 76.39                | 12.56                                 | 21.29                                 | 534                               |
| 44                                   | 1.069           | 3519.                                                                                  | 0.025                                                            | 540.5                         | 901.7               | 76.98                | 12.57                                 | 21.28                                 | 547                               |
| 46                                   | 1.119           | 3687.                                                                                  | 0.025                                                            | 565.7                         | 943.7               | 77.54                | 12.60                                 | 21.28                                 | 560                               |
| 48                                   | 1.169           | 3854.                                                                                  | 0.025                                                            | 590.9                         | 985.7               | 78.07                | 12.63                                 | 21.30                                 | 572                               |
| 50                                   | 1.219           | 4022.                                                                                  | 0.025                                                            | 616.2                         | 1027.8              | 78.59                | 12.67                                 | 21.32                                 | 583                               |
| 55                                   | 1.343           | 4440.                                                                                  | 0.025                                                            | 679.9                         | 1133.5              | 79.80                | 12.84                                 | 21.45                                 | 611                               |
| 60                                   | 1.467           | 4858.                                                                                  | 0.025                                                            | 744.8                         | 1240.3              | 80.93                | 13.11                                 | 21.69                                 | 636                               |
| 65                                   | 1.591           | 5275.                                                                                  | 0.025                                                            | 811.3                         | 1348.7              | 82.00                | 13.50                                 | 22.05                                 | 658                               |
| 70                                   | 1.715           | 5693.                                                                                  | 0.025                                                            | 880.0                         | 1459.4              | 83.01                | 14.00                                 | 22.53                                 | 679                               |
| 75                                   | 1.840           | 6110.                                                                                  | 0.025                                                            | 951.5                         | 1572.8              | 84.00                | 14.62                                 | 23.13                                 | 697                               |
| 80                                   | 1.964           | 6527.                                                                                  | 0.025                                                            | 1026.3                        | 1689.6              | 84.97                | 15.33                                 | 23.83                                 | 714                               |
| 85                                   | 2.088           | 6944.                                                                                  | 0.025                                                            | 1104.9                        | 1810.0              | 85.92                | 16.12                                 | 24.60                                 | 730                               |
| 90                                   | 2.212           | 7361.                                                                                  | 0.025                                                            | 1187.5                        | 1934.6              | 86.86                | 16.96                                 | 25.43                                 | 745                               |
| 95                                   | 2.336           | 7779.                                                                                  | 0.025                                                            | 1274.5                        | 2063.5              | 87.80                | 17.83                                 | 26.29                                 | 759                               |
| 100                                  | 2.460           | 8195.                                                                                  | 0.025                                                            | 1365.8                        | 2196.7              | 88.74                | 18.70                                 | 27.16                                 | 773                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUEO

| TEMPERATURE<br>DEG. KELVIN         | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0004 GM/CM <sup>3</sup> ISOCHORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 18.493                           | 0.567           | 1315.                                                                                  | 0.034                                                            | 216.0                         | 359.5               | 63.61                | 12.90                                 | 23.17                                 | 345                               |
| 19                                 | 0.584           | 1360.                                                                                  | 0.034                                                            | 222.5                         | 370.4               | 63.96                | 12.85                                 | 23.00                                 | 350                               |
| 20                                 | 0.618           | 1447.                                                                                  | 0.034                                                            | 235.3                         | 391.8               | 64.61                | 12.77                                 | 22.75                                 | 360                               |
| 21                                 | 0.652           | 1534.                                                                                  | 0.034                                                            | 248.0                         | 413.1               | 65.23                | 12.72                                 | 22.56                                 | 370                               |
| 22                                 | 0.685           | 1621.                                                                                  | 0.034                                                            | 260.7                         | 434.3               | 65.83                | 12.68                                 | 22.40                                 | 379                               |
| 23                                 | 0.719           | 1707.                                                                                  | 0.034                                                            | 273.4                         | 455.5               | 66.39                | 12.66                                 | 22.28                                 | 389                               |
| 24                                 | 0.752           | 1793.                                                                                  | 0.034                                                            | 286.1                         | 476.6               | 66.93                | 12.64                                 | 22.18                                 | 398                               |
| 25                                 | 0.786           | 1878.                                                                                  | 0.034                                                            | 298.7                         | 497.8               | 67.44                | 12.62                                 | 22.09                                 | 406                               |
| 26                                 | 0.819           | 1964.                                                                                  | 0.033                                                            | 311.3                         | 518.9               | 67.94                | 12.61                                 | 22.01                                 | 415                               |
| 27                                 | 0.853           | 2049.                                                                                  | 0.033                                                            | 323.9                         | 539.9               | 68.41                | 12.60                                 | 21.95                                 | 424                               |
| 28                                 | 0.886           | 2135.                                                                                  | 0.033                                                            | 336.5                         | 561.0               | 68.87                | 12.60                                 | 21.89                                 | 432                               |
| 29                                 | 0.920           | 2220.                                                                                  | 0.033                                                            | 349.1                         | 582.1               | 69.31                | 12.59                                 | 21.84                                 | 440                               |
| 30                                 | 0.953           | 2305.                                                                                  | 0.033                                                            | 361.7                         | 603.1               | 69.74                | 12.59                                 | 21.79                                 | 448                               |
| 31                                 | 0.987           | 2390.                                                                                  | 0.033                                                            | 374.3                         | 624.2               | 70.15                | 12.58                                 | 21.74                                 | 456                               |
| 32                                 | 1.020           | 2475.                                                                                  | 0.033                                                            | 386.8                         | 645.2               | 70.55                | 12.58                                 | 21.70                                 | 463                               |
| 33                                 | 1.053           | 2560.                                                                                  | 0.033                                                            | 399.4                         | 666.3               | 70.94                | 12.57                                 | 21.67                                 | 471                               |
| 34                                 | 1.087           | 2644.                                                                                  | 0.033                                                            | 412.0                         | 687.3               | 71.31                | 12.57                                 | 21.63                                 | 478                               |
| 35                                 | 1.120           | 2729.                                                                                  | 0.033                                                            | 424.6                         | 708.3               | 71.68                | 12.57                                 | 21.60                                 | 486                               |
| 36                                 | 1.153           | 2814.                                                                                  | 0.033                                                            | 437.1                         | 729.3               | 72.03                | 12.56                                 | 21.57                                 | 493                               |
| 37                                 | 1.187           | 2899.                                                                                  | 0.033                                                            | 449.7                         | 750.3               | 72.38                | 12.56                                 | 21.54                                 | 500                               |
| 38                                 | 1.220           | 2984.                                                                                  | 0.033                                                            | 462.3                         | 771.3               | 72.71                | 12.56                                 | 21.52                                 | 507                               |
| 39                                 | 1.253           | 3067.                                                                                  | 0.033                                                            | 474.8                         | 792.3               | 73.04                | 12.56                                 | 21.50                                 | 514                               |
| 40                                 | 1.287           | 3151.                                                                                  | 0.033                                                            | 487.4                         | 813.3               | 73.36                | 12.56                                 | 21.48                                 | 520                               |
| 42                                 | 1.353           | 3321.                                                                                  | 0.033                                                            | 512.5                         | 855.3               | 73.97                | 12.57                                 | 21.45                                 | 534                               |
| 44                                 | 1.420           | 3490.                                                                                  | 0.033                                                            | 537.7                         | 897.4               | 74.55                | 12.59                                 | 21.43                                 | 546                               |
| 46                                 | 1.486           | 3658.                                                                                  | 0.033                                                            | 562.9                         | 939.4               | 75.11                | 12.61                                 | 21.42                                 | 559                               |
| 48                                 | 1.553           | 3827.                                                                                  | 0.033                                                            | 588.1                         | 981.5               | 75.65                | 12.64                                 | 21.43                                 | 571                               |
| 50                                 | 1.620           | 3995.                                                                                  | 0.033                                                            | 613.5                         | 1023.7              | 76.17                | 12.69                                 | 21.45                                 | 583                               |
| 55                                 | 1.786           | 4416.                                                                                  | 0.033                                                            | 677.3                         | 1129.6              | 77.39                | 12.85                                 | 21.57                                 | 610                               |
| 60                                 | 1.952           | 4836.                                                                                  | 0.033                                                            | 742.2                         | 1236.6              | 78.51                | 13.12                                 | 21.79                                 | 635                               |
| 65                                 | 2.118           | 5256.                                                                                  | 0.033                                                            | 808.7                         | 1345.2              | 79.58                | 13.51                                 | 22.14                                 | 658                               |
| 70                                 | 2.284           | 5676.                                                                                  | 0.033                                                            | 877.4                         | 1456.0              | 80.60                | 14.01                                 | 22.62                                 | 679                               |
| 75                                 | 2.450           | 6096.                                                                                  | 0.033                                                            | 949.0                         | 1569.6              | 81.58                | 14.62                                 | 23.21                                 | 697                               |
| 80                                 | 2.616           | 6515.                                                                                  | 0.033                                                            | 1023.8                        | 1686.5              | 82.55                | 15.33                                 | 23.90                                 | 714                               |
| 85                                 | 2.782           | 6935.                                                                                  | 0.033                                                            | 1102.4                        | 1807.1              | 83.50                | 16.12                                 | 24.67                                 | 730                               |
| 90                                 | 2.948           | 7354.                                                                                  | 0.033                                                            | 1185.1                        | 1931.8              | 84.45                | 16.96                                 | 25.49                                 | 745                               |
| 95                                 | 3.114           | 7773.                                                                                  | 0.033                                                            | 1272.1                        | 2060.8              | 85.39                | 17.83                                 | 26.35                                 | 760                               |
| 100                                | 3.279           | 8192.                                                                                  | 0.033                                                            | 1363.5                        | 2194.2              | 86.33                | 18.71                                 | 27.21                                 | 774                               |
| 0.0005 GM/CM <sup>3</sup> ISOCHORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 19.243                           | 0.728           | 1331.                                                                                  | 0.043                                                            | 221.8                         | 369.4               | 62.20                | 12.99                                 | 23.68                                 | 349                               |
| 20                                 | 0.760           | 1399.                                                                                  | 0.043                                                            | 231.6                         | 385.7               | 62.70                | 12.90                                 | 23.40                                 | 357                               |
| 21                                 | 0.803           | 1487.                                                                                  | 0.042                                                            | 244.5                         | 407.1               | 63.32                | 12.82                                 | 23.12                                 | 367                               |
| 22                                 | 0.845           | 1575.                                                                                  | 0.042                                                            | 257.3                         | 428.5               | 63.92                | 12.76                                 | 22.90                                 | 377                               |
| 23                                 | 0.887           | 1662.                                                                                  | 0.042                                                            | 270.0                         | 449.8               | 64.49                | 12.72                                 | 22.72                                 | 386                               |
| 24                                 | 0.929           | 1749.                                                                                  | 0.042                                                            | 282.7                         | 471.1               | 65.03                | 12.69                                 | 22.58                                 | 396                               |
| 25                                 | 0.972           | 1836.                                                                                  | 0.042                                                            | 295.4                         | 492.3               | 65.54                | 12.67                                 | 22.46                                 | 404                               |
| 26                                 | 1.014           | 1927.                                                                                  | 0.042                                                            | 308.0                         | 513.5               | 66.04                | 12.65                                 | 22.36                                 | 413                               |
| 27                                 | 1.056           | 2000.                                                                                  | 0.042                                                            | 320.7                         | 534.6               | 66.52                | 12.64                                 | 22.27                                 | 422                               |
| 28                                 | 1.098           | 2094.                                                                                  | 0.042                                                            | 333.3                         | 555.8               | 66.98                | 12.63                                 | 22.19                                 | 430                               |
| 29                                 | 1.140           | 2180.                                                                                  | 0.042                                                            | 346.0                         | 576.9               | 67.42                | 12.62                                 | 22.12                                 | 438                               |
| 30                                 | 1.182           | 2266.                                                                                  | 0.042                                                            | 358.6                         | 598.1               | 67.85                | 12.62                                 | 22.06                                 | 446                               |
| 31                                 | 1.224           | 2352.                                                                                  | 0.042                                                            | 371.2                         | 619.2               | 68.26                | 12.61                                 | 22.00                                 | 454                               |
| 32                                 | 1.266           | 2438.                                                                                  | 0.042                                                            | 383.8                         | 640.3               | 68.66                | 12.60                                 | 21.95                                 | 462                               |
| 33                                 | 1.308           | 2523.                                                                                  | 0.042                                                            | 396.4                         | 661.4               | 69.05                | 12.60                                 | 21.90                                 | 469                               |
| 34                                 | 1.349           | 2609.                                                                                  | 0.042                                                            | 409.0                         | 682.4               | 69.43                | 12.59                                 | 21.85                                 | 477                               |
| 35                                 | 1.391           | 2694.                                                                                  | 0.042                                                            | 421.6                         | 703.5               | 69.79                | 12.59                                 | 21.81                                 | 484                               |
| 36                                 | 1.433           | 2779.                                                                                  | 0.042                                                            | 434.2                         | 724.6               | 70.14                | 12.59                                 | 21.77                                 | 492                               |
| 37                                 | 1.475           | 2864.                                                                                  | 0.042                                                            | 446.8                         | 745.6               | 70.49                | 12.58                                 | 21.74                                 | 499                               |
| 38                                 | 1.517           | 2950.                                                                                  | 0.042                                                            | 459.3                         | 766.7               | 70.83                | 12.58                                 | 21.71                                 | 506                               |
| 39                                 | 1.559           | 3035.                                                                                  | 0.042                                                            | 471.9                         | 787.8               | 71.15                | 12.58                                 | 21.68                                 | 513                               |
| 40                                 | 1.600           | 3120.                                                                                  | 0.042                                                            | 484.5                         | 808.8               | 71.47                | 12.58                                 | 21.65                                 | 519                               |
| 42                                 | 1.684           | 3290.                                                                                  | 0.042                                                            | 509.7                         | 850.9               | 72.08                | 12.59                                 | 21.61                                 | 533                               |
| 44                                 | 1.767           | 3460.                                                                                  | 0.042                                                            | 534.9                         | 893.0               | 72.67                | 12.60                                 | 21.58                                 | 546                               |
| 46                                 | 1.851           | 3630.                                                                                  | 0.042                                                            | 560.1                         | 935.2               | 73.23                | 12.62                                 | 21.57                                 | 558                               |
| 48                                 | 1.934           | 3799.                                                                                  | 0.042                                                            | 585.4                         | 977.4               | 73.77                | 12.66                                 | 21.56                                 | 570                               |
| 50                                 | 2.018           | 3969.                                                                                  | 0.042                                                            | 610.7                         | 1019.6              | 74.29                | 12.70                                 | 21.58                                 | 582                               |
| 55                                 | 2.226           | 4392.                                                                                  | 0.042                                                            | 674.6                         | 1125.7              | 75.50                | 12.86                                 | 21.68                                 | 610                               |
| 60                                 | 2.434           | 4815.                                                                                  | 0.042                                                            | 739.6                         | 1232.9              | 76.63                | 13.13                                 | 21.89                                 | 635                               |
| 65                                 | 2.643           | 5238.                                                                                  | 0.042                                                            | 806.1                         | 1341.7              | 77.70                | 13.52                                 | 22.23                                 | 658                               |
| 70                                 | 2.851           | 5660.                                                                                  | 0.042                                                            | 874.9                         | 1452.6              | 78.72                | 14.02                                 | 22.70                                 | 679                               |
| 75                                 | 3.059           | 6082.                                                                                  | 0.042                                                            | 946.5                         | 1566.3              | 79.71                | 14.63                                 | 23.28                                 | 697                               |
| 80                                 | 3.267           | 6504.                                                                                  | 0.042                                                            | 1021.4                        | 1683.4              | 80.67                | 15.34                                 | 23.96                                 | 715                               |
| 85                                 | 3.475           | 6925.                                                                                  | 0.042                                                            | 1100.0                        | 1804.2              | 81.63                | 16.13                                 | 24.73                                 | 731                               |
| 90                                 | 3.683           | 7347.                                                                                  | 0.042                                                            | 1182.7                        | 1929.0              | 82.57                | 16.97                                 | 25.55                                 | 746                               |
| 95                                 | 3.891           | 7768.                                                                                  | 0.042                                                            | 1269.7                        | 2058.2              | 83.51                | 17.84                                 | 26.40                                 | 760                               |
| 100                                | 4.098           | 8189.                                                                                  | 0.042                                                            | 1361.1                        | 2191.7              | 84.45                | 18.71                                 | 27.26                                 | 774                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN            | PRESSURE<br>ATM | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_P$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GPOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|---------------------------------------|-----------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.00075 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                     |                                                               |                               |                     |                      |                                                |                                                |                                   |
| * 20.725                              | 1.142           | 1343.                                                                               | 0.065                                                         | 231.8                         | 386.1               | 59.63                | 13.17                                          | 24.92                                          | 357                               |
| 21                                    | 1.160           | 1369.                                                                               | 0.065                                                         | 235.4                         | 392.1               | 59.81                | 13.13                                          | 24.77                                          | 360                               |
| 22                                    | 1.224           | 1460.                                                                               | 0.065                                                         | 248.5                         | 413.9               | 60.41                | 13.00                                          | 24.32                                          | 371                               |
| 23                                    | 1.289           | 1551.                                                                               | 0.064                                                         | 261.4                         | 435.5               | 60.99                | 12.91                                          | 23.98                                          | 381                               |
| 24                                    | 1.353           | 1640.                                                                               | 0.064                                                         | 274.3                         | 457.1               | 61.54                | 12.84                                          | 23.70                                          | 390                               |
| 25                                    | 1.417           | 1729.                                                                               | 0.064                                                         | 287.1                         | 478.6               | 62.06                | 12.80                                          | 23.48                                          | 399                               |
| 26                                    | 1.481           | 1818.                                                                               | 0.064                                                         | 299.9                         | 500.0               | 62.56                | 12.76                                          | 23.30                                          | 408                               |
| 27                                    | 1.545           | 1907.                                                                               | 0.064                                                         | 312.6                         | 521.4               | 63.04                | 12.74                                          | 23.14                                          | 417                               |
| 28                                    | 1.609           | 1995.                                                                               | 0.064                                                         | 325.4                         | 542.7               | 63.51                | 12.72                                          | 23.00                                          | 426                               |
| 29                                    | 1.673           | 2083.                                                                               | 0.064                                                         | 338.1                         | 564.1               | 63.95                | 12.71                                          | 22.88                                          | 434                               |
| 30                                    | 1.736           | 2171.                                                                               | 0.064                                                         | 350.8                         | 585.4               | 64.38                | 12.70                                          | 22.78                                          | 442                               |
| 31                                    | 1.800           | 2259.                                                                               | 0.064                                                         | 363.5                         | 606.6               | 64.80                | 12.68                                          | 22.68                                          | 450                               |
| 32                                    | 1.863           | 2346.                                                                               | 0.064                                                         | 376.2                         | 627.9               | 65.20                | 12.68                                          | 22.59                                          | 458                               |
| 33                                    | 1.927           | 2433.                                                                               | 0.063                                                         | 388.8                         | 649.2               | 65.59                | 12.67                                          | 22.51                                          | 466                               |
| 34                                    | 1.990           | 2520.                                                                               | 0.063                                                         | 401.5                         | 670.4               | 65.97                | 12.66                                          | 22.43                                          | 474                               |
| 35                                    | 2.054           | 2607.                                                                               | 0.063                                                         | 414.1                         | 691.6               | 66.34                | 12.65                                          | 22.36                                          | 481                               |
| 36                                    | 2.117           | 2694.                                                                               | 0.063                                                         | 426.8                         | 712.8               | 66.69                | 12.64                                          | 22.30                                          | 489                               |
| 37                                    | 2.181           | 2781.                                                                               | 0.063                                                         | 439.4                         | 734.0               | 67.04                | 12.64                                          | 22.24                                          | 496                               |
| 38                                    | 2.244           | 2868.                                                                               | 0.063                                                         | 452.1                         | 755.2               | 67.38                | 12.63                                          | 22.19                                          | 503                               |
| 39                                    | 2.307           | 2954.                                                                               | 0.063                                                         | 464.7                         | 776.4               | 67.70                | 12.63                                          | 22.15                                          | 510                               |
| 40                                    | 2.370           | 3041.                                                                               | 0.063                                                         | 477.3                         | 797.6               | 68.02                | 12.63                                          | 22.10                                          | 517                               |
| 42                                    | 2.497           | 3214.                                                                               | 0.063                                                         | 502.6                         | 839.9               | 68.64                | 12.63                                          | 22.03                                          | 531                               |
| 44                                    | 2.623           | 3387.                                                                               | 0.063                                                         | 527.8                         | 882.2               | 69.23                | 12.64                                          | 21.97                                          | 544                               |
| 46                                    | 2.749           | 3559.                                                                               | 0.063                                                         | 553.1                         | 924.6               | 69.79                | 12.66                                          | 21.93                                          | 557                               |
| 48                                    | 2.876           | 3732.                                                                               | 0.063                                                         | 578.5                         | 967.0               | 70.33                | 12.69                                          | 21.91                                          | 569                               |
| 50                                    | 3.002           | 3904.                                                                               | 0.063                                                         | 603.9                         | 1009.5              | 70.85                | 12.73                                          | 21.90                                          | 581                               |
| 55                                    | 3.317           | 4334.                                                                               | 0.063                                                         | 667.9                         | 1116.0              | 72.07                | 12.89                                          | 21.96                                          | 609                               |
| 60                                    | 3.632           | 4763.                                                                               | 0.063                                                         | 733.0                         | 1223.7              | 73.20                | 13.16                                          | 22.15                                          | 635                               |
| 65                                    | 3.946           | 5192.                                                                               | 0.063                                                         | 799.7                         | 1332.8              | 74.27                | 13.54                                          | 22.46                                          | 658                               |
| 70                                    | 4.261           | 5620.                                                                               | 0.063                                                         | 868.6                         | 1444.2              | 75.29                | 14.03                                          | 22.90                                          | 679                               |
| 75                                    | 4.575           | 6048.                                                                               | 0.063                                                         | 940.2                         | 1558.3              | 76.28                | 14.64                                          | 23.47                                          | 698                               |
| 80                                    | 4.889           | 6476.                                                                               | 0.063                                                         | 1015.2                        | 1675.7              | 77.24                | 15.35                                          | 24.14                                          | 715                               |
| 85                                    | 5.203           | 6903.                                                                               | 0.063                                                         | 1093.9                        | 1796.9              | 78.20                | 16.14                                          | 24.89                                          | 731                               |
| 90                                    | 5.517           | 7330.                                                                               | 0.063                                                         | 1176.7                        | 1922.1              | 79.14                | 16.98                                          | 25.70                                          | 747                               |
| 95                                    | 5.831           | 7757.                                                                               | 0.063                                                         | 1263.7                        | 2051.5              | 80.09                | 17.85                                          | 26.54                                          | 761                               |
| 100                                   | 6.145           | 8184.                                                                               | 0.063                                                         | 1355.2                        | 2185.4              | 81.02                | 18.72                                          | 27.39                                          | 776                               |
| 0.0010 GMOLE/CM <sup>3</sup> ISOCORE  |                 |                                                                                     |                                                               |                               |                     |                      |                                                |                                                |                                   |
| * 21.887                              | 1.566           | 1335.                                                                               | 0.088                                                         | 238.0                         | 396.7               | 57.81                | 13.32                                          | 26.13                                          | 363                               |
| 22                                    | 1.575           | 1346.                                                                               | 0.088                                                         | 239.5                         | 399.1               | 57.88                | 13.30                                          | 26.06                                          | 364                               |
| 23                                    | 1.663           | 1440.                                                                               | 0.087                                                         | 252.7                         | 421.2               | 58.47                | 13.13                                          | 25.46                                          | 375                               |
| 24                                    | 1.750           | 1533.                                                                               | 0.087                                                         | 265.8                         | 443.1               | 59.02                | 13.02                                          | 25.01                                          | 385                               |
| 25                                    | 1.836           | 1624.                                                                               | 0.087                                                         | 278.8                         | 464.9               | 59.55                | 12.95                                          | 24.64                                          | 394                               |
| 26                                    | 1.923           | 1716.                                                                               | 0.086                                                         | 291.7                         | 486.6               | 60.06                | 12.89                                          | 24.35                                          | 404                               |
| 27                                    | 2.009           | 1806.                                                                               | 0.086                                                         | 304.6                         | 508.2               | 60.55                | 12.85                                          | 24.10                                          | 413                               |
| 28                                    | 2.095           | 1897.                                                                               | 0.086                                                         | 317.4                         | 529.7               | 61.01                | 12.82                                          | 23.90                                          | 422                               |
| 29                                    | 2.181           | 1987.                                                                               | 0.086                                                         | 330.2                         | 551.2               | 61.46                | 12.80                                          | 23.71                                          | 430                               |
| 30                                    | 2.267           | 2077.                                                                               | 0.086                                                         | 343.0                         | 572.7               | 61.90                | 12.78                                          | 23.55                                          | 439                               |
| 31                                    | 2.353           | 2166.                                                                               | 0.086                                                         | 355.8                         | 594.2               | 62.31                | 12.76                                          | 23.41                                          | 447                               |
| 32                                    | 2.439           | 2255.                                                                               | 0.086                                                         | 368.5                         | 615.6               | 62.72                | 12.75                                          | 23.28                                          | 455                               |
| 33                                    | 2.524           | 2344.                                                                               | 0.085                                                         | 381.3                         | 637.0               | 63.11                | 12.74                                          | 23.16                                          | 463                               |
| 34                                    | 2.610           | 2433.                                                                               | 0.085                                                         | 394.0                         | 658.4               | 63.49                | 12.72                                          | 23.05                                          | 471                               |
| 35                                    | 2.695           | 2522.                                                                               | 0.085                                                         | 406.7                         | 679.8               | 63.86                | 12.71                                          | 22.95                                          | 478                               |
| 36                                    | 2.780           | 2610.                                                                               | 0.085                                                         | 419.4                         | 701.1               | 64.22                | 12.70                                          | 22.86                                          | 486                               |
| 37                                    | 2.865           | 2699.                                                                               | 0.085                                                         | 432.1                         | 722.5               | 64.57                | 12.69                                          | 22.77                                          | 493                               |
| 38                                    | 2.951           | 2787.                                                                               | 0.085                                                         | 444.8                         | 743.8               | 64.90                | 12.68                                          | 22.70                                          | 501                               |
| 39                                    | 3.036           | 2875.                                                                               | 0.085                                                         | 457.5                         | 765.1               | 65.23                | 12.67                                          | 22.63                                          | 508                               |
| 40                                    | 3.121           | 2963.                                                                               | 0.085                                                         | 470.2                         | 786.4               | 65.55                | 12.67                                          | 22.57                                          | 515                               |
| 42                                    | 3.291           | 3139.                                                                               | 0.085                                                         | 495.5                         | 829.0               | 66.17                | 12.67                                          | 22.46                                          | 529                               |
| 44                                    | 3.461           | 3315.                                                                               | 0.085                                                         | 520.9                         | 871.5               | 66.76                | 12.68                                          | 22.37                                          | 542                               |
| 46                                    | 3.631           | 3491.                                                                               | 0.085                                                         | 546.2                         | 914.1               | 67.33                | 12.69                                          | 22.31                                          | 555                               |
| 48                                    | 3.800           | 3666.                                                                               | 0.085                                                         | 571.6                         | 956.7               | 67.87                | 12.72                                          | 22.26                                          | 568                               |
| 50                                    | 3.970           | 3841.                                                                               | 0.085                                                         | 597.1                         | 999.4               | 68.39                | 12.76                                          | 22.23                                          | 580                               |
| 55                                    | 4.393           | 4277.                                                                               | 0.085                                                         | 661.3                         | 1106.4              | 69.61                | 12.92                                          | 22.25                                          | 609                               |
| 60                                    | 4.816           | 4713.                                                                               | 0.085                                                         | 726.5                         | 1214.5              | 70.75                | 13.18                                          | 22.40                                          | 634                               |
| 65                                    | 5.239           | 5148.                                                                               | 0.084                                                         | 793.3                         | 1324.1              | 71.81                | 13.56                                          | 22.69                                          | 658                               |
| 70                                    | 5.661           | 5582.                                                                               | 0.084                                                         | 862.3                         | 1435.9              | 72.84                | 14.05                                          | 23.11                                          | 679                               |
| 75                                    | 6.083           | 6016.                                                                               | 0.084                                                         | 934.0                         | 1550.4              | 73.83                | 14.66                                          | 23.65                                          | 698                               |
| 80                                    | 6.505           | 6449.                                                                               | 0.084                                                         | 1009.1                        | 1668.1              | 74.79                | 15.37                                          | 24.31                                          | 716                               |
| 85                                    | 6.926           | 6882.                                                                               | 0.084                                                         | 1087.8                        | 1789.6              | 75.75                | 16.15                                          | 25.05                                          | 732                               |
| 90                                    | 7.348           | 7315.                                                                               | 0.084                                                         | 1170.7                        | 1915.2              | 76.70                | 16.99                                          | 25.84                                          | 748                               |
| 95                                    | 7.769           | 7748.                                                                               | 0.084                                                         | 1257.8                        | 2045.0              | 77.64                | 17.86                                          | 26.68                                          | 763                               |
| 100                                   | 8.190           | 8180.                                                                               | 0.084                                                         | 1349.3                        | 2179.2              | 78.58                | 18.73                                          | 27.52                                          | 777                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GPOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0015 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 23.660                             | 2.416           | 1286.                                                                                 | 0.135                                                            | 244.1                         | 407.3               | 55.21                | 13.55                                 | 28.62                                 | 370                               |
| 24                                   | 2.463           | 1320.                                                                                 | 0.135                                                            | 248.7                         | 415.0               | 55.40                | 13.47                                 | 28.30                                 | 373                               |
| 25                                   | 2.597           | 1418.                                                                                 | 0.134                                                            | 262.0                         | 437.5               | 55.95                | 13.30                                 | 27.51                                 | 384                               |
| 26                                   | 2.730           | 1514.                                                                                 | 0.133                                                            | 275.3                         | 459.7               | 56.47                | 13.19                                 | 26.89                                 | 394                               |
| 27                                   | 2.863           | 1610.                                                                                 | 0.133                                                            | 288.4                         | 481.8               | 56.96                | 13.10                                 | 26.39                                 | 404                               |
| 28                                   | 2.996           | 1705.                                                                                 | 0.132                                                            | 301.5                         | 503.9               | 57.44                | 13.04                                 | 25.97                                 | 413                               |
| 29                                   | 3.128           | 1799.                                                                                 | 0.132                                                            | 314.5                         | 525.8               | 57.89                | 13.00                                 | 25.62                                 | 422                               |
| 30                                   | 3.259           | 1893.                                                                                 | 0.132                                                            | 327.5                         | 547.7               | 58.33                | 12.96                                 | 25.32                                 | 431                               |
| 31                                   | 3.391           | 1986.                                                                                 | 0.131                                                            | 340.5                         | 569.5               | 58.76                | 12.94                                 | 25.05                                 | 440                               |
| 32                                   | 3.522           | 2079.                                                                                 | 0.131                                                            | 353.4                         | 591.3               | 59.17                | 12.91                                 | 24.81                                 | 448                               |
| 33                                   | 3.653           | 2177.                                                                                 | 0.131                                                            | 366.3                         | 613.0               | 59.57                | 12.89                                 | 24.60                                 | 456                               |
| 34                                   | 3.784           | 2264.                                                                                 | 0.131                                                            | 379.2                         | 634.7               | 59.95                | 12.86                                 | 24.40                                 | 465                               |
| 35                                   | 3.914           | 2356.                                                                                 | 0.130                                                            | 392.0                         | 656.4               | 60.32                | 12.83                                 | 24.21                                 | 473                               |
| 36                                   | 4.044           | 2448.                                                                                 | 0.130                                                            | 404.8                         | 678.0               | 60.69                | 12.81                                 | 24.05                                 | 481                               |
| 37                                   | 4.175           | 2539.                                                                                 | 0.130                                                            | 417.6                         | 699.6               | 61.04                | 12.79                                 | 23.91                                 | 488                               |
| 38                                   | 4.305           | 2631.                                                                                 | 0.130                                                            | 430.4                         | 721.2               | 61.38                | 12.78                                 | 23.78                                 | 496                               |
| 39                                   | 4.435           | 2722.                                                                                 | 0.130                                                            | 443.2                         | 742.8               | 61.71                | 12.77                                 | 23.66                                 | 504                               |
| 40                                   | 4.565           | 2813.                                                                                 | 0.130                                                            | 456.0                         | 764.3               | 62.03                | 12.76                                 | 23.55                                 | 511                               |
| 42                                   | 4.824           | 2995.                                                                                 | 0.130                                                            | 481.5                         | 807.3               | 62.65                | 12.75                                 | 23.37                                 | 525                               |
| 44                                   | 5.083           | 3176.                                                                                 | 0.130                                                            | 507.0                         | 850.3               | 63.25                | 12.75                                 | 23.21                                 | 539                               |
| 46                                   | 5.342           | 3357.                                                                                 | 0.129                                                            | 532.5                         | 893.3               | 63.81                | 12.76                                 | 23.09                                 | 553                               |
| 48                                   | 5.601           | 3538.                                                                                 | 0.129                                                            | 558.0                         | 936.3               | 64.36                | 12.78                                 | 22.99                                 | 565                               |
| 50                                   | 5.859           | 3718.                                                                                 | 0.129                                                            | 583.6                         | 979.4               | 64.88                | 12.82                                 | 22.92                                 | 578                               |
| 55                                   | 6.504           | 416 <sup>a</sup> .                                                                    | 0.129                                                            | 648.1                         | 1087.4              | 66.11                | 12.97                                 | 22.85                                 | 607                               |
| 60                                   | 7.148           | 4617.                                                                                 | 0.129                                                            | 713.5                         | 1196.4              | 67.25                | 13.23                                 | 22.92                                 | 634                               |
| 65                                   | 7.791           | 5064.                                                                                 | 0.129                                                            | 780.5                         | 1306.9              | 68.32                | 13.60                                 | 23.15                                 | 658                               |
| 70                                   | 8.434           | 5511.                                                                                 | 0.128                                                            | 849.7                         | 1419.4              | 69.35                | 14.09                                 | 23.52                                 | 680                               |
| 75                                   | 9.076           | 5957.                                                                                 | 0.128                                                            | 921.6                         | 1534.7              | 70.34                | 14.69                                 | 24.03                                 | 700                               |
| 80                                   | 9.717           | 6407.                                                                                 | 0.128                                                            | 996.8                         | 1653.2              | 71.31                | 15.40                                 | 24.65                                 | 718                               |
| 85                                   | 10.358          | 6846.                                                                                 | 0.128                                                            | 1075.7                        | 1775.4              | 72.26                | 16.18                                 | 25.36                                 | 734                               |
| 90                                   | 10.999          | 7291.                                                                                 | 0.128                                                            | 1158.7                        | 1901.7              | 73.21                | 17.01                                 | 26.14                                 | 750                               |
| 95                                   | 11.639          | 7735.                                                                                 | 0.128                                                            | 1245.9                        | 2032.2              | 74.16                | 17.88                                 | 26.95                                 | 765                               |
| 100                                  | 12.280          | 817 <sup>a</sup> .                                                                    | 0.128                                                            | 1337.5                        | 2167.0              | 75.09                | 18.75                                 | 27.77                                 | 780                               |
| 0.0020 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 25.018                             | 3.258           | 121 <sup>a</sup> .                                                                    | 0.184                                                            | 245.4                         | 410.4               | 53.32                | 13.74                                 | 31.33                                 | 374                               |
| 26                                   | 3.438           | 131 <sup>a</sup> .                                                                    | 0.183                                                            | 258.8                         | 433.0               | 53.84                | 13.54                                 | 30.18                                 | 384                               |
| 27                                   | 3.620           | 141 <sup>a</sup> .                                                                    | 0.181                                                            | 272.2                         | 455.6               | 54.35                | 13.40                                 | 29.27                                 | 395                               |
| 28                                   | 3.801           | 151 <sup>a</sup> .                                                                    | 0.181                                                            | 285.6                         | 478.2               | 54.84                | 13.30                                 | 28.54                                 | 405                               |
| 29                                   | 3.981           | 1617.                                                                                 | 0.180                                                            | 298.8                         | 500.6               | 55.30                | 13.23                                 | 27.93                                 | 414                               |
| 30                                   | 4.161           | 171 <sup>a</sup> .                                                                    | 0.179                                                            | 312.0                         | 522.9               | 55.75                | 13.17                                 | 27.42                                 | 424                               |
| 31                                   | 4.340           | 1817.                                                                                 | 0.179                                                            | 325.2                         | 545.1               | 56.18                | 13.13                                 | 26.98                                 | 433                               |
| 32                                   | 4.519           | 1909.                                                                                 | 0.178                                                            | 338.3                         | 567.2               | 56.60                | 13.09                                 | 26.59                                 | 442                               |
| 33                                   | 4.697           | 2005.                                                                                 | 0.178                                                            | 351.4                         | 589.3               | 57.00                | 13.05                                 | 26.24                                 | 450                               |
| 34                                   | 4.875           | 2101.                                                                                 | 0.177                                                            | 364.4                         | 611.4               | 57.39                | 13.00                                 | 25.92                                 | 459                               |
| 35                                   | 5.052           | 2196.                                                                                 | 0.177                                                            | 377.4                         | 633.3               | 57.77                | 12.96                                 | 25.63                                 | 467                               |
| 36                                   | 5.229           | 2291.                                                                                 | 0.177                                                            | 390.3                         | 655.3               | 58.13                | 12.93                                 | 25.38                                 | 475                               |
| 37                                   | 5.406           | 2386.                                                                                 | 0.177                                                            | 403.3                         | 677.1               | 58.48                | 12.90                                 | 25.16                                 | 484                               |
| 38                                   | 5.582           | 2480.                                                                                 | 0.176                                                            | 416.1                         | 698.9               | 58.83                | 12.87                                 | 24.96                                 | 492                               |
| 39                                   | 5.759           | 2574.                                                                                 | 0.176                                                            | 429.0                         | 720.7               | 59.16                | 12.86                                 | 24.78                                 | 499                               |
| 40                                   | 5.935           | 2668.                                                                                 | 0.176                                                            | 441.9                         | 742.5               | 59.49                | 12.84                                 | 24.61                                 | 507                               |
| 42                                   | 6.287           | 2856.                                                                                 | 0.176                                                            | 467.5                         | 786.0               | 60.11                | 12.82                                 | 24.33                                 | 522                               |
| 44                                   | 6.638           | 3043.                                                                                 | 0.176                                                            | 493.2                         | 829.4               | 60.71                | 12.82                                 | 24.10                                 | 536                               |
| 46                                   | 6.989           | 3230.                                                                                 | 0.175                                                            | 518.8                         | 872.9               | 61.28                | 12.83                                 | 23.91                                 | 550                               |
| 48                                   | 7.339           | 3416.                                                                                 | 0.175                                                            | 544.5                         | 916.3               | 61.83                | 12.84                                 | 23.76                                 | 563                               |
| 50                                   | 7.689           | 3602.                                                                                 | 0.175                                                            | 570.2                         | 959.7               | 62.35                | 12.88                                 | 23.63                                 | 576                               |
| 55                                   | 8.563           | 4065.                                                                                 | 0.174                                                            | 634.9                         | 1068.7              | 63.59                | 13.02                                 | 23.46                                 | 607                               |
| 60                                   | 9.434           | 4527.                                                                                 | 0.174                                                            | 700.6                         | 1178.6              | 64.73                | 13.27                                 | 23.45                                 | 634                               |
| 65                                   | 10.304          | 4987.                                                                                 | 0.174                                                            | 767.9                         | 1289.9              | 65.80                | 13.64                                 | 23.62                                 | 659                               |
| 70                                   | 11.173          | 5446.                                                                                 | 0.174                                                            | 837.2                         | 1403.3              | 66.83                | 14.12                                 | 23.94                                 | 681                               |
| 75                                   | 12.041          | 5904.                                                                                 | 0.173                                                            | 909.3                         | 1519.3              | 67.83                | 14.72                                 | 24.41                                 | 701                               |
| 80                                   | 12.908          | 6361.                                                                                 | 0.173                                                            | 984.6                         | 1638.6              | 68.80                | 15.42                                 | 24.99                                 | 720                               |
| 85                                   | 13.774          | 6817.                                                                                 | 0.173                                                            | 1063.7                        | 1761.5              | 69.76                | 16.20                                 | 25.68                                 | 737                               |
| 90                                   | 14.640          | 7273.                                                                                 | 0.173                                                            | 1146.8                        | 1888.4              | 70.71                | 17.04                                 | 26.43                                 | 753                               |
| 95                                   | 15.505          | 7729.                                                                                 | 0.173                                                            | 1234.1                        | 2019.6              | 71.65                | 17.90                                 | 27.22                                 | 769                               |
| 100                                  | 16.370          | 8184.                                                                                 | 0.173                                                            | 1325.8                        | 2155.1              | 72.59                | 18.77                                 | 28.02                                 | 784                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN            | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CH <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|---------------------------------------|-----------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0025 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                        |                                                                   |                               |                     |                      |                                       |                                       |                                   |
| * 26.119                              | 4.077           | 1140.                                                                                  | 0.234                                                             | 243.8                         | 409.1               | 51.82                | 13.92                                 | 34.35                                 | 376                               |
| 27                                    | 4.283           | 1233.                                                                                  | 0.233                                                             | 256.0                         | 429.6               | 52.28                | 13.73                                 | 32.99                                 | 386                               |
| 28                                    | 4.515           | 1338.                                                                                  | 0.231                                                             | 269.7                         | 452.7               | 52.77                | 13.58                                 | 31.75                                 | 396                               |
| 29                                    | 4.746           | 1441.                                                                                  | 0.230                                                             | 283.2                         | 475.5               | 53.25                | 13.48                                 | 30.76                                 | 407                               |
| 30                                    | 4.975           | 1543.                                                                                  | 0.229                                                             | 296.6                         | 498.3               | 53.70                | 13.40                                 | 29.94                                 | 416                               |
| 31                                    | 5.204           | 1645.                                                                                  | 0.228                                                             | 310.0                         | 520.9               | 54.14                | 13.33                                 | 29.25                                 | 426                               |
| 32                                    | 5.432           | 1745.                                                                                  | 0.227                                                             | 323.3                         | 543.5               | 54.56                | 13.28                                 | 28.65                                 | 435                               |
| 33                                    | 5.659           | 1845.                                                                                  | 0.227                                                             | 336.6                         | 566.0               | 54.97                | 13.23                                 | 28.13                                 | 444                               |
| 34                                    | 5.885           | 1944.                                                                                  | 0.226                                                             | 349.8                         | 588.3               | 55.37                | 13.16                                 | 27.64                                 | 453                               |
| 35                                    | 6.111           | 2042.                                                                                  | 0.225                                                             | 362.9                         | 610.6               | 55.75                | 13.09                                 | 27.22                                 | 462                               |
| 36                                    | 6.336           | 2140.                                                                                  | 0.225                                                             | 376.0                         | 632.8               | 56.11                | 13.04                                 | 26.85                                 | 471                               |
| 37                                    | 6.561           | 2238.                                                                                  | 0.225                                                             | 389.0                         | 654.9               | 56.47                | 13.00                                 | 26.53                                 | 479                               |
| 38                                    | 6.786           | 2336.                                                                                  | 0.224                                                             | 402.0                         | 677.0               | 56.82                | 12.97                                 | 26.24                                 | 487                               |
| 39                                    | 7.010           | 2433.                                                                                  | 0.224                                                             | 414.9                         | 699.1               | 57.15                | 12.94                                 | 25.99                                 | 495                               |
| 40                                    | 7.234           | 2530.                                                                                  | 0.224                                                             | 427.9                         | 721.1               | 57.48                | 12.92                                 | 25.76                                 | 503                               |
| 42                                    | 7.681           | 2723.                                                                                  | 0.223                                                             | 453.7                         | 765.0               | 58.11                | 12.89                                 | 25.37                                 | 519                               |
| 44                                    | 8.127           | 2916.                                                                                  | 0.223                                                             | 479.5                         | 808.9               | 58.71                | 12.88                                 | 25.04                                 | 534                               |
| 46                                    | 8.573           | 3108.                                                                                  | 0.223                                                             | 505.2                         | 852.7               | 59.28                | 12.89                                 | 24.78                                 | 548                               |
| 48                                    | 9.018           | 3300.                                                                                  | 0.222                                                             | 531.0                         | 896.5               | 59.83                | 12.90                                 | 24.56                                 | 562                               |
| 50                                    | 9.462           | 3491.                                                                                  | 0.222                                                             | 556.9                         | 940.4               | 60.36                | 12.93                                 | 24.38                                 | 575                               |
| 55                                    | 10.571          | 3968.                                                                                  | 0.221                                                             | 621.8                         | 1050.3              | 61.60                | 13.07                                 | 24.09                                 | 606                               |
| 60                                    | 11.676          | 4443.                                                                                  | 0.221                                                             | 687.8                         | 1161.1              | 62.75                | 13.32                                 | 24.00                                 | 634                               |
| 65                                    | 12.779          | 4916.                                                                                  | 0.220                                                             | 755.3                         | 1273.2              | 63.83                | 13.68                                 | 24.09                                 | 660                               |
| 70                                    | 13.881          | 5387.                                                                                  | 0.220                                                             | 824.8                         | 1387.4              | 64.86                | 14.16                                 | 24.36                                 | 683                               |
| 75                                    | 14.981          | 5857.                                                                                  | 0.220                                                             | 897.0                         | 1504.2              | 65.85                | 14.75                                 | 24.79                                 | 703                               |
| 80                                    | 16.079          | 6327.                                                                                  | 0.220                                                             | 972.5                         | 1624.2              | 66.83                | 15.45                                 | 25.34                                 | 722                               |
| 85                                    | 17.177          | 6795.                                                                                  | 0.219                                                             | 1051.7                        | 1747.9              | 67.79                | 16.23                                 | 25.99                                 | 740                               |
| 90                                    | 18.274          | 7263.                                                                                  | 0.219                                                             | 1134.9                        | 1875.5              | 68.74                | 17.06                                 | 26.72                                 | 756                               |
| 95                                    | 19.369          | 7730.                                                                                  | 0.219                                                             | 1222.3                        | 2007.4              | 69.68                | 17.92                                 | 27.49                                 | 772                               |
| 100                                   | 20.465          | 8197.                                                                                  | 0.219                                                             | 1314.1                        | 2143.6              | 70.62                | 18.79                                 | 28.27                                 | 787                               |
| 0.0030 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                        |                                                                   |                               |                     |                      |                                       |                                       |                                   |
| * 27.041                              | 4.866           | 1059.                                                                                  | 0.287                                                             | 240.3                         | 404.6               | 50.55                | 14.10                                 | 37.80                                 | 377                               |
| 28                                    | 5.140           | 1163.                                                                                  | 0.285                                                             | 253.7                         | 427.3               | 51.04                | 13.90                                 | 35.86                                 | 388                               |
| 29                                    | 5.424           | 1271.                                                                                  | 0.283                                                             | 267.6                         | 450.7               | 51.53                | 13.75                                 | 34.28                                 | 399                               |
| 30                                    | 5.706           | 1378.                                                                                  | 0.281                                                             | 281.3                         | 474.0               | 51.99                | 13.64                                 | 33.01                                 | 409                               |
| 31                                    | 5.986           | 1487.                                                                                  | 0.280                                                             | 294.9                         | 497.0               | 52.44                | 13.56                                 | 31.96                                 | 419                               |
| 32                                    | 6.265           | 1587.                                                                                  | 0.278                                                             | 308.4                         | 520.0               | 52.87                | 13.48                                 | 31.07                                 | 429                               |
| 33                                    | 6.543           | 1691.                                                                                  | 0.277                                                             | 321.9                         | 542.9               | 53.28                | 13.42                                 | 30.30                                 | 438                               |
| 34                                    | 6.819           | 1793.                                                                                  | 0.276                                                             | 335.3                         | 565.6               | 53.68                | 13.32                                 | 29.60                                 | 448                               |
| 35                                    | 7.095           | 1895.                                                                                  | 0.275                                                             | 348.5                         | 588.2               | 54.07                | 13.23                                 | 29.00                                 | 457                               |
| 36                                    | 7.370           | 1996.                                                                                  | 0.275                                                             | 361.7                         | 610.7               | 54.44                | 13.16                                 | 28.49                                 | 466                               |
| 37                                    | 7.645           | 2097.                                                                                  | 0.274                                                             | 374.9                         | 633.1               | 54.80                | 13.11                                 | 28.04                                 | 475                               |
| 38                                    | 7.919           | 2197.                                                                                  | 0.274                                                             | 388.0                         | 655.4               | 55.15                | 13.06                                 | 27.65                                 | 483                               |
| 39                                    | 8.192           | 2297.                                                                                  | 0.273                                                             | 401.0                         | 677.7               | 55.49                | 13.03                                 | 27.30                                 | 492                               |
| 40                                    | 8.465           | 2397.                                                                                  | 0.273                                                             | 414.0                         | 699.9               | 55.81                | 13.00                                 | 26.99                                 | 500                               |
| 42                                    | 9.011           | 2596.                                                                                  | 0.272                                                             | 440.0                         | 744.3               | 56.45                | 12.96                                 | 26.47                                 | 516                               |
| 44                                    | 9.555           | 2795.                                                                                  | 0.272                                                             | 465.9                         | 788.6               | 57.05                | 12.95                                 | 26.04                                 | 532                               |
| 46                                    | 10.098          | 2992.                                                                                  | 0.271                                                             | 491.8                         | 832.8               | 57.63                | 12.94                                 | 25.68                                 | 546                               |
| 48                                    | 10.640          | 3190.                                                                                  | 0.271                                                             | 517.7                         | 877.0               | 58.18                | 12.96                                 | 25.39                                 | 561                               |
| 50                                    | 11.181          | 3387.                                                                                  | 0.271                                                             | 543.6                         | 921.3               | 58.71                | 12.99                                 | 25.15                                 | 574                               |
| 55                                    | 12.532          | 3878.                                                                                  | 0.270                                                             | 608.8                         | 1032.1              | 59.95                | 13.12                                 | 24.74                                 | 606                               |
| 60                                    | 13.878          | 4365.                                                                                  | 0.269                                                             | 675.1                         | 1143.8              | 61.10                | 13.36                                 | 24.55                                 | 635                               |
| 65                                    | 15.221          | 4851.                                                                                  | 0.268                                                             | 742.7                         | 1256.8              | 62.19                | 13.71                                 | 24.57                                 | 661                               |
| 70                                    | 16.561          | 5335.                                                                                  | 0.268                                                             | 812.5                         | 1371.8              | 63.22                | 14.19                                 | 24.79                                 | 684                               |
| 75                                    | 17.899          | 5818.                                                                                  | 0.267                                                             | 884.9                         | 1489.4              | 64.22                | 14.78                                 | 25.17                                 | 705                               |
| 80                                    | 19.236          | 6299.                                                                                  | 0.267                                                             | 960.5                         | 1610.2              | 65.19                | 15.48                                 | 25.68                                 | 725                               |
| 85                                    | 20.570          | 6780.                                                                                  | 0.267                                                             | 1039.8                        | 1734.5              | 66.15                | 16.25                                 | 26.30                                 | 743                               |
| 90                                    | 21.904          | 7260.                                                                                  | 0.267                                                             | 1123.1                        | 1862.9              | 67.11                | 17.08                                 | 27.00                                 | 759                               |
| 95                                    | 23.237          | 7739.                                                                                  | 0.266                                                             | 1210.7                        | 1995.5              | 68.05                | 17.94                                 | 27.75                                 | 776                               |
| 100                                   | 24.568          | 8218.                                                                                  | 0.266                                                             | 1302.5                        | 2132.3              | 69.00                | 18.81                                 | 28.52                                 | 791                               |
| 0.0035 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                        |                                                                   |                               |                     |                      |                                       |                                       |                                   |
| * 27.828                              | 5.619           | 973.9                                                                                  | 0.341                                                             | 235.3                         | 398.0               | 49.45                | 14.30                                 | 41.77                                 | 378                               |
| 28                                    | 5.679           | 993.6                                                                                  | 0.340                                                             | 237.8                         | 402.2               | 49.54                | 14.25                                 | 41.27                                 | 380                               |
| 29                                    | 6.018           | 1107.                                                                                  | 0.338                                                             | 252.0                         | 426.2               | 50.04                | 14.06                                 | 38.75                                 | 392                               |
| 30                                    | 6.354           | 1219.                                                                                  | 0.335                                                             | 265.9                         | 449.9               | 50.51                | 13.91                                 | 36.79                                 | 402                               |
| 31                                    | 6.688           | 1327.                                                                                  | 0.333                                                             | 279.8                         | 473.4               | 50.97                | 13.80                                 | 35.22                                 | 413                               |
| 32                                    | 7.020           | 1436.                                                                                  | 0.331                                                             | 293.5                         | 496.8               | 51.40                | 13.70                                 | 33.93                                 | 423                               |
| 33                                    | 7.351           | 1543.                                                                                  | 0.329                                                             | 307.3                         | 520.1               | 51.83                | 13.63                                 | 32.82                                 | 432                               |
| 34                                    | 7.680           | 1648.                                                                                  | 0.328                                                             | 320.8                         | 543.2               | 52.23                | 13.49                                 | 31.84                                 | 442                               |
| 35                                    | 8.007           | 1753.                                                                                  | 0.327                                                             | 334.3                         | 566.1               | 52.62                | 13.38                                 | 31.02                                 | 452                               |
| 36                                    | 8.333           | 1858.                                                                                  | 0.326                                                             | 347.6                         | 588.9               | 53.00                | 13.29                                 | 30.32                                 | 462                               |
| 37                                    | 8.659           | 1961.                                                                                  | 0.325                                                             | 360.9                         | 611.5               | 53.36                | 13.22                                 | 29.72                                 | 471                               |
| 38                                    | 8.984           | 2065.                                                                                  | 0.325                                                             | 374.0                         | 634.1               | 53.71                | 13.16                                 | 29.19                                 | 480                               |
| 39                                    | 9.308           | 2169.                                                                                  | 0.324                                                             | 387.2                         | 656.6               | 54.05                | 13.11                                 | 28.73                                 | 489                               |
| 40                                    | 9.632           | 2270.                                                                                  | 0.324                                                             | 400.3                         | 679.1               | 54.38                | 13.08                                 | 28.33                                 | 497                               |
| 42                                    | 10.278          | 2475.                                                                                  | 0.323                                                             | 426.4                         | 723.9               | 55.02                | 13.03                                 | 27.64                                 | 514                               |
| 44                                    | 10.923          | 2679.                                                                                  | 0.322                                                             | 452.4                         | 768.6               | 55.62                | 13.00                                 | 27.09                                 | 530                               |
| 46                                    | 11.566          | 2883.                                                                                  | 0.321                                                             | 478.4                         | 813.2               | 56.20                | 13.00                                 | 26.63                                 | 545                               |
| 48                                    | 12.209          | 3086.                                                                                  | 0.321                                                             | 504.4                         | 857.8               | 56.76                | 13.01                                 | 26.26                                 | 560                               |
| 50                                    | 12.850          | 3289.                                                                                  | 0.320                                                             | 530.5                         | 902.5               | 57.29                | 13.04                                 | 25.95                                 | 574                               |
| 55                                    | 14.449          | 3793.                                                                                  | 0.319                                                             | 555.9                         | 1014.2              | 58.54                | 13.17                                 | 25.40                                 | 606                               |
| 60                                    | 16.042          | 4293.                                                                                  | 0.318                                                             | 662.4                         | 1126.9              | 59.69                | 13.40                                 | 25.11                                 | 636                               |
| 65                                    | 17.631          | 4792.                                                                                  | 0.317                                                             | 730.3                         | 1240.7              | 60.78                | 13.75                                 | 25.06                                 | 662                               |
| 70                                    | 19.217          | 5289.                                                                                  | 0.317                                                             | 800.2                         | 1356.5              | 61.81                | 14.23                                 | 25.21                                 | 686                               |
| 75                                    | 20.800          | 5785.                                                                                  | 0.316                                                             | 872.7                         | 1474.9              | 62.82                | 14.81                                 | 25.54                                 | 708                               |
| 80                                    | 22.380          | 6279.                                                                                  | 0.316                                                             | 948.5                         | 1596.4              | 63.79                | 15.51                                 | 26.02                                 | 728                               |
| 85                                    | 23.958          | 6773.                                                                                  | 0.315                                                             | 1027.9                        | 1721.5              | 64.76                | 16.28                                 | 26.61                                 | 746                               |
| 90                                    | 25.535          | 7264.                                                                                  | 0.315                                                             | 1111.4                        | 1850.6              | 65.71                | 17.10                                 | 27.28                                 | 763                               |
| 95                                    | 27.110          | 7756.                                                                                  | 0.315                                                             | 1199.0                        | 1983.9              | 66.66                | 17.96                                 | 28.01                                 | 780                               |
| 100                                   | 28.684          | 8247.                                                                                  | 0.315                                                             | 1291.0                        | 2121.4              | 67.60                | 18.82                                 | 28.76                                 | 796                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0040 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 28.509                             | 6.334           | 89 <sup>o</sup> .4                                                                     | 0.397                                                            | 229.3                         | 389.7               | 48.47                | 14.50                                 | 46.41                                 | 378                               |
| 29                                   | 6.531           | 948.2                                                                                  | 0.395                                                            | 236.4                         | 401.8               | 48.72                | 14.38                                 | 44.57                                 | 384                               |
| 30                                   | 6.924           | 1064.                                                                                  | 0.391                                                            | 250.7                         | 426.1               | 49.20                | 14.20                                 | 41.55                                 | 396                               |
| 31                                   | 7.314           | 1178.                                                                                  | 0.388                                                            | 264.8                         | 450.1               | 49.67                | 14.06                                 | 39.21                                 | 406                               |
| 32                                   | 7.701           | 1290.                                                                                  | 0.386                                                            | 278.8                         | 473.9               | 50.11                | 13.94                                 | 37.33                                 | 417                               |
| 33                                   | 8.087           | 1401.                                                                                  | 0.383                                                            | 292.8                         | 497.6               | 50.54                | 13.84                                 | 35.77                                 | 427                               |
| 34                                   | 8.469           | 1510.                                                                                  | 0.381                                                            | 306.5                         | 521.1               | 50.95                | 13.67                                 | 34.42                                 | 437                               |
| 35                                   | 8.850           | 1618.                                                                                  | 0.380                                                            | 320.1                         | 544.3               | 51.35                | 13.53                                 | 33.30                                 | 447                               |
| 36                                   | 9.229           | 1725.                                                                                  | 0.379                                                            | 333.6                         | 567.4               | 51.72                | 13.41                                 | 32.36                                 | 457                               |
| 37                                   | 9.607           | 1832.                                                                                  | 0.378                                                            | 347.0                         | 590.3               | 52.09                | 13.32                                 | 31.57                                 | 467                               |
| 38                                   | 9.984           | 1938.                                                                                  | 0.377                                                            | 360.3                         | 613.2               | 52.45                | 13.25                                 | 30.88                                 | 476                               |
| 39                                   | 10.361          | 2044.                                                                                  | 0.376                                                            | 373.5                         | 635.9               | 52.79                | 13.20                                 | 30.29                                 | 486                               |
| 40                                   | 10.737          | 2150.                                                                                  | 0.376                                                            | 386.6                         | 658.6               | 53.12                | 13.15                                 | 29.77                                 | 495                               |
| 42                                   | 11.487          | 2360.                                                                                  | 0.374                                                            | 412.9                         | 703.9               | 53.76                | 13.09                                 | 28.90                                 | 512                               |
| 44                                   | 12.235          | 2570.                                                                                  | 0.374                                                            | 439.0                         | 749.0               | 54.37                | 13.06                                 | 28.20                                 | 528                               |
| 46                                   | 12.981          | 2779.                                                                                  | 0.373                                                            | 465.1                         | 794.0               | 54.95                | 13.05                                 | 27.63                                 | 544                               |
| 48                                   | 13.727          | 298 <sup>o</sup> .                                                                     | 0.372                                                            | 491.2                         | 839.0               | 55.51                | 13.06                                 | 27.16                                 | 559                               |
| 50                                   | 14.471          | 3196.                                                                                  | 0.372                                                            | 517.4                         | 883.9               | 56.04                | 13.08                                 | 26.77                                 | 573                               |
| 55                                   | 16.326          | 3714.                                                                                  | 0.370                                                            | 583.1                         | 996.6               | 57.29                | 13.22                                 | 26.08                                 | 607                               |
| 60                                   | 18.172          | 422 <sup>o</sup> .                                                                     | 0.369                                                            | 649.9                         | 1110.2              | 58.45                | 13.44                                 | 25.67                                 | 637                               |
| 65                                   | 20.014          | 4740.                                                                                  | 0.368                                                            | 717.9                         | 1224.9              | 59.54                | 13.79                                 | 25.54                                 | 664                               |
| 70                                   | 21.851          | 5250.                                                                                  | 0.367                                                            | 788.0                         | 1341.5              | 60.58                | 14.26                                 | 25.64                                 | 689                               |
| 75                                   | 23.685          | 5758.                                                                                  | 0.366                                                            | 860.7                         | 1460.6              | 61.58                | 14.84                                 | 25.92                                 | 711                               |
| 80                                   | 25.516          | 626 <sup>o</sup> .                                                                     | 0.366                                                            | 936.6                         | 1582.9              | 62.56                | 15.53                                 | 26.35                                 | 731                               |
| 85                                   | 27.344          | 6771.                                                                                  | 0.365                                                            | 1016.1                        | 1708.8              | 63.53                | 16.30                                 | 26.91                                 | 750                               |
| 90                                   | 29.170          | 7276.                                                                                  | 0.365                                                            | 1099.7                        | 1838.6              | 64.48                | 17.12                                 | 27.56                                 | 767                               |
| 95                                   | 30.994          | 777 <sup>o</sup> .                                                                     | 0.365                                                            | 1187.4                        | 1972.5              | 65.43                | 17.98                                 | 28.26                                 | 784                               |
| 100                                  | 32.816          | 8287.                                                                                  | 0.364                                                            | 1279.5                        | 2110.8              | 66.38                | 18.84                                 | 28.99                                 | 800                               |
| 0.0045 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 29.103                             | 7.007           | 80 <sup>o</sup> .0                                                                     | 0.454                                                            | 222.3                         | 380.1               | 47.58                | 14.71                                 | 51.86                                 | 378                               |
| 30                                   | 7.419           | 916.1                                                                                  | 0.450                                                            | 235.4                         | 402.5               | 48.02                | 14.51                                 | 47.68                                 | 389                               |
| 31                                   | 7.867           | 1034.                                                                                  | 0.446                                                            | 249.8                         | 427.0               | 48.49                | 14.33                                 | 44.16                                 | 400                               |
| 32                                   | 8.311           | 115 <sup>o</sup> .                                                                     | 0.443                                                            | 264.1                         | 451.2               | 48.95                | 14.19                                 | 41.44                                 | 411                               |
| 33                                   | 8.753           | 126 <sup>o</sup> .                                                                     | 0.439                                                            | 278.4                         | 475.5               | 49.39                | 14.07                                 | 39.24                                 | 421                               |
| 34                                   | 9.191           | 137 <sup>o</sup> .                                                                     | 0.437                                                            | 292.3                         | 499.3               | 49.80                | 13.85                                 | 37.39                                 | 432                               |
| 35                                   | 9.626           | 148 <sup>o</sup> .                                                                     | 0.435                                                            | 306.1                         | 522.9               | 50.20                | 13.68                                 | 35.89                                 | 443                               |
| 36                                   | 10.060          | 159 <sup>o</sup> .                                                                     | 0.433                                                            | 319.7                         | 546.2               | 50.59                | 13.54                                 | 34.65                                 | 454                               |
| 37                                   | 10.492          | 170 <sup>o</sup> .                                                                     | 0.432                                                            | 333.2                         | 569.4               | 50.96                | 13.43                                 | 33.62                                 | 464                               |
| 38                                   | 10.923          | 181 <sup>o</sup> .                                                                     | 0.431                                                            | 346.6                         | 592.5               | 51.31                | 13.34                                 | 32.73                                 | 473                               |
| 39                                   | 11.353          | 1927.                                                                                  | 0.430                                                            | 359.9                         | 615.5               | 51.66                | 13.28                                 | 31.98                                 | 483                               |
| 40                                   | 11.783          | 2035.                                                                                  | 0.429                                                            | 373.1                         | 638.4               | 51.99                | 13.22                                 | 31.32                                 | 492                               |
| 42                                   | 12.639          | 2251.                                                                                  | 0.428                                                            | 399.5                         | 684.1               | 52.64                | 13.15                                 | 30.23                                 | 510                               |
| 44                                   | 13.494          | 2466.                                                                                  | 0.427                                                            | 425.8                         | 729.6               | 53.25                | 13.11                                 | 29.36                                 | 527                               |
| 46                                   | 14.346          | 2681.                                                                                  | 0.426                                                            | 452.0                         | 775.0               | 53.83                | 13.10                                 | 28.67                                 | 543                               |
| 48                                   | 15.197          | 289 <sup>o</sup> .                                                                     | 0.425                                                            | 478.4                         | 820.4               | 54.39                | 13.10                                 | 28.09                                 | 559                               |
| 50                                   | 16.047          | 3109.                                                                                  | 0.424                                                            | 504.4                         | 865.7               | 54.92                | 13.13                                 | 27.62                                 | 573                               |
| 55                                   | 18.164          | 364 <sup>o</sup> .                                                                     | 0.423                                                            | 570.3                         | 979.3               | 56.18                | 13.26                                 | 26.76                                 | 608                               |
| 60                                   | 20.271          | 416 <sup>o</sup> .                                                                     | 0.421                                                            | 637.4                         | 1093.8              | 57.35                | 13.48                                 | 26.24                                 | 639                               |
| 65                                   | 22.372          | 4694.                                                                                  | 0.420                                                            | 705.6                         | 1209.3              | 58.44                | 13.82                                 | 26.03                                 | 666                               |
| 70                                   | 24.468          | 5217.                                                                                  | 0.419                                                            | 775.8                         | 1326.8              | 59.48                | 14.29                                 | 26.06                                 | 691                               |
| 75                                   | 26.559          | 573 <sup>o</sup> .                                                                     | 0.418                                                            | 848.7                         | 1446.7              | 60.48                | 14.87                                 | 26.29                                 | 714                               |
| 80                                   | 28.646          | 625 <sup>o</sup> .                                                                     | 0.417                                                            | 924.7                         | 1569.7              | 61.47                | 15.56                                 | 26.69                                 | 735                               |
| 85                                   | 30.730          | 6777.                                                                                  | 0.417                                                            | 1004.4                        | 1696.3              | 62.43                | 16.32                                 | 27.21                                 | 754                               |
| 90                                   | 32.812          | 7294.                                                                                  | 0.416                                                            | 1088.1                        | 1826.9              | 63.39                | 17.15                                 | 27.83                                 | 771                               |
| 95                                   | 34.891          | 781 <sup>o</sup> .                                                                     | 0.416                                                            | 1175.9                        | 1961.5              | 64.34                | 18.00                                 | 28.51                                 | 789                               |
| 100                                  | 36.968          | 832 <sup>o</sup> .                                                                     | 0.415                                                            | 1268.1                        | 2100.5              | 65.28                | 18.86                                 | 29.22                                 | 805                               |
| 0.0050 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 29.626                             | 7.640           | 727.6                                                                                  | 0.513                                                            | 214.7                         | 369.5               | 46.76                | 14.93                                 | 58.35                                 | 378                               |
| 30                                   | 7.842           | 774.2                                                                                  | 0.511                                                            | 220.2                         | 379.1               | 46.94                | 14.84                                 | 55.81                                 | 383                               |
| 31                                   | 8.350           | 896.9                                                                                  | 0.506                                                            | 235.0                         | 404.2               | 47.43                | 14.63                                 | 50.44                                 | 394                               |
| 32                                   | 8.853           | 1017.                                                                                  | 0.501                                                            | 249.5                         | 428.9               | 47.89                | 14.45                                 | 46.47                                 | 405                               |
| 33                                   | 9.353           | 1135.                                                                                  | 0.497                                                            | 264.1                         | 453.6               | 48.34                | 14.32                                 | 43.36                                 | 416                               |
| 34                                   | 9.848           | 1251.                                                                                  | 0.493                                                            | 278.3                         | 477.8               | 48.76                | 14.05                                 | 40.85                                 | 428                               |
| 35                                   | 10.340          | 1366.                                                                                  | 0.491                                                            | 292.2                         | 501.7               | 49.16                | 13.84                                 | 38.85                                 | 439                               |
| 36                                   | 10.829          | 1479.                                                                                  | 0.489                                                            | 305.9                         | 525.4               | 49.55                | 13.67                                 | 37.23                                 | 450                               |
| 37                                   | 11.317          | 1592.                                                                                  | 0.487                                                            | 319.6                         | 548.9               | 49.92                | 13.54                                 | 35.89                                 | 460                               |
| 38                                   | 11.803          | 1704.                                                                                  | 0.486                                                            | 333.0                         | 572.2               | 50.28                | 13.44                                 | 34.76                                 | 471                               |
| 39                                   | 12.289          | 181 <sup>o</sup> .                                                                     | 0.485                                                            | 346.4                         | 595.5               | 50.63                | 13.36                                 | 33.81                                 | 481                               |
| 40                                   | 12.773          | 1924.                                                                                  | 0.484                                                            | 359.8                         | 618.6               | 50.97                | 13.29                                 | 32.98                                 | 490                               |
| 42                                   | 13.739          | 214 <sup>o</sup> .                                                                     | 0.482                                                            | 386.2                         | 664.7               | 51.61                | 13.21                                 | 31.64                                 | 509                               |
| 44                                   | 14.702          | 2369.                                                                                  | 0.481                                                            | 412.6                         | 710.5               | 52.23                | 13.16                                 | 30.59                                 | 526                               |
| 46                                   | 15.663          | 2589.                                                                                  | 0.480                                                            | 438.9                         | 756.3               | 52.81                | 13.14                                 | 29.74                                 | 543                               |
| 48                                   | 16.623          | 2809.                                                                                  | 0.479                                                            | 465.2                         | 802.1               | 53.37                | 13.15                                 | 29.06                                 | 559                               |
| 50                                   | 17.581          | 3028.                                                                                  | 0.478                                                            | 491.5                         | 847.8               | 53.91                | 13.17                                 | 28.49                                 | 574                               |
| 55                                   | 19.968          | 3574.                                                                                  | 0.476                                                            | 557.7                         | 962.3               | 55.17                | 13.31                                 | 27.46                                 | 609                               |
| 60                                   | 22.342          | 4115.                                                                                  | 0.474                                                            | 625.0                         | 1077.7              | 56.34                | 13.52                                 | 26.81                                 | 640                               |
| 65                                   | 24.709          | 4654.                                                                                  | 0.473                                                            | 693.4                         | 1194.1              | 57.44                | 13.86                                 | 26.51                                 | 669                               |
| 70                                   | 27.069          | 5190.                                                                                  | 0.472                                                            | 763.8                         | 1312.3              | 58.48                | 14.32                                 | 26.47                                 | 694                               |
| 75                                   | 29.424          | 5725.                                                                                  | 0.471                                                            | 836.8                         | 1433.1              | 59.49                | 14.90                                 | 26.65                                 | 717                               |
| 80                                   | 31.775          | 6258.                                                                                  | 0.470                                                            | 912.9                         | 1556.9              | 60.47                | 15.58                                 | 27.01                                 | 738                               |
| 85                                   | 34.121          | 6789.                                                                                  | 0.469                                                            | 992.7                         | 1684.2              | 61.44                | 16.35                                 | 27.51                                 | 758                               |
| 90                                   | 36.465          | 7320.                                                                                  | 0.468                                                            | 1076.5                        | 1815.5              | 62.39                | 17.17                                 | 28.10                                 | 776                               |
| 95                                   | 38.805          | 7849.                                                                                  | 0.468                                                            | 1164.5                        | 1950.8              | 63.35                | 18.02                                 | 28.76                                 | 793                               |
| 100                                  | 41.143          | 8377.                                                                                  | 0.467                                                            | 1256.7                        | 2090.5              | 64.29                | 18.88                                 | 29.44                                 | 810                               |
| * TWO-PHASE BOUNDARY                 |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.0055 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 30.087                             | 8.232           | 649.4                                                                                 | 0.573                                                            | 206.4                         | 358.1               | 45.99                | 15.17                                          | 66.18                                          | 377                               |
| 31                                   | 8.765           | 765.4                                                                                 | 0.567                                                            | 220.2                         | 381.6               | 46.44                | 14.94                                          | 58.60                                          | 388                               |
| 32                                   | 9.329           | 889.7                                                                                 | 0.562                                                            | 235.0                         | 406.9               | 46.91                | 14.73                                          | 52.72                                          | 400                               |
| 33                                   | 9.889           | 1017.                                                                                 | 0.556                                                            | 249.9                         | 432.1               | 47.37                | 14.57                                          | 48.32                                          | 411                               |
| 34                                   | 10.443          | 1131.                                                                                 | 0.552                                                            | 264.3                         | 456.7               | 47.80                | 14.25                                          | 44.89                                          | 423                               |
| 35                                   | 10.993          | 1249.                                                                                 | 0.548                                                            | 278.4                         | 480.9               | 48.21                | 14.00                                          | 42.24                                          | 435                               |
| 36                                   | 11.540          | 1365.                                                                                 | 0.546                                                            | 292.3                         | 504.9               | 48.60                | 13.81                                          | 40.13                                          | 447                               |
| 37                                   | 12.085          | 1481.                                                                                 | 0.544                                                            | 306.0                         | 528.7               | 48.98                | 13.65                                          | 38.41                                          | 458                               |
| 38                                   | 12.628          | 1595.                                                                                 | 0.542                                                            | 319.6                         | 552.3               | 49.34                | 13.53                                          | 36.99                                          | 468                               |
| 39                                   | 13.170          | 1710.                                                                                 | 0.541                                                            | 333.1                         | 575.7               | 49.69                | 13.43                                          | 35.79                                          | 479                               |
| 40                                   | 13.710          | 1824.                                                                                 | 0.540                                                            | 346.5                         | 599.1               | 50.03                | 13.36                                          | 34.78                                          | 488                               |
| 42                                   | 14.788          | 2051.                                                                                 | 0.538                                                            | 373.1                         | 645.5               | 50.68                | 13.26                                          | 33.13                                          | 508                               |
| 44                                   | 15.863          | 2277.                                                                                 | 0.537                                                            | 399.5                         | 691.8               | 51.29                | 13.20                                          | 31.87                                          | 526                               |
| 46                                   | 16.936          | 2503.                                                                                 | 0.536                                                            | 425.9                         | 737.9               | 51.88                | 13.18                                          | 30.86                                          | 543                               |
| 48                                   | 18.007          | 2728.                                                                                 | 0.535                                                            | 452.3                         | 784.0               | 52.44                | 13.19                                          | 30.05                                          | 559                               |
| 50                                   | 19.076          | 2953.                                                                                 | 0.534                                                            | 478.7                         | 830.1               | 52.98                | 13.21                                          | 29.38                                          | 574                               |
| 55                                   | 21.739          | 3514.                                                                                 | 0.532                                                            | 545.1                         | 945.6               | 54.24                | 13.35                                          | 28.17                                          | 610                               |
| 60                                   | 24.387          | 4068.                                                                                 | 0.529                                                            | 612.6                         | 1061.9              | 55.42                | 13.56                                          | 27.38                                          | 642                               |
| 65                                   | 27.027          | 4620.                                                                                 | 0.527                                                            | 681.2                         | 1179.1              | 56.52                | 13.89                                          | 26.99                                          | 672                               |
| 70                                   | 29.659          | 5170.                                                                                 | 0.526                                                            | 751.8                         | 1298.2              | 57.56                | 14.35                                          | 26.89                                          | 698                               |
| 75                                   | 32.285          | 5718.                                                                                 | 0.525                                                            | 824.9                         | 1419.7              | 58.57                | 14.93                                          | 27.02                                          | 721                               |
| 80                                   | 34.905          | 6264.                                                                                 | 0.524                                                            | 901.2                         | 1544.3              | 59.56                | 15.61                                          | 27.33                                          | 743                               |
| 85                                   | 37.521          | 6809.                                                                                 | 0.523                                                            | 981.1                         | 1672.4              | 60.53                | 16.37                                          | 27.79                                          | 762                               |
| 90                                   | 40.132          | 7357.                                                                                 | 0.522                                                            | 1065.0                        | 1804.4              | 61.48                | 17.19                                          | 28.36                                          | 781                               |
| 95                                   | 42.741          | 7894.                                                                                 | 0.521                                                            | 1153.1                        | 1940.5              | 62.44                | 18.04                                          | 28.99                                          | 799                               |
| 100                                  | 45.346          | 8436.                                                                                 | 0.521                                                            | 1245.4                        | 2080.8              | 63.38                | 18.89                                          | 29.66                                          | 816                               |
| 0.0060 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 30.495                             | 8.782           | 574.0                                                                                 | 0.635                                                            | 197.7                         | 346.0               | 45.27                | 15.41                                          | 75.76                                          | 377                               |
| 31                                   | 9.116           | 640.1                                                                                 | 0.631                                                            | 205.4                         | 359.4               | 45.52                | 15.27                                          | 69.58                                          | 383                               |
| 32                                   | 9.744           | 768.5                                                                                 | 0.624                                                            | 220.6                         | 385.1               | 46.00                | 15.02                                          | 60.66                                          | 395                               |
| 33                                   | 10.366          | 894.7                                                                                 | 0.617                                                            | 235.8                         | 410.8               | 46.47                | 14.84                                          | 54.34                                          | 406                               |
| 34                                   | 10.980          | 1017.                                                                                 | 0.612                                                            | 250.4                         | 435.8               | 46.91                | 14.47                                          | 49.66                                          | 419                               |
| 35                                   | 11.589          | 1138.                                                                                 | 0.608                                                            | 264.7                         | 460.4               | 47.32                | 14.17                                          | 46.13                                          | 431                               |
| 36                                   | 12.195          | 1257.                                                                                 | 0.605                                                            | 278.8                         | 484.7               | 47.72                | 13.94                                          | 43.39                                          | 443                               |
| 37                                   | 12.799          | 1376.                                                                                 | 0.602                                                            | 292.6                         | 508.8               | 48.10                | 13.76                                          | 41.21                                          | 455                               |
| 38                                   | 13.400          | 1493.                                                                                 | 0.600                                                            | 306.3                         | 532.6               | 48.46                | 13.62                                          | 39.42                                          | 466                               |
| 39                                   | 13.999          | 1610.                                                                                 | 0.599                                                            | 319.9                         | 556.3               | 48.81                | 13.51                                          | 37.94                                          | 477                               |
| 40                                   | 14.597          | 1727.                                                                                 | 0.597                                                            | 333.3                         | 579.8               | 49.16                | 13.42                                          | 36.70                                          | 487                               |
| 42                                   | 15.790          | 1959.                                                                                 | 0.596                                                            | 360.1                         | 626.7               | 49.81                | 13.31                                          | 34.71                                          | 507                               |
| 44                                   | 16.980          | 2191.                                                                                 | 0.594                                                            | 386.6                         | 673.4               | 50.43                | 13.25                                          | 33.20                                          | 525                               |
| 46                                   | 18.167          | 2423.                                                                                 | 0.593                                                            | 413.1                         | 719.9               | 51.01                | 13.22                                          | 32.01                                          | 543                               |
| 48                                   | 19.352          | 2654.                                                                                 | 0.592                                                            | 439.5                         | 766.3               | 51.58                | 13.23                                          | 31.06                                          | 560                               |
| 50                                   | 20.535          | 2884.                                                                                 | 0.591                                                            | 466.0                         | 812.8               | 52.12                | 13.25                                          | 30.28                                          | 576                               |
| 55                                   | 23.482          | 3459.                                                                                 | 0.588                                                            | 532.6                         | 929.1               | 53.39                | 13.39                                          | 28.87                                          | 612                               |
| 60                                   | 26.411          | 4027.                                                                                 | 0.585                                                            | 600.4                         | 1046.4              | 54.57                | 13.60                                          | 27.95                                          | 645                               |
| 65                                   | 29.330          | 4593.                                                                                 | 0.583                                                            | 669.1                         | 1164.4              | 55.67                | 13.93                                          | 27.46                                          | 675                               |
| 70                                   | 32.241          | 5157.                                                                                 | 0.581                                                            | 739.8                         | 1284.3              | 56.71                | 14.38                                          | 27.29                                          | 701                               |
| 75                                   | 35.144          | 5718.                                                                                 | 0.580                                                            | 813.1                         | 1406.6              | 57.73                | 14.95                                          | 27.37                                          | 725                               |
| 80                                   | 38.040          | 6278.                                                                                 | 0.579                                                            | 889.6                         | 1532.0              | 58.71                | 15.63                                          | 27.65                                          | 747                               |
| 85                                   | 40.932          | 6835.                                                                                 | 0.578                                                            | 969.6                         | 1660.8              | 59.68                | 16.39                                          | 28.07                                          | 767                               |
| 90                                   | 43.818          | 7392.                                                                                 | 0.577                                                            | 1053.6                        | 1793.5              | 60.64                | 17.21                                          | 28.61                                          | 786                               |
| 95                                   | 46.701          | 7947.                                                                                 | 0.576                                                            | 1141.7                        | 1930.4              | 61.59                | 18.06                                          | 29.22                                          | 804                               |
| 100                                  | 49.580          | 8502.                                                                                 | 0.576                                                            | 1234.1                        | 2071.4              | 62.54                | 18.91                                          | 29.88                                          | 822                               |
| 0.0065 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 30.856                             | 9.292           | 501.4                                                                                 | 0.699                                                            | 188.5                         | 333.3               | 44.59                | 15.66                                          | 87.73                                          | 376                               |
| 31                                   | 9.406           | 520.8                                                                                 | 0.697                                                            | 190.7                         | 337.4               | 44.66                | 15.61                                          | 85.04                                          | 378                               |
| 32                                   | 10.099          | 653.4                                                                                 | 0.689                                                            | 206.2                         | 363.6               | 45.15                | 15.33                                          | 71.01                                          | 390                               |
| 33                                   | 10.785          | 783.5                                                                                 | 0.680                                                            | 221.8                         | 389.9               | 45.63                | 15.12                                          | 61.77                                          | 401                               |
| 34                                   | 11.461          | 909.4                                                                                 | 0.673                                                            | 236.6                         | 415.3               | 46.07                | 14.69                                          | 55.32                                          | 415                               |
| 35                                   | 12.132          | 1033.                                                                                 | 0.668                                                            | 251.2                         | 440.3               | 46.49                | 14.35                                          | 50.63                                          | 428                               |
| 36                                   | 12.798          | 1156.                                                                                 | 0.665                                                            | 265.4                         | 464.9               | 46.90                | 14.08                                          | 47.09                                          | 441                               |
| 37                                   | 13.461          | 1277.                                                                                 | 0.662                                                            | 279.3                         | 489.2               | 47.28                | 13.87                                          | 44.31                                          | 453                               |
| 38                                   | 14.122          | 1397.                                                                                 | 0.660                                                            | 293.1                         | 513.3               | 47.65                | 13.71                                          | 42.09                                          | 464                               |
| 39                                   | 14.781          | 1517.                                                                                 | 0.658                                                            | 306.8                         | 537.2               | 48.00                | 13.58                                          | 40.26                                          | 475                               |
| 40                                   | 15.438          | 1636.                                                                                 | 0.656                                                            | 320.3                         | 561.0               | 48.34                | 13.48                                          | 38.75                                          | 486                               |
| 42                                   | 16.749          | 1874.                                                                                 | 0.654                                                            | 347.1                         | 608.2               | 49.00                | 13.35                                          | 36.36                                          | 506                               |
| 44                                   | 18.056          | 2111.                                                                                 | 0.653                                                            | 373.8                         | 655.2               | 49.62                | 13.28                                          | 34.58                                          | 526                               |
| 46                                   | 19.360          | 2348.                                                                                 | 0.651                                                            | 400.3                         | 702.1               | 50.21                | 13.26                                          | 33.20                                          | 544                               |
| 48                                   | 20.662          | 2585.                                                                                 | 0.650                                                            | 426.8                         | 748.9               | 50.77                | 13.26                                          | 32.09                                          | 561                               |
| 50                                   | 21.961          | 2821.                                                                                 | 0.649                                                            | 453.4                         | 795.7               | 51.31                | 13.29                                          | 31.19                                          | 577                               |
| 55                                   | 25.199          | 3410.                                                                                 | 0.646                                                            | 520.1                         | 912.9               | 52.58                | 13.43                                          | 29.58                                          | 614                               |
| 60                                   | 28.415          | 3992.                                                                                 | 0.642                                                            | 588.2                         | 1031.1              | 53.77                | 13.64                                          | 28.51                                          | 648                               |
| 65                                   | 31.621          | 4572.                                                                                 | 0.640                                                            | 657.1                         | 1150.0              | 54.87                | 13.96                                          | 27.93                                          | 678                               |
| 70                                   | 34.817          | 5149.                                                                                 | 0.638                                                            | 728.0                         | 1270.7              | 55.92                | 14.41                                          | 27.69                                          | 705                               |
| 75                                   | 38.004          | 5724.                                                                                 | 0.637                                                            | 801.4                         | 1393.8              | 56.94                | 14.98                                          | 27.72                                          | 730                               |
| 80                                   | 41.184          | 6298.                                                                                 | 0.635                                                            | 878.0                         | 1520.0              | 57.92                | 15.66                                          | 27.95                                          | 752                               |
| 85                                   | 44.357          | 6869.                                                                                 | 0.634                                                            | 958.1                         | 1649.6              | 58.90                | 16.41                                          | 28.35                                          | 772                               |
| 90                                   | 47.526          | 7439.                                                                                 | 0.633                                                            | 1042.2                        | 1783.0              | 59.86                | 17.23                                          | 28.86                                          | 791                               |
| 95                                   | 50.689          | 8008.                                                                                 | 0.632                                                            | 1130.4                        | 1920.6              | 60.81                | 18.07                                          | 29.45                                          | 810                               |
| 100                                  | 53.849          | 8575.                                                                                 | 0.632                                                            | 1222.9                        | 2062.4              | 61.76                | 18.93                                          | 30.08                                          | 828                               |
| * TWO-PHASE BOUNDARY                 |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |

TABLE XI. THERMOODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN          | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|-------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0070 GMOL/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 31.176                            | 9.761           | 431.9                                                                                 | 0.764                                                            | 178.9                         | 320.2               | 43.94                | 15.92                                 | 102.98                                | 375                               |
| 32                                  | 10.398          | 544.5                                                                                 | 0.755                                                            | 191.9                         | 342.4               | 44.35                | 15.66                                 | 84.93                                 | 385                               |
| 33                                  | 11.150          | 678.4                                                                                 | 0.744                                                            | 207.8                         | 369.2               | 44.84                | 15.42                                 | 71.11                                 | 397                               |
| 34                                  | 11.890          | 807.7                                                                                 | 0.736                                                            | 223.0                         | 395.1               | 45.29                | 14.92                                 | 62.12                                 | 411                               |
| 35                                  | 12.624          | 934.7                                                                                 | 0.731                                                            | 237.7                         | 420.4               | 45.72                | 14.53                                 | 55.86                                 | 425                               |
| 36                                  | 13.352          | 1060.                                                                                 | 0.726                                                            | 252.1                         | 445.4               | 46.12                | 14.22                                 | 51.26                                 | 438                               |
| 37                                  | 14.076          | 1184.                                                                                 | 0.723                                                            | 266.2                         | 469.9               | 46.51                | 13.98                                 | 47.75                                 | 451                               |
| 38                                  | 14.798          | 1307.                                                                                 | 0.720                                                            | 280.1                         | 494.3               | 46.88                | 13.80                                 | 44.99                                 | 463                               |
| 39                                  | 15.517          | 1429.                                                                                 | 0.718                                                            | 293.8                         | 518.4               | 47.23                | 13.65                                 | 42.76                                 | 474                               |
| 40                                  | 16.234          | 1551.                                                                                 | 0.717                                                            | 307.4                         | 542.4               | 47.58                | 13.54                                 | 40.93                                 | 485                               |
| 42                                  | 17.665          | 1795.                                                                                 | 0.714                                                            | 334.3                         | 590.0               | 48.24                | 13.40                                 | 38.09                                 | 506                               |
| 44                                  | 19.092          | 2037.                                                                                 | 0.713                                                            | 361.0                         | 637.4               | 48.86                | 13.32                                 | 36.00                                 | 526                               |
| 46                                  | 20.517          | 2280.                                                                                 | 0.711                                                            | 387.6                         | 684.6               | 49.45                | 13.29                                 | 34.40                                 | 545                               |
| 48                                  | 21.938          | 2522.                                                                                 | 0.710                                                            | 414.2                         | 731.8               | 50.01                | 13.29                                 | 33.14                                 | 562                               |
| 50                                  | 23.357          | 2764.                                                                                 | 0.709                                                            | 440.8                         | 778.9               | 50.56                | 13.32                                 | 32.12                                 | 579                               |
| 55                                  | 26.893          | 3368.                                                                                 | 0.706                                                            | 507.8                         | 897.0               | 51.83                | 13.47                                 | 30.28                                 | 617                               |
| 60                                  | 30.404          | 3963.                                                                                 | 0.701                                                            | 576.1                         | 1016.2              | 53.02                | 13.67                                 | 29.06                                 | 651                               |
| 65                                  | 33.903          | 4557.                                                                                 | 0.699                                                            | 645.2                         | 1135.9              | 54.13                | 13.99                                 | 28.39                                 | 682                               |
| 70                                  | 37.391          | 5149.                                                                                 | 0.697                                                            | 716.2                         | 1257.4              | 55.18                | 14.44                                 | 28.08                                 | 709                               |
| 75                                  | 40.869          | 5737.                                                                                 | 0.695                                                            | 789.8                         | 1381.3              | 56.20                | 15.01                                 | 28.05                                 | 734                               |
| 80                                  | 44.339          | 6324.                                                                                 | 0.693                                                            | 866.4                         | 1508.3              | 57.19                | 15.68                                 | 28.25                                 | 757                               |
| 85                                  | 47.802          | 6909.                                                                                 | 0.692                                                            | 946.7                         | 1638.6              | 58.16                | 16.43                                 | 28.61                                 | 778                               |
| 90                                  | 51.258          | 7493.                                                                                 | 0.691                                                            | 1030.9                        | 1772.8              | 59.12                | 17.25                                 | 29.10                                 | 797                               |
| 95                                  | 54.710          | 8075.                                                                                 | 0.690                                                            | 1119.2                        | 1911.1              | 60.08                | 18.09                                 | 29.67                                 | 816                               |
| 100                                 | 58.157          | 8657.                                                                                 | 0.689                                                            | 1211.8                        | 2053.6              | 61.03                | 18.94                                 | 30.28                                 | 834                               |
| 0.0075 GMOL/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 31.459                            | 10.190          | 378.1                                                                                 | 0.823                                                            | 169.2                         | 306.8               | 43.32                | 16.13                                 | 117.58                                | 372                               |
| 32                                  | 10.638          | 452.3                                                                                 | 0.818                                                            | 177.8                         | 321.5               | 43.59                | 15.94                                 | 101.25                                | 380                               |
| 33                                  | 11.458          | 589.4                                                                                 | 0.814                                                            | 194.0                         | 348.8               | 44.09                | 15.73                                 | 82.56                                 | 394                               |
| 34                                  | 12.266          | 719.7                                                                                 | 0.804                                                            | 209.4                         | 375.1               | 44.55                | 15.17                                 | 70.22                                 | 409                               |
| 35                                  | 13.066          | 848.7                                                                                 | 0.798                                                            | 224.3                         | 400.9               | 44.98                | 14.69                                 | 61.96                                 | 424                               |
| 36                                  | 13.862          | 976.3                                                                                 | 0.793                                                            | 238.9                         | 426.1               | 45.39                | 14.36                                 | 56.18                                 | 438                               |
| 37                                  | 14.653          | 1103.                                                                                 | 0.789                                                            | 253.1                         | 451.0               | 45.78                | 14.12                                 | 51.75                                 | 451                               |
| 38                                  | 15.440          | 1229.                                                                                 | 0.786                                                            | 267.1                         | 475.7               | 46.15                | 13.90                                 | 48.36                                 | 464                               |
| 39                                  | 16.224          | 1354.                                                                                 | 0.783                                                            | 280.9                         | 500.1               | 46.51                | 13.74                                 | 45.58                                 | 475                               |
| 40                                  | 17.006          | 1478.                                                                                 | 0.781                                                            | 294.6                         | 524.3               | 46.86                | 13.62                                 | 43.32                                 | 486                               |
| 42                                  | 18.561          | 1726.                                                                                 | 0.776                                                            | 321.6                         | 572.4               | 47.52                | 13.45                                 | 39.87                                 | 507                               |
| 44                                  | 20.108          | 1974.                                                                                 | 0.773                                                            | 348.4                         | 620.1               | 48.14                | 13.37                                 | 37.36                                 | 527                               |
| 46                                  | 21.652          | 2220.                                                                                 | 0.770                                                            | 375.1                         | 667.6               | 48.73                | 13.33                                 | 35.47                                 | 545                               |
| 48                                  | 23.191          | 2466.                                                                                 | 0.768                                                            | 401.8                         | 715.1               | 49.30                | 13.33                                 | 34.02                                 | 562                               |
| 50                                  | 24.728          | 2712.                                                                                 | 0.766                                                            | 428.4                         | 762.5               | 49.85                | 13.36                                 | 32.86                                 | 579                               |
| 55                                  | 28.553          | 3324.                                                                                 | 0.763                                                            | 495.5                         | 881.3               | 51.13                | 13.50                                 | 30.86                                 | 618                               |
| 60                                  | 32.363          | 3934.                                                                                 | 0.761                                                            | 564.0                         | 1001.3              | 52.32                | 13.70                                 | 29.60                                 | 654                               |
| 65                                  | 36.168          | 4544.                                                                                 | 0.759                                                            | 633.3                         | 1121.9              | 53.43                | 14.02                                 | 28.86                                 | 686                               |
| 70                                  | 39.956          | 5151.                                                                                 | 0.757                                                            | 704.4                         | 1244.2              | 54.48                | 14.46                                 | 28.50                                 | 714                               |
| 75                                  | 43.730          | 5755.                                                                                 | 0.756                                                            | 778.1                         | 1368.9              | 55.50                | 15.03                                 | 28.43                                 | 740                               |
| 80                                  | 47.500          | 6359.                                                                                 | 0.754                                                            | 854.9                         | 1496.7              | 56.49                | 15.70                                 | 28.58                                 | 763                               |
| 85                                  | 51.265          | 6963.                                                                                 | 0.752                                                            | 935.3                         | 1627.9              | 57.46                | 16.46                                 | 28.89                                 | 784                               |
| 90                                  | 55.029          | 7564.                                                                                 | 0.750                                                            | 1019.6                        | 1763.1              | 58.43                | 17.27                                 | 29.32                                 | 803                               |
| 95                                  | 58.771          | 8159.                                                                                 | 0.748                                                            | 1108.1                        | 1902.1              | 59.38                | 18.12                                 | 29.85                                 | 822                               |
| 100                                 | 62.501          | 8753.                                                                                 | 0.746                                                            | 1200.8                        | 2045.2              | 60.33                | 18.97                                 | 30.41                                 | 840                               |
| 0.0080 GMOL/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 31.709                            | 10.582          | 322.8                                                                                 | 0.888                                                            | 159.2                         | 293.2               | 42.72                | 16.28                                 | 138.86                                | 372                               |
| 32                                  | 10.842          | 363.3                                                                                 | 0.885                                                            | 163.9                         | 301.2               | 42.87                | 16.17                                 | 125.40                                | 376                               |
| 33                                  | 11.730          | 502.7                                                                                 | 0.881                                                            | 180.2                         | 328.7               | 43.37                | 16.07                                 | 96.83                                 | 390                               |
| 34                                  | 12.605          | 635.2                                                                                 | 0.870                                                            | 195.9                         | 355.5               | 43.84                | 15.43                                 | 79.53                                 | 406                               |
| 35                                  | 13.470          | 766.6                                                                                 | 0.863                                                            | 211.0                         | 381.6               | 44.28                | 14.82                                 | 68.60                                 | 422                               |
| 36                                  | 14.330          | 896.1                                                                                 | 0.858                                                            | 225.7                         | 407.2               | 44.69                | 14.50                                 | 61.27                                 | 436                               |
| 37                                  | 15.185          | 1024.                                                                                 | 0.853                                                            | 240.1                         | 432.4               | 45.09                | 14.27                                 | 55.83                                 | 449                               |
| 38                                  | 16.035          | 1153.                                                                                 | 0.850                                                            | 254.1                         | 457.2               | 45.46                | 14.01                                 | 51.71                                 | 462                               |
| 39                                  | 16.882          | 1280.                                                                                 | 0.847                                                            | 268.0                         | 481.9               | 45.82                | 13.84                                 | 48.40                                 | 474                               |
| 40                                  | 17.727          | 1407.                                                                                 | 0.844                                                            | 281.8                         | 506.3               | 46.17                | 13.70                                 | 45.75                                 | 486                               |
| 42                                  | 19.407          | 1659.                                                                                 | 0.839                                                            | 309.0                         | 554.8               | 46.84                | 13.52                                 | 41.73                                 | 507                               |
| 44                                  | 21.080          | 1912.                                                                                 | 0.835                                                            | 336.0                         | 602.9               | 47.46                | 13.42                                 | 38.84                                 | 527                               |
| 46                                  | 22.748          | 2164.                                                                                 | 0.832                                                            | 362.8                         | 650.9               | 48.06                | 13.38                                 | 36.69                                 | 546                               |
| 48                                  | 24.411          | 2416.                                                                                 | 0.830                                                            | 389.5                         | 698.7               | 48.63                | 13.37                                 | 35.05                                 | 564                               |
| 50                                  | 26.073          | 2667.                                                                                 | 0.828                                                            | 416.3                         | 746.5               | 49.17                | 13.39                                 | 33.75                                 | 581                               |
| 55                                  | 30.208          | 3294.                                                                                 | 0.825                                                            | 483.5                         | 866.1               | 50.46                | 13.53                                 | 31.52                                 | 621                               |
| 60                                  | 34.326          | 3919.                                                                                 | 0.823                                                            | 552.1                         | 986.9               | 51.65                | 13.72                                 | 30.12                                 | 658                               |
| 65                                  | 38.439          | 4543.                                                                                 | 0.821                                                            | 621.5                         | 1108.3              | 52.76                | 14.04                                 | 29.29                                 | 690                               |
| 70                                  | 42.535          | 5165.                                                                                 | 0.819                                                            | 692.7                         | 1231.4              | 53.82                | 14.49                                 | 28.87                                 | 719                               |
| 75                                  | 46.614          | 5783.                                                                                 | 0.817                                                            | 766.5                         | 1356.9              | 54.83                | 15.06                                 | 28.75                                 | 745                               |
| 80                                  | 50.690          | 6402.                                                                                 | 0.815                                                            | 843.4                         | 1485.5              | 55.83                | 15.73                                 | 28.86                                 | 768                               |
| 85                                  | 54.761          | 7022.                                                                                 | 0.813                                                            | 924.0                         | 1617.6              | 56.80                | 16.49                                 | 29.15                                 | 790                               |
| 90                                  | 58.829          | 7637.                                                                                 | 0.810                                                            | 1008.4                        | 1753.5              | 57.77                | 17.31                                 | 29.56                                 | 810                               |
| 95                                  | 62.872          | 8247.                                                                                 | 0.808                                                            | 1097.1                        | 1893.4              | 58.73                | 18.15                                 | 30.06                                 | 828                               |
| 100                                 | 66.903          | 8854.                                                                                 | 0.806                                                            | 1190.0                        | 2037.4              | 59.68                | 19.01                                 | 30.61                                 | 847                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN            | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|---------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.0085 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 31.928                              | 10.934          | 277.7                                                                                 | 0.954                                                            | 149.0                         | 279.3               | 42.15                | 16.42                                          | 165.68                                         | 372                               |
| 32                                    | 11.003          | 287.9                                                                                 | 0.953                                                            | 150.2                         | 281.3               | 42.19                | 16.40                                          | 160.43                                         | 373                               |
| 33                                    | 11.961          | 422.2                                                                                 | 0.950                                                            | 166.5                         | 309.1               | 42.69                | 16.46                                          | 115.13                                         | 386                               |
| 34                                    | 12.903          | 558.0                                                                                 | 0.936                                                            | 182.6                         | 336.4               | 43.17                | 15.68                                          | 90.58                                          | 403                               |
| 35                                    | 13.834          | 691.5                                                                                 | 0.928                                                            | 197.9                         | 362.8               | 43.61                | 14.97                                          | 76.13                                          | 420                               |
| 36                                    | 14.759          | 827.7                                                                                 | 0.922                                                            | 212.7                         | 388.6               | 44.03                | 14.64                                          | 66.85                                          | 434                               |
| 37                                    | 15.679          | 957.8                                                                                 | 0.917                                                            | 227.2                         | 414.1               | 44.43                | 14.40                                          | 60.22                                          | 448                               |
| 38                                    | 16.593          | 1083.                                                                                 | 0.915                                                            | 241.3                         | 439.1               | 44.81                | 14.11                                          | 55.27                                          | 462                               |
| 39                                    | 17.505          | 1213.                                                                                 | 0.911                                                            | 255.3                         | 464.0               | 45.17                | 13.93                                          | 51.35                                          | 474                               |
| 40                                    | 18.414          | 1347.                                                                                 | 0.908                                                            | 269.2                         | 488.7               | 45.52                | 13.79                                          | 48.25                                          | 486                               |
| 42                                    | 20.221          | 1599.                                                                                 | 0.903                                                            | 296.6                         | 537.6               | 46.19                | 13.59                                          | 43.62                                          | 508                               |
| 44                                    | 22.022          | 1858.                                                                                 | 0.899                                                            | 323.6                         | 586.1               | 46.82                | 13.48                                          | 40.32                                          | 528                               |
| 46                                    | 23.818          | 2115.                                                                                 | 0.896                                                            | 350.5                         | 634.4               | 47.42                | 13.42                                          | 37.91                                          | 548                               |
| 48                                    | 25.608          | 2377.                                                                                 | 0.894                                                            | 377.3                         | 682.6               | 47.99                | 13.41                                          | 36.07                                          | 566                               |
| 50                                    | 27.396          | 2629.                                                                                 | 0.892                                                            | 404.2                         | 730.7               | 48.53                | 13.42                                          | 34.63                                          | 584                               |
| 55                                    | 31.848          | 3270.                                                                                 | 0.888                                                            | 471.5                         | 851.2               | 49.82                | 13.55                                          | 32.16                                          | 625                               |
| 60                                    | 36.283          | 3911.                                                                                 | 0.886                                                            | 540.2                         | 972.8               | 51.01                | 13.74                                          | 30.62                                          | 662                               |
| 65                                    | 40.712          | 4550.                                                                                 | 0.884                                                            | 609.7                         | 1095.0              | 52.13                | 14.06                                          | 29.70                                          | 695                               |
| 70                                    | 45.123          | 5187.                                                                                 | 0.882                                                            | 681.0                         | 1218.9              | 53.18                | 14.51                                          | 29.22                                          | 725                               |
| 75                                    | 49.514          | 5820.                                                                                 | 0.880                                                            | 755.0                         | 1345.2              | 54.20                | 15.08                                          | 29.06                                          | 751                               |
| 80                                    | 53.904          | 6455.                                                                                 | 0.877                                                            | 832.0                         | 1474.6              | 55.20                | 15.76                                          | 29.14                                          | 775                               |
| 85                                    | 58.289          | 7089.                                                                                 | 0.875                                                            | 912.7                         | 1607.5              | 56.17                | 16.52                                          | 29.39                                          | 796                               |
| 90                                    | 62.668          | 7710.                                                                                 | 0.872                                                            | 997.3                         | 1744.3              | 57.14                | 17.34                                          | 29.78                                          | 816                               |
| 95                                    | 67.019          | 8344.                                                                                 | 0.870                                                            | 1086.1                        | 1885.0              | 58.10                | 18.19                                          | 30.27                                          | 835                               |
| 100                                   | 71.358          | 8968.                                                                                 | 0.867                                                            | 1179.2                        | 2029.8              | 59.06                | 19.05                                          | 30.80                                          | 854                               |
| 0.0090 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 32.120                              | 11.250          | 230.4                                                                                 | 1.030                                                            | 137.6                         | 264.2               | 41.57                | 17.34                                          | 202.34                                         | 368                               |
| 33                                    | 12.155          | 351.0                                                                                 | 1.016                                                            | 153.0                         | 289.9               | 42.04                | 16.80                                          | 138.23                                         | 381                               |
| 34                                    | 13.164          | 488.1                                                                                 | 1.004                                                            | 169.4                         | 317.6               | 42.53                | 15.91                                          | 103.71                                         | 400                               |
| 35                                    | 14.162          | 623.2                                                                                 | 0.995                                                            | 184.9                         | 344.3               | 42.98                | 15.13                                          | 84.64                                          | 419                               |
| 36                                    | 15.153          | 755.9                                                                                 | 0.988                                                            | 199.8                         | 370.4               | 43.40                | 14.78                                          | 72.95                                          | 433                               |
| 37                                    | 16.138          | 887.7                                                                                 | 0.983                                                            | 214.5                         | 396.1               | 43.80                | 14.51                                          | 64.88                                          | 447                               |
| 38                                    | 17.119          | 1020.                                                                                 | 0.980                                                            | 228.7                         | 421.4               | 44.18                | 14.21                                          | 58.97                                          | 461                               |
| 39                                    | 18.096          | 1157.                                                                                 | 0.976                                                            | 242.8                         | 446.5               | 44.55                | 14.02                                          | 54.39                                          | 474                               |
| 40                                    | 19.070          | 1287.                                                                                 | 0.973                                                            | 256.7                         | 471.4               | 44.90                | 13.87                                          | 50.81                                          | 486                               |
| 42                                    | 21.006          | 1545.                                                                                 | 0.968                                                            | 284.2                         | 520.7               | 45.57                | 13.65                                          | 45.51                                          | 509                               |
| 44                                    | 22.938          | 1800.                                                                                 | 0.964                                                            | 311.4                         | 569.6               | 46.20                | 13.53                                          | 41.80                                          | 530                               |
| 46                                    | 24.864          | 2071.                                                                                 | 0.961                                                            | 338.4                         | 618.3               | 46.80                | 13.46                                          | 39.11                                          | 550                               |
| 48                                    | 26.784          | 2334.                                                                                 | 0.959                                                            | 365.3                         | 666.8               | 47.37                | 13.44                                          | 37.08                                          | 569                               |
| 50                                    | 28.702          | 2597.                                                                                 | 0.957                                                            | 392.2                         | 715.3               | 47.92                | 13.45                                          | 35.49                                          | 587                               |
| 55                                    | 33.479          | 3254.                                                                                 | 0.953                                                            | 459.6                         | 836.6               | 49.21                | 13.57                                          | 32.78                                          | 628                               |
| 60                                    | 38.238          | 3909.                                                                                 | 0.950                                                            | 528.5                         | 958.9               | 50.41                | 13.76                                          | 31.10                                          | 666                               |
| 65                                    | 42.990          | 4564.                                                                                 | 0.948                                                            | 598.0                         | 1082.0              | 51.52                | 14.08                                          | 30.09                                          | 700                               |
| 70                                    | 47.723          | 5217.                                                                                 | 0.946                                                            | 669.4                         | 1206.7              | 52.58                | 14.53                                          | 29.55                                          | 730                               |
| 75                                    | 52.435          | 5866.                                                                                 | 0.944                                                            | 743.5                         | 1333.8              | 53.60                | 15.10                                          | 29.35                                          | 757                               |
| 80                                    | 57.146          | 6515.                                                                                 | 0.941                                                            | 820.6                         | 1464.0              | 54.60                | 15.78                                          | 29.39                                          | 781                               |
| 85                                    | 61.852          | 7165.                                                                                 | 0.939                                                            | 901.4                         | 1597.8              | 55.57                | 16.55                                          | 29.63                                          | 803                               |
| 90                                    | 66.549          | 7810.                                                                                 | 0.936                                                            | 986.2                         | 1735.4              | 56.54                | 17.37                                          | 30.00                                          | 823                               |
| 95                                    | 71.218          | 8451.                                                                                 | 0.933                                                            | 1075.2                        | 1877.0              | 57.51                | 18.23                                          | 30.47                                          | 843                               |
| 100                                   | 75.872          | 9090.                                                                                 | 0.930                                                            | 1168.5                        | 2022.7              | 58.46                | 19.09                                          | 30.99                                          | 861                               |
| 0.0095 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 32.287                              | 11.531          | 187.1                                                                                 | 1.097                                                            | 126.9                         | 249.9               | 41.03                | 17.55                                          | 250.73                                         | 367                               |
| 33                                    | 12.314          | 286.2                                                                                 | 1.085                                                            | 139.7                         | 271.1               | 41.42                | 17.09                                          | 169.59                                         | 378                               |
| 34                                    | 13.392          | 425.3                                                                                 | 1.072                                                            | 156.3                         | 299.2               | 41.91                | 16.13                                          | 119.33                                         | 398                               |
| 35                                    | 14.458          | 561.7                                                                                 | 1.062                                                            | 172.0                         | 326.2               | 42.37                | 15.29                                          | 94.20                                          | 417                               |
| 36                                    | 15.516          | 695.6                                                                                 | 1.055                                                            | 187.1                         | 352.6               | 42.79                | 14.91                                          | 79.53                                          | 432                               |
| 37                                    | 16.567          | 829.0                                                                                 | 1.049                                                            | 201.9                         | 378.6               | 43.20                | 14.61                                          | 69.78                                          | 446                               |
| 38                                    | 17.615          | 963.2                                                                                 | 1.047                                                            | 216.1                         | 404.0               | 43.58                | 14.30                                          | 62.83                                          | 461                               |
| 39                                    | 18.658          | 1097.                                                                                 | 1.043                                                            | 230.3                         | 429.3               | 43.95                | 14.10                                          | 57.50                                          | 474                               |
| 40                                    | 19.698          | 1230.                                                                                 | 1.040                                                            | 244.4                         | 454.4               | 44.30                | 13.94                                          | 53.39                                          | 487                               |
| 42                                    | 21.767          | 1498.                                                                                 | 1.034                                                            | 272.0                         | 504.1               | 44.98                | 13.71                                          | 47.40                                          | 510                               |
| 44                                    | 23.832          | 1767.                                                                                 | 1.030                                                            | 299.3                         | 553.4               | 45.61                | 13.57                                          | 43.26                                          | 532                               |
| 46                                    | 25.890          | 2035.                                                                                 | 1.027                                                            | 326.3                         | 602.5               | 46.21                | 13.50                                          | 40.29                                          | 552                               |
| 48                                    | 27.943          | 2303.                                                                                 | 1.025                                                            | 353.3                         | 651.3               | 46.79                | 13.47                                          | 38.05                                          | 572                               |
| 50                                    | 29.994          | 2577.                                                                                 | 1.023                                                            | 380.2                         | 700.1               | 47.34                | 13.47                                          | 36.31                                          | 590                               |
| 55                                    | 35.103          | 3244.                                                                                 | 1.019                                                            | 447.8                         | 822.2               | 48.62                | 13.59                                          | 33.37                                          | 633                               |
| 60                                    | 40.194          | 3914.                                                                                 | 1.017                                                            | 516.7                         | 945.4               | 49.82                | 13.77                                          | 31.56                                          | 672                               |
| 65                                    | 45.277          | 4588.                                                                                 | 1.014                                                            | 586.3                         | 1069.3              | 50.94                | 14.09                                          | 30.47                                          | 706                               |
| 70                                    | 50.341          | 5255.                                                                                 | 1.012                                                            | 657.9                         | 1194.8              | 52.00                | 14.55                                          | 29.87                                          | 736                               |
| 75                                    | 55.382          | 5920.                                                                                 | 1.010                                                            | 732.0                         | 1322.7              | 53.02                | 15.12                                          | 29.62                                          | 763                               |
| 80                                    | 60.421          | 6585.                                                                                 | 1.007                                                            | 809.3                         | 1453.7              | 54.02                | 15.81                                          | 29.64                                          | 788                               |
| 85                                    | 65.455          | 7250.                                                                                 | 1.004                                                            | 890.2                         | 1588.3              | 55.00                | 16.58                                          | 29.85                                          | 810                               |
| 90                                    | 70.479          | 7910.                                                                                 | 1.001                                                            | 975.2                         | 1726.9              | 55.97                | 17.40                                          | 30.21                                          | 831                               |
| 95                                    | 75.472          | 8568.                                                                                 | 0.998                                                            | 1064.3                        | 1869.3              | 56.93                | 18.26                                          | 30.66                                          | 850                               |
| 100                                   | 80.450          | 9227.                                                                                 | 0.994                                                            | 1157.8                        | 2015.9              | 57.89                | 19.13                                          | 31.17                                          | 869                               |
| * TWO-PHASE BOUNDARY                  |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P / \partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P / \partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0100 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                         |                                                                    |                               |                     |                      |                                       |                                       |                                   |
| * 32.430                             | 11.777          | 148.7                                                                                   | 1.167                                                              | 116.1                         | 235.5               | 40.50                | 17.75                                 | 318.69                                | 366                               |
| 33                                   | 12.442          | 228.9                                                                                   | 1.157                                                              | 126.6                         | 252.7               | 40.82                | 17.36                                 | 212.75                                | 375                               |
| 34                                   | 13.590          | 369.5                                                                                   | 1.141                                                              | 143.5                         | 281.2               | 41.32                | 16.36                                 | 137.83                                | 396                               |
| 35                                   | 14.725          | 506.7                                                                                   | 1.130                                                              | 159.4                         | 308.6               | 41.78                | 15.46                                 | 104.82                                | 415                               |
| 36                                   | 15.850          | 641.8                                                                                   | 1.122                                                              | 174.6                         | 335.2               | 42.21                | 15.03                                 | 86.55                                 | 431                               |
| 37                                   | 16.969          | 776.7                                                                                   | 1.117                                                              | 189.5                         | 361.4               | 42.62                | 14.69                                 | 74.88                                 | 446                               |
| 38                                   | 18.083          | 912.7                                                                                   | 1.114                                                              | 203.8                         | 387.0               | 43.00                | 14.39                                 | 66.77                                 | 461                               |
| 39                                   | 19.194          | 1049.                                                                                   | 1.111                                                              | 218.1                         | 412.5               | 43.37                | 14.17                                 | 60.65                                 | 475                               |
| 40                                   | 20.301          | 1184.                                                                                   | 1.107                                                              | 232.1                         | 437.8               | 43.73                | 14.00                                 | 55.97                                 | 488                               |
| 42                                   | 22.505          | 1457.                                                                                   | 1.102                                                              | 259.9                         | 487.9               | 44.41                | 13.76                                 | 49.24                                 | 512                               |
| 44                                   | 24.706          | 1731.                                                                                   | 1.098                                                              | 287.2                         | 537.6               | 45.04                | 13.61                                 | 44.68                                 | 534                               |
| 46                                   | 26.900          | 2004.                                                                                   | 1.095                                                              | 314.4                         | 586.9               | 45.65                | 13.53                                 | 41.42                                 | 555                               |
| 48                                   | 29.088          | 2279.                                                                                   | 1.093                                                              | 341.4                         | 636.1               | 46.22                | 13.50                                 | 38.98                                 | 575                               |
| 50                                   | 31.275          | 2554.                                                                                   | 1.091                                                              | 368.4                         | 685.3               | 46.77                | 13.50                                 | 37.10                                 | 594                               |
| 55                                   | 36.725          | 3242.                                                                                   | 1.087                                                              | 436.1                         | 808.2               | 48.06                | 13.61                                 | 33.93                                 | 637                               |
| 60                                   | 42.155          | 3930.                                                                                   | 1.085                                                              | 505.1                         | 932.2               | 49.26                | 13.79                                 | 31.99                                 | 677                               |
| 65                                   | 47.577          | 4616.                                                                                   | 1.082                                                              | 574.8                         | 1056.9              | 50.38                | 14.11                                 | 30.82                                 | 712                               |
| 70                                   | 52.980          | 5302.                                                                                   | 1.080                                                              | 646.4                         | 1183.2              | 51.44                | 14.56                                 | 30.16                                 | 743                               |
| 75                                   | 58.357          | 5983.                                                                                   | 1.077                                                              | 720.6                         | 1311.9              | 52.46                | 15.14                                 | 29.88                                 | 770                               |
| 80                                   | 63.733          | 6665.                                                                                   | 1.074                                                              | 798.0                         | 1443.8              | 53.46                | 15.83                                 | 29.87                                 | 795                               |
| 85                                   | 69.103          | 7345.                                                                                   | 1.071                                                              | 879.1                         | 1579.3              | 54.45                | 16.60                                 | 30.06                                 | 817                               |
| 90                                   | 74.461          | 8021.                                                                                   | 1.068                                                              | 964.2                         | 1718.6              | 55.42                | 17.43                                 | 30.40                                 | 838                               |
| 95                                   | 79.787          | 8695.                                                                                   | 1.064                                                              | 1053.5                        | 1861.9              | 56.38                | 18.30                                 | 30.84                                 | 858                               |
| 100                                  | 85.096          | 9366.                                                                                   | 1.061                                                              | 1147.2                        | 2009.4              | 57.35                | 19.17                                 | 31.34                                 | 877                               |
| 0.0105 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                         |                                                                    |                               |                     |                      |                                       |                                       |                                   |
| * 32.553                             | 11.991          | 115.7                                                                                   | 1.239                                                              | 105.2                         | 220.9               | 39.99                | 17.97                                 | 414.68                                | 366                               |
| 33                                   | 12.544          | 179.0                                                                                   | 1.229                                                              | 113.7                         | 234.7               | 40.24                | 17.66                                 | 273.50                                | 373                               |
| 34                                   | 13.762          | 320.5                                                                                   | 1.211                                                              | 130.8                         | 263.6               | 40.76                | 16.59                                 | 159.60                                | 394                               |
| 35                                   | 14.966          | 458.0                                                                                   | 1.198                                                              | 146.9                         | 291.3               | 41.22                | 15.63                                 | 116.45                                | 414                               |
| 36                                   | 16.159          | 594.2                                                                                   | 1.190                                                              | 162.3                         | 318.2               | 41.66                | 15.14                                 | 93.94                                 | 430                               |
| 37                                   | 17.345          | 730.6                                                                                   | 1.185                                                              | 177.2                         | 344.6               | 42.07                | 14.75                                 | 80.09                                 | 446                               |
| 38                                   | 18.528          | 868.4                                                                                   | 1.183                                                              | 191.6                         | 370.4               | 42.45                | 14.46                                 | 70.73                                 | 462                               |
| 39                                   | 19.708          | 1006.                                                                                   | 1.179                                                              | 205.9                         | 396.1               | 42.82                | 14.24                                 | 63.77                                 | 476                               |
| 40                                   | 20.883          | 1144.                                                                                   | 1.176                                                              | 220.1                         | 421.6               | 43.18                | 14.06                                 | 58.50                                 | 489                               |
| 42                                   | 23.225          | 1422.                                                                                   | 1.171                                                              | 247.9                         | 472.0               | 43.86                | 13.80                                 | 51.03                                 | 514                               |
| 44                                   | 25.564          | 1702.                                                                                   | 1.167                                                              | 275.3                         | 522.0               | 44.50                | 13.65                                 | 46.03                                 | 537                               |
| 46                                   | 27.896          | 1981.                                                                                   | 1.164                                                              | 302.5                         | 571.7               | 45.10                | 13.56                                 | 42.50                                 | 559                               |
| 48                                   | 30.223          | 2262.                                                                                   | 1.162                                                              | 329.6                         | 621.3               | 45.68                | 13.52                                 | 39.86                                 | 579                               |
| 50                                   | 32.549          | 2543.                                                                                   | 1.160                                                              | 356.7                         | 670.8               | 46.23                | 13.52                                 | 37.85                                 | 598                               |
| 55                                   | 38.347          | 3248.                                                                                   | 1.157                                                              | 424.5                         | 794.5               | 47.52                | 13.62                                 | 34.45                                 | 643                               |
| 60                                   | 44.125          | 3952.                                                                                   | 1.154                                                              | 493.5                         | 919.3               | 48.72                | 13.80                                 | 32.39                                 | 683                               |
| 65                                   | 49.895          | 4655.                                                                                   | 1.152                                                              | 563.3                         | 1044.8              | 49.84                | 14.12                                 | 31.14                                 | 718                               |
| 70                                   | 55.644          | 5357.                                                                                   | 1.149                                                              | 635.0                         | 1171.9              | 50.90                | 14.58                                 | 30.44                                 | 750                               |
| 75                                   | 61.366          | 6056.                                                                                   | 1.146                                                              | 709.3                         | 1301.5              | 51.93                | 15.16                                 | 30.12                                 | 777                               |
| 80                                   | 67.087          | 6754.                                                                                   | 1.143                                                              | 786.8                         | 1434.2              | 52.93                | 15.85                                 | 30.08                                 | 802                               |
| 85                                   | 72.801          | 7450.                                                                                   | 1.140                                                              | 868.0                         | 1570.5              | 53.91                | 16.63                                 | 30.25                                 | 825                               |
| 90                                   | 78.501          | 8142.                                                                                   | 1.136                                                              | 953.2                         | 1710.8              | 54.89                | 17.47                                 | 30.58                                 | 846                               |
| 95                                   | 84.169          | 8833.                                                                                   | 1.132                                                              | 1042.7                        | 1854.9              | 55.85                | 18.33                                 | 31.01                                 | 867                               |
| 100                                  | 89.817          | 9520.                                                                                   | 1.128                                                              | 1136.6                        | 2003.3              | 56.82                | 19.21                                 | 31.50                                 | 886                               |
| 0.0110 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                         |                                                                    |                               |                     |                      |                                       |                                       |                                   |
| * 32.656                             | 12.174          | 87.75                                                                                   | 1.310                                                              | 94.2                          | 206.3               | 39.49                | 18.22                                 | 552.88                                | 366                               |
| 33                                   | 12.622          | 136.4                                                                                   | 1.301                                                              | 100.9                         | 217.2               | 39.69                | 17.97                                 | 360.82                                | 371                               |
| 34                                   | 13.912          | 277.8                                                                                   | 1.281                                                              | 118.3                         | 246.4               | 40.21                | 16.84                                 | 184.95                                | 392                               |
| 35                                   | 15.184          | 415.5                                                                                   | 1.267                                                              | 134.6                         | 274.5               | 40.68                | 15.80                                 | 128.99                                | 413                               |
| 36                                   | 16.445          | 552.7                                                                                   | 1.258                                                              | 150.1                         | 301.6               | 41.12                | 15.24                                 | 101.57                                | 430                               |
| 37                                   | 17.700          | 690.6                                                                                   | 1.254                                                              | 165.1                         | 328.2               | 41.53                | 14.80                                 | 85.32                                 | 447                               |
| 38                                   | 18.953          | 830.1                                                                                   | 1.252                                                              | 179.5                         | 354.1               | 41.91                | 14.52                                 | 74.65                                 | 463                               |
| 39                                   | 20.202          | 970.1                                                                                   | 1.249                                                              | 193.9                         | 380.0               | 42.29                | 14.29                                 | 66.81                                 | 477                               |
| 40                                   | 21.446          | 1111.                                                                                   | 1.246                                                              | 208.1                         | 405.6               | 42.65                | 14.11                                 | 60.94                                 | 491                               |
| 42                                   | 23.928          | 1394.                                                                                   | 1.242                                                              | 236.0                         | 456.4               | 43.33                | 13.84                                 | 52.72                                 | 517                               |
| 44                                   | 26.409          | 1679.                                                                                   | 1.238                                                              | 263.5                         | 506.8               | 43.97                | 13.68                                 | 47.31                                 | 540                               |
| 46                                   | 28.882          | 1964.                                                                                   | 1.235                                                              | 290.8                         | 556.8               | 44.58                | 13.59                                 | 43.51                                 | 562                               |
| 48                                   | 31.351          | 2257.                                                                                   | 1.233                                                              | 317.9                         | 606.7               | 45.15                | 13.54                                 | 40.69                                 | 583                               |
| 50                                   | 33.820          | 2539.                                                                                   | 1.231                                                              | 345.0                         | 656.5               | 45.71                | 13.54                                 | 38.54                                 | 603                               |
| 55                                   | 39.974          | 3261.                                                                                   | 1.228                                                              | 412.9                         | 781.1               | 47.00                | 13.64                                 | 34.94                                 | 648                               |
| 60                                   | 46.109          | 3987.                                                                                   | 1.225                                                              | 482.0                         | 906.7               | 48.20                | 13.82                                 | 32.76                                 | 689                               |
| 65                                   | 52.234          | 4707.                                                                                   | 1.223                                                              | 551.8                         | 1033.0              | 49.32                | 14.14                                 | 31.44                                 | 725                               |
| 70                                   | 58.339          | 5427.                                                                                   | 1.220                                                              | 623.6                         | 1161.0              | 50.38                | 14.60                                 | 30.69                                 | 757                               |
| 75                                   | 64.414          | 6139.                                                                                   | 1.217                                                              | 698.0                         | 1291.4              | 51.41                | 15.18                                 | 30.34                                 | 785                               |
| 80                                   | 70.488          | 6853.                                                                                   | 1.214                                                              | 775.6                         | 1424.9              | 52.41                | 15.88                                 | 30.28                                 | 810                               |
| 85                                   | 76.554          | 7565.                                                                                   | 1.210                                                              | 857.0                         | 1562.1              | 53.40                | 16.66                                 | 30.43                                 | 833                               |
| 90                                   | 82.605          | 8273.                                                                                   | 1.206                                                              | 942.3                         | 1703.2              | 54.37                | 17.50                                 | 30.75                                 | 855                               |
| 95                                   | 88.623          | 8983.                                                                                   | 1.202                                                              | 1032.0                        | 1848.3              | 55.34                | 18.37                                 | 31.16                                 | 875                               |
| 100                                  | 94.618          | 9686.                                                                                   | 1.198                                                              | 1126.0                        | 1997.6              | 56.31                | 19.25                                 | 31.65                                 | 895                               |

\* TWO-PHASE BOUNDARY

TABLE X1. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0115 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.742                             | 12.329          | 64.68                                                                                  | 1.381                                                            | 83.1                          | 191.7               | 39.00                | 18.49                                 | 758.14                                | 365                               |
| 33                                   | 12.681          | 100.9                                                                                  | 1.373                                                            | 88.3                          | 200.0               | 39.16                | 18.29                                 | 490.81                                | 369                               |
| 34                                   | 14.041          | 241.2                                                                                  | 1.350                                                            | 106.0                         | 229.7               | 39.68                | 17.08                                 | 214.02                                | 390                               |
| 35                                   | 15.382          | 378.7                                                                                  | 1.336                                                            | 122.5                         | 258.0               | 40.16                | 15.96                                 | 142.26                                | 412                               |
| 36                                   | 16.712          | 517.0                                                                                  | 1.327                                                            | 138.1                         | 285.4               | 40.60                | 15.33                                 | 109.30                                | 430                               |
| 37                                   | 18.037          | 656.6                                                                                  | 1.323                                                            | 153.2                         | 312.1               | 41.02                | 14.83                                 | 90.46                                 | 449                               |
| 38                                   | 19.359          | 798.0                                                                                  | 1.323                                                            | 167.6                         | 338.2               | 41.40                | 14.57                                 | 78.43                                 | 465                               |
| 39                                   | 20.679          | 940.1                                                                                  | 1.320                                                            | 182.0                         | 364.2               | 41.77                | 14.34                                 | 69.71                                 | 479                               |
| 40                                   | 21.995          | 1083.                                                                                  | 1.317                                                            | 196.3                         | 390.1               | 42.14                | 14.15                                 | 63.24                                 | 493                               |
| 42                                   | 24.620          | 1373.                                                                                  | 1.313                                                            | 224.3                         | 441.2               | 42.82                | 13.88                                 | 54.30                                 | 520                               |
| 44                                   | 27.244          | 1663.                                                                                  | 1.310                                                            | 251.8                         | 491.9               | 43.46                | 13.71                                 | 48.50                                 | 544                               |
| 46                                   | 29.861          | 1955.                                                                                  | 1.308                                                            | 279.1                         | 542.3               | 44.07                | 13.61                                 | 44.44                                 | 566                               |
| 48                                   | 32.476          | 2249.                                                                                  | 1.306                                                            | 306.3                         | 592.5               | 44.64                | 13.56                                 | 41.45                                 | 588                               |
| 50                                   | 35.090          | 2543.                                                                                  | 1.304                                                            | 333.4                         | 642.6               | 45.20                | 13.55                                 | 39.17                                 | 608                               |
| 55                                   | 41.609          | 3283.                                                                                  | 1.301                                                            | 401.4                         | 768.0               | 46.49                | 13.65                                 | 35.38                                 | 654                               |
| 60                                   | 48.110          | 4022.                                                                                  | 1.298                                                            | 470.5                         | 894.4               | 47.70                | 13.83                                 | 33.10                                 | 696                               |
| 65                                   | 54.599          | 4760.                                                                                  | 1.296                                                            | 540.4                         | 1021.5              | 48.82                | 14.15                                 | 31.72                                 | 732                               |
| 70                                   | 61.068          | 5497.                                                                                  | 1.293                                                            | 612.3                         | 1150.4              | 49.88                | 14.62                                 | 30.92                                 | 765                               |
| 75                                   | 67.506          | 6231.                                                                                  | 1.289                                                            | 686.8                         | 1281.6              | 50.91                | 15.20                                 | 30.54                                 | 793                               |
| 80                                   | 73.941          | 6963.                                                                                  | 1.286                                                            | 764.5                         | 1416.0              | 51.91                | 15.90                                 | 30.46                                 | 819                               |
| 85                                   | 80.368          | 7691.                                                                                  | 1.282                                                            | 846.0                         | 1554.1              | 52.90                | 16.68                                 | 30.60                                 | 842                               |
| 90                                   | 86.777          | 8417.                                                                                  | 1.278                                                            | 931.5                         | 1696.1              | 53.88                | 17.53                                 | 30.90                                 | 864                               |
| 95                                   | 93.154          | 9144.                                                                                  | 1.273                                                            | 1021.3                        | 1842.1              | 54.85                | 18.40                                 | 31.31                                 | 884                               |
| 100                                  | 99.505          | 9865.                                                                                  | 1.269                                                            | 1115.5                        | 1992.2              | 55.81                | 19.28                                 | 31.79                                 | 904                               |
| 0.0120 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.811                             | 12.454          | 45.91                                                                                  | 1.451                                                            | 71.9                          | 177.0               | 38.52                | 18.78                                 | 1077.27                               | 364                               |
| 33                                   | 12.724          | 77.04                                                                                  | 1.444                                                            | 75.9                          | 183.3               | 38.64                | 18.63                                 | 691.01                                | 366                               |
| 34                                   | 14.154          | 210.3                                                                                  | 1.420                                                            | 93.9                          | 213.4               | 39.17                | 17.32                                 | 246.58                                | 388                               |
| 35                                   | 15.564          | 347.5                                                                                  | 1.405                                                            | 110.6                         | 242.0               | 39.66                | 16.10                                 | 155.90                                | 411                               |
| 36                                   | 16.963          | 487.0                                                                                  | 1.397                                                            | 126.3                         | 269.5               | 40.10                | 15.40                                 | 116.91                                | 431                               |
| 37                                   | 18.358          | 628.4                                                                                  | 1.394                                                            | 141.4                         | 296.4               | 40.52                | 14.84                                 | 95.38                                 | 451                               |
| 38                                   | 19.752          | 771.8                                                                                  | 1.394                                                            | 155.8                         | 322.6               | 40.90                | 14.61                                 | 81.97                                 | 466                               |
| 39                                   | 21.143          | 916.2                                                                                  | 1.392                                                            | 170.3                         | 348.8               | 41.28                | 14.37                                 | 72.40                                 | 482                               |
| 40                                   | 22.531          | 1062.                                                                                  | 1.390                                                            | 184.6                         | 374.8               | 41.64                | 14.18                                 | 65.35                                 | 496                               |
| 42                                   | 25.303          | 1358.                                                                                  | 1.386                                                            | 212.6                         | 426.3               | 42.32                | 13.90                                 | 55.73                                 | 523                               |
| 44                                   | 28.073          | 1654.                                                                                  | 1.384                                                            | 240.2                         | 477.3               | 42.97                | 13.73                                 | 49.57                                 | 548                               |
| 46                                   | 30.838          | 1952.                                                                                  | 1.382                                                            | 267.6                         | 528.0               | 43.57                | 13.62                                 | 45.28                                 | 571                               |
| 48                                   | 33.601          | 2254.                                                                                  | 1.380                                                            | 294.8                         | 578.5               | 44.15                | 13.58                                 | 42.13                                 | 593                               |
| 50                                   | 36.364          | 2555.                                                                                  | 1.379                                                            | 321.9                         | 629.0               | 44.71                | 13.56                                 | 39.74                                 | 613                               |
| 55                                   | 43.258          | 3312.                                                                                  | 1.376                                                            | 389.9                         | 755.2               | 46.00                | 13.66                                 | 35.78                                 | 660                               |
| 60                                   | 50.132          | 4070.                                                                                  | 1.373                                                            | 459.2                         | 882.5               | 47.21                | 13.84                                 | 33.40                                 | 703                               |
| 65                                   | 56.995          | 4826.                                                                                  | 1.370                                                            | 529.1                         | 1010.4              | 48.33                | 14.17                                 | 31.96                                 | 740                               |
| 70                                   | 63.838          | 5587.                                                                                  | 1.367                                                            | 601.1                         | 1140.1              | 49.39                | 14.63                                 | 31.12                                 | 773                               |
| 75                                   | 70.647          | 6335.                                                                                  | 1.364                                                            | 675.7                         | 1272.2              | 50.42                | 15.22                                 | 30.71                                 | 801                               |
| 80                                   | 77.453          | 7084.                                                                                  | 1.360                                                            | 753.5                         | 1407.5              | 51.43                | 15.92                                 | 30.62                                 | 827                               |
| 85                                   | 84.247          | 7829.                                                                                  | 1.356                                                            | 835.0                         | 1546.4              | 52.42                | 16.71                                 | 30.75                                 | 851                               |
| 90                                   | 91.023          | 8577.                                                                                  | 1.351                                                            | 920.7                         | 1689.3              | 53.39                | 17.55                                 | 31.04                                 | 873                               |
| 95                                   | 97.769          | 9318.                                                                                  | 1.347                                                            | 1010.7                        | 1836.2              | 54.37                | 18.43                                 | 31.44                                 | 894                               |
| 100                                  | 104.485         | 10056.                                                                                 | 1.342                                                            | 1105.0                        | 1987.3              | 55.34                | 19.32                                 | 31.92                                 | 914                               |
| 0.0125 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.866                             | 12.555          | 31.18                                                                                  | 1.518                                                            | 60.7                          | 162.5               | 38.05                | 19.07                                 | 1594.65                               | 362                               |
| 33                                   | 12.754          | 49.31                                                                                  | 1.513                                                            | 63.7                          | 167.1               | 38.14                | 18.97                                 | 1012.79                               | 364                               |
| 34                                   | 14.252          | 184.7                                                                                  | 1.488                                                            | 82.0                          | 197.5               | 38.68                | 17.55                                 | 281.98                                | 386                               |
| 35                                   | 15.731          | 321.7                                                                                  | 1.474                                                            | 98.8                          | 226.4               | 39.17                | 16.21                                 | 169.49                                | 411                               |
| 36                                   | 17.200          | 462.6                                                                                  | 1.468                                                            | 114.7                         | 254.1               | 39.62                | 15.45                                 | 124.15                                | 432                               |
| 37                                   | 18.666          | 606.1                                                                                  | 1.466                                                            | 129.8                         | 281.1               | 40.03                | 14.84                                 | 99.92                                 | 453                               |
| 38                                   | 20.132          | 751.6                                                                                  | 1.467                                                            | 144.2                         | 307.4               | 40.42                | 14.64                                 | 85.19                                 | 469                               |
| 39                                   | 21.596          | 898.6                                                                                  | 1.465                                                            | 158.7                         | 333.8               | 40.79                | 14.40                                 | 74.82                                 | 484                               |
| 40                                   | 23.058          | 1048.                                                                                  | 1.464                                                            | 173.0                         | 359.9               | 41.16                | 14.20                                 | 67.23                                 | 499                               |
| 42                                   | 25.979          | 1350.                                                                                  | 1.461                                                            | 201.1                         | 411.7               | 41.84                | 13.92                                 | 57.00                                 | 527                               |
| 44                                   | 28.900          | 1653.                                                                                  | 1.459                                                            | 228.8                         | 463.0               | 42.49                | 13.74                                 | 50.51                                 | 553                               |
| 46                                   | 31.815          | 1958.                                                                                  | 1.458                                                            | 256.1                         | 514.0               | 43.09                | 13.64                                 | 46.02                                 | 576                               |
| 48                                   | 34.731          | 2266.                                                                                  | 1.457                                                            | 283.3                         | 564.9               | 43.67                | 13.59                                 | 42.73                                 | 598                               |
| 50                                   | 37.646          | 2575.                                                                                  | 1.455                                                            | 310.5                         | 615.7               | 44.23                | 13.57                                 | 40.25                                 | 619                               |
| 55                                   | 44.923          | 3351.                                                                                  | 1.453                                                            | 378.5                         | 742.7               | 45.52                | 13.67                                 | 36.13                                 | 667                               |
| 60                                   | 52.181          | 4127.                                                                                  | 1.450                                                            | 447.8                         | 870.8               | 46.73                | 13.85                                 | 33.67                                 | 710                               |
| 65                                   | 59.427          | 4903.                                                                                  | 1.447                                                            | 517.9                         | 999.6               | 47.85                | 14.18                                 | 32.18                                 | 748                               |
| 70                                   | 66.652          | 5678.                                                                                  | 1.443                                                            | 589.9                         | 1130.2              | 48.92                | 14.65                                 | 31.30                                 | 781                               |
| 75                                   | 73.843          | 6456.                                                                                  | 1.440                                                            | 664.6                         | 1263.1              | 49.95                | 15.24                                 | 30.87                                 | 810                               |
| 80                                   | 81.027          | 7217.                                                                                  | 1.435                                                            | 742.5                         | 1399.3              | 50.96                | 15.95                                 | 30.76                                 | 836                               |
| 85                                   | 88.199          | 7979.                                                                                  | 1.431                                                            | 824.2                         | 1539.1              | 51.95                | 16.73                                 | 30.88                                 | 860                               |
| 90                                   | 95.351          | 8740.                                                                                  | 1.426                                                            | 910.0                         | 1682.9              | 52.93                | 17.58                                 | 31.17                                 | 882                               |
| 95                                   | 102.474         | 9504.                                                                                  | 1.422                                                            | 1000.1                        | 1830.7              | 53.90                | 18.46                                 | 31.56                                 | 904                               |
| 100                                  | 109.564         | 10260.                                                                                 | 1.417                                                            | 1094.6                        | 1982.7              | 54.87                | 19.35                                 | 32.04                                 | 924                               |

\* TWO-PHASE BOUNDARY

TABLE X1. THERMOODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0130 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.908                             | 12.633          | 19.89                                                                                  | 1.583                                                            | 49.5                          | 148.0               | 37.59                | 19.34                                 | 2504.38                               | 360                               |
| 33                                   | 12.775          | 32.02                                                                                  | 1.580                                                            | 51.8                          | 151.4               | 37.66                | 19.28                                 | 1560.85                               | 361                               |
| 34                                   | 14.339          | 163.9                                                                                  | 1.556                                                            | 70.3                          | 182.1               | 38.21                | 17.75                                 | 318.81                                | 385                               |
| 35                                   | 15.886          | 301.0                                                                                  | 1.544                                                            | 87.3                          | 211.1               | 38.70                | 16.29                                 | 182.41                                | 412                               |
| 36                                   | 17.427          | 443.6                                                                                  | 1.539                                                            | 103.2                         | 239.0               | 39.15                | 15.49                                 | 130.77                                | 434                               |
| 37                                   | 18.965          | 589.4                                                                                  | 1.539                                                            | 118.3                         | 266.2               | 39.57                | 14.83                                 | 103.95                                | 456                               |
| 38                                   | 20.504          | 737.5                                                                                  | 1.540                                                            | 132.7                         | 292.5               | 39.95                | 14.66                                 | 87.97                                 | 472                               |
| 39                                   | 22.042          | 887.2                                                                                  | 1.540                                                            | 147.2                         | 319.1               | 40.33                | 14.41                                 | 76.89                                 | 488                               |
| 40                                   | 23.580          | 1040.                                                                                  | 1.539                                                            | 161.6                         | 345.3               | 40.69                | 14.22                                 | 68.84                                 | 503                               |
| 42                                   | 26.654          | 1349.                                                                                  | 1.538                                                            | 189.7                         | 397.4               | 41.38                | 13.93                                 | 58.07                                 | 532                               |
| 44                                   | 29.727          | 1658.                                                                                  | 1.537                                                            | 217.3                         | 449.0               | 42.02                | 13.75                                 | 51.31                                 | 558                               |
| 46                                   | 32.797          | 1971.                                                                                  | 1.536                                                            | 244.7                         | 500.4               | 42.63                | 13.65                                 | 46.65                                 | 582                               |
| 48                                   | 35.869          | 2287.                                                                                  | 1.535                                                            | 272.0                         | 551.5               | 43.21                | 13.59                                 | 43.24                                 | 605                               |
| 50                                   | 38.940          | 2603.                                                                                  | 1.534                                                            | 299.1                         | 602.7               | 43.76                | 13.58                                 | 40.68                                 | 626                               |
| 55                                   | 46.610          | 3399.                                                                                  | 1.531                                                            | 367.2                         | 730.5               | 45.06                | 13.68                                 | 36.43                                 | 674                               |
| 60                                   | 54.261          | 4194.                                                                                  | 1.528                                                            | 436.6                         | 859.5               | 46.27                | 13.87                                 | 33.90                                 | 718                               |
| 65                                   | 61.900          | 4990.                                                                                  | 1.525                                                            | 506.7                         | 989.1               | 47.39                | 14.19                                 | 32.36                                 | 756                               |
| 70                                   | 69.517          | 5784.                                                                                  | 1.521                                                            | 578.8                         | 1120.6              | 48.46                | 14.66                                 | 31.46                                 | 790                               |
| 75                                   | 77.099          | 6576.                                                                                  | 1.517                                                            | 653.5                         | 1254.5              | 49.49                | 15.26                                 | 31.01                                 | 819                               |
| 80                                   | 84.671          | 7362.                                                                                  | 1.513                                                            | 731.6                         | 1391.5              | 50.50                | 15.97                                 | 30.88                                 | 846                               |
| 85                                   | 92.229          | 8142.                                                                                  | 1.508                                                            | 813.4                         | 1532.2              | 51.49                | 16.76                                 | 31.00                                 | 870                               |
| 90                                   | 99.766          | 8921.                                                                                  | 1.504                                                            | 899.3                         | 1676.9              | 52.47                | 17.61                                 | 31.28                                 | 892                               |
| 95                                   | 107.276         | 9704.                                                                                  | 1.498                                                            | 989.5                         | 1825.7              | 53.44                | 18.49                                 | 31.67                                 | 914                               |
| 100                                  | 114.748         | 10478.                                                                                 | 1.493                                                            | 1084.2                        | 1978.6              | 54.42                | 19.38                                 | 32.14                                 | 934                               |
| 0.0135 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.938                             | 12.688          | 11.48                                                                                  | 1.644                                                            | 38.5                          | 133.7               | 37.14                | 19.57                                 | 4332.45                               | 357                               |
| 33                                   | 12.787          | 19.43                                                                                  | 1.642                                                            | 40.1                          | 136.1               | 37.19                | 19.54                                 | 2566.29                               | 358                               |
| 34                                   | 14.417          | 147.7                                                                                  | 1.623                                                            | 58.9                          | 167.1               | 37.75                | 17.91                                 | 354.86                                | 384                               |
| 35                                   | 16.033          | 285.3                                                                                  | 1.614                                                            | 76.0                          | 196.3               | 38.25                | 16.34                                 | 193.96                                | 413                               |
| 36                                   | 17.645          | 430.0                                                                                  | 1.612                                                            | 91.9                          | 224.3               | 38.70                | 15.50                                 | 136.43                                | 436                               |
| 37                                   | 19.256          | 578.6                                                                                  | 1.613                                                            | 107.0                         | 251.6               | 39.11                | 14.81                                 | 107.30                                | 459                               |
| 38                                   | 20.871          | 729.5                                                                                  | 1.615                                                            | 121.4                         | 278.0               | 39.49                | 14.66                                 | 90.24                                 | 475                               |
| 39                                   | 22.485          | 887.3                                                                                  | 1.616                                                            | 135.9                         | 304.7               | 39.87                | 14.42                                 | 78.55                                 | 492                               |
| 40                                   | 24.099          | 1038.                                                                                  | 1.616                                                            | 150.2                         | 331.1               | 40.23                | 14.22                                 | 70.13                                 | 507                               |
| 42                                   | 27.329          | 1355.                                                                                  | 1.616                                                            | 178.4                         | 383.5               | 40.92                | 13.93                                 | 58.93                                 | 537                               |
| 44                                   | 30.559          | 1677.                                                                                  | 1.616                                                            | 206.0                         | 435.4               | 41.56                | 13.75                                 | 51.95                                 | 563                               |
| 46                                   | 33.787          | 1997.                                                                                  | 1.615                                                            | 233.4                         | 487.0               | 42.17                | 13.65                                 | 47.16                                 | 588                               |
| 48                                   | 37.019          | 2316.                                                                                  | 1.615                                                            | 260.7                         | 538.5               | 42.75                | 13.60                                 | 43.65                                 | 611                               |
| 50                                   | 40.251          | 2640.                                                                                  | 1.614                                                            | 287.9                         | 590.0               | 43.31                | 13.59                                 | 41.03                                 | 633                               |
| 55                                   | 48.324          | 3454.                                                                                  | 1.612                                                            | 356.0                         | 718.7               | 44.61                | 13.69                                 | 36.68                                 | 682                               |
| 60                                   | 56.377          | 4277.                                                                                  | 1.609                                                            | 425.4                         | 848.5               | 45.81                | 13.88                                 | 34.10                                 | 726                               |
| 65                                   | 64.419          | 5088.                                                                                  | 1.606                                                            | 495.5                         | 979.0               | 46.94                | 14.21                                 | 32.52                                 | 765                               |
| 70                                   | 72.438          | 5907.                                                                                  | 1.602                                                            | 567.7                         | 1111.4              | 48.01                | 14.68                                 | 31.59                                 | 799                               |
| 75                                   | 80.421          | 6714.                                                                                  | 1.597                                                            | 642.6                         | 1246.2              | 49.04                | 15.28                                 | 31.12                                 | 829                               |
| 80                                   | 88.391          | 7519.                                                                                  | 1.592                                                            | 720.7                         | 1384.1              | 50.05                | 15.99                                 | 30.99                                 | 856                               |
| 85                                   | 96.343          | 8318.                                                                                  | 1.588                                                            | 802.6                         | 1525.7              | 51.04                | 16.78                                 | 31.10                                 | 880                               |
| 90                                   | 104.275         | 9117.                                                                                  | 1.582                                                            | 888.6                         | 1671.3              | 52.02                | 17.64                                 | 31.38                                 | 903                               |
| 95                                   | 112.181         | 9918.                                                                                  | 1.577                                                            | 979.0                         | 1821.0              | 53.00                | 18.52                                 | 31.77                                 | 925                               |
| 100                                  | 120.044         | 10711.                                                                                 | 1.572                                                            | 1073.9                        | 1974.9              | 53.97                | 19.42                                 | 32.24                                 | 945                               |
| 0.0140 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.958                             | 12.726          | 5.523                                                                                  | 1.703                                                            | 27.5                          | 119.6               | 36.71                | 19.74                                 | 8968.32                               | 355                               |
| 33                                   | 12.795          | 10.78                                                                                  | 1.702                                                            | 28.8                          | 121.4               | 36.74                | 19.73                                 | 4606.63                               | 356                               |
| 34                                   | 14.488          | 135.9                                                                                  | 1.689                                                            | 47.6                          | 152.5               | 37.31                | 18.01                                 | 387.00                                | 383                               |
| 35                                   | 16.172          | 274.7                                                                                  | 1.685                                                            | 64.8                          | 181.9               | 37.81                | 16.35                                 | 203.35                                | 414                               |
| 36                                   | 17.858          | 421.9                                                                                  | 1.686                                                            | 80.7                          | 210.0               | 38.25                | 15.50                                 | 140.88                                | 439                               |
| 37                                   | 19.544          | 573.6                                                                                  | 1.689                                                            | 95.9                          | 237.3               | 38.67                | 14.78                                 | 109.86                                | 463                               |
| 38                                   | 21.235          | 727.7                                                                                  | 1.692                                                            | 110.2                         | 263.9               | 39.05                | 14.66                                 | 91.90                                 | 479                               |
| 39                                   | 22.926          | 884.1                                                                                  | 1.693                                                            | 124.7                         | 290.6               | 39.43                | 14.41                                 | 79.77                                 | 496                               |
| 40                                   | 24.619          | 1044.                                                                                  | 1.694                                                            | 139.0                         | 317.2               | 39.79                | 14.21                                 | 71.07                                 | 512                               |
| 42                                   | 28.010          | 1368.                                                                                  | 1.696                                                            | 167.1                         | 369.9               | 40.48                | 13.93                                 | 59.57                                 | 542                               |
| 44                                   | 31.400          | 1693.                                                                                  | 1.697                                                            | 194.8                         | 422.1               | 41.12                | 13.75                                 | 52.43                                 | 570                               |
| 46                                   | 34.790          | 2021.                                                                                  | 1.697                                                            | 222.2                         | 474.0               | 41.73                | 13.65                                 | 47.54                                 | 595                               |
| 48                                   | 38.186          | 2354.                                                                                  | 1.697                                                            | 249.5                         | 525.8               | 42.31                | 13.60                                 | 43.97                                 | 618                               |
| 50                                   | 41.582          | 2687.                                                                                  | 1.697                                                            | 276.6                         | 577.6               | 42.86                | 13.59                                 | 41.30                                 | 641                               |
| 55                                   | 50.068          | 3523.                                                                                  | 1.695                                                            | 344.8                         | 707.2               | 44.16                | 13.70                                 | 36.88                                 | 691                               |
| 60                                   | 58.535          | 4360.                                                                                  | 1.692                                                            | 414.2                         | 837.9               | 45.37                | 13.89                                 | 34.25                                 | 735                               |
| 65                                   | 66.989          | 5198.                                                                                  | 1.688                                                            | 484.5                         | 969.3               | 46.50                | 14.22                                 | 32.64                                 | 774                               |
| 70                                   | 75.421          | 6034.                                                                                  | 1.684                                                            | 556.7                         | 1102.6              | 47.57                | 14.70                                 | 31.70                                 | 809                               |
| 75                                   | 83.815          | 6865.                                                                                  | 1.679                                                            | 631.7                         | 1238.3              | 48.60                | 15.30                                 | 31.22                                 | 839                               |
| 80                                   | 92.193          | 7690.                                                                                  | 1.674                                                            | 709.9                         | 1377.1              | 49.61                | 16.01                                 | 31.08                                 | 866                               |
| 85                                   | 100.549         | 8508.                                                                                  | 1.669                                                            | 791.9                         | 1519.6              | 50.60                | 16.81                                 | 31.19                                 | 891                               |
| 90                                   | 108.885         | 9326.                                                                                  | 1.663                                                            | 878.1                         | 1666.1              | 51.59                | 17.66                                 | 31.46                                 | 914                               |
| 95                                   | 117.196         | 10147.                                                                                 | 1.658                                                            | 968.6                         | 1816.8              | 52.57                | 18.55                                 | 31.85                                 | 936                               |
| 100                                  | 125.461         | 10958.                                                                                 | 1.652                                                            | 1063.6                        | 1971.6              | 53.54                | 19.45                                 | 32.32                                 | 957                               |

• TWO-PHASE BOUNDARY

TABLE X1. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN            | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|---------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0145 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.970                              | 12.748          | 1.655                                                                                 | 1.759                                                            | 16.7                          | 105.8               | 36.28                | 19.82                                 |                                       | 353                               |
| 33                                    | 12.799          | 5.341                                                                                 | 1.758                                                            | 17.7                          | 107.2               | 36.31                | 19.84                                 | 9225.50                               | 353                               |
| 34                                    | 14.554          | 128.2                                                                                 | 1.755                                                            | 36.7                          | 138.4               | 36.88                | 18.05                                 | 411.55                                | 383                               |
| 35                                    | 16.308          | 269.0                                                                                 | 1.757                                                            | 53.8                          | 167.8               | 37.38                | 16.33                                 | 209.88                                | 417                               |
| 36                                    | 18.068          | 419.3                                                                                 | 1.761                                                            | 69.7                          | 196.0               | 37.82                | 15.47                                 | 143.85                                | 443                               |
| 37                                    | 19.831          | 574.7                                                                                 | 1.766                                                            | 84.8                          | 223.4               | 38.24                | 14.74                                 | 111.51                                | 467                               |
| 38                                    | 21.600          | 732.4                                                                                 | 1.769                                                            | 99.1                          | 250.1               | 38.62                | 14.63                                 | 92.92                                 | 483                               |
| 39                                    | 23.370          | 892.7                                                                                 | 1.772                                                            | 113.6                         | 276.9               | 39.00                | 14.39                                 | 80.51                                 | 501                               |
| 40                                    | 25.144          | 1056.                                                                                 | 1.774                                                            | 127.9                         | 303.6               | 39.36                | 14.20                                 | 71.65                                 | 518                               |
| 42                                    | 28.699          | 1389.                                                                                 | 1.778                                                            | 156.0                         | 356.6               | 40.04                | 13.92                                 | 59.98                                 | 548                               |
| 44                                    | 32.254          | 1723.                                                                                 | 1.780                                                            | 183.7                         | 409.1               | 40.69                | 13.75                                 | 52.74                                 | 576                               |
| 46                                    | 35.810          | 2060.                                                                                 | 1.781                                                            | 211.1                         | 461.3               | 41.30                | 13.65                                 | 47.80                                 | 602                               |
| 48                                    | 39.374          | 2401.                                                                                 | 1.782                                                            | 238.3                         | 513.4               | 41.87                | 13.60                                 | 44.19                                 | 626                               |
| 50                                    | 42.939          | 2743.                                                                                 | 1.782                                                            | 265.5                         | 565.5               | 42.43                | 13.59                                 | 41.49                                 | 649                               |
| 55                                    | 51.849          | 3601.                                                                                 | 1.780                                                            | 333.7                         | 696.0               | 43.73                | 13.70                                 | 37.03                                 | 699                               |
| 60                                    | 60.739          | 4460.                                                                                 | 1.777                                                            | 403.2                         | 827.6               | 44.94                | 13.90                                 | 34.37                                 | 744                               |
| 65                                    | 69.618          | 5319.                                                                                 | 1.772                                                            | 473.4                         | 959.9               | 46.06                | 14.24                                 | 32.74                                 | 784                               |
| 70                                    | 78.473          | 6176.                                                                                 | 1.768                                                            | 545.8                         | 1094.1              | 47.14                | 14.71                                 | 31.78                                 | 819                               |
| 75                                    | 87.288          | 7029.                                                                                 | 1.763                                                            | 620.8                         | 1230.8              | 48.17                | 15.32                                 | 31.29                                 | 850                               |
| 80                                    | 96.083          | 7874.                                                                                 | 1.757                                                            | 699.1                         | 1370.6              | 49.18                | 16.03                                 | 31.15                                 | 877                               |
| 85                                    | 104.854         | 8713.                                                                                 | 1.752                                                            | 781.3                         | 1514.0              | 50.18                | 16.83                                 | 31.26                                 | 902                               |
| 90                                    | 113.604         | 9551.                                                                                 | 1.746                                                            | 867.5                         | 1661.4              | 51.16                | 17.69                                 | 31.53                                 | 925                               |
| 95                                    | 122.330         | 10390.                                                                                | 1.740                                                            | 958.2                         | 1813.0              | 52.14                | 18.58                                 | 31.92                                 | 947                               |
| 100                                   | 131.005         | 11221.                                                                                | 1.735                                                            | 1053.3                        | 1968.8              | 53.12                | 19.47                                 | 32.40                                 | 969                               |
| 0.0150 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.975                              | 12.757          | 0.512                                                                                 | 1.812                                                            | 6.0                           | 92.2                | 35.87                | 19.81                                 |                                       | 352                               |
| 33                                    | 12.800          | 7.543                                                                                 | 1.812                                                            | 7.0                           | 93.4                | 35.90                | 19.83                                 | 19210.94                              | 352                               |
| 34                                    | 14.617          | 124.8                                                                                 | 1.821                                                            | 25.9                          | 124.6               | 36.46                | 18.02                                 | 424.99                                | 385                               |
| 35                                    | 16.442          | 268.5                                                                                 | 1.831                                                            | 43.0                          | 154.1               | 36.96                | 16.27                                 | 212.97                                | 420                               |
| 36                                    | 18.278          | 422.5                                                                                 | 1.839                                                            | 58.9                          | 182.3               | 37.40                | 15.43                                 | 145.17                                | 447                               |
| 37                                    | 20.120          | 587.0                                                                                 | 1.845                                                            | 73.9                          | 209.8               | 37.82                | 14.69                                 | 112.17                                | 473                               |
| 38                                    | 21.968          | 744.0                                                                                 | 1.849                                                            | 88.2                          | 236.6               | 38.20                | 14.60                                 | 93.25                                 | 489                               |
| 39                                    | 23.820          | 908.6                                                                                 | 1.853                                                            | 102.7                         | 263.6               | 38.57                | 14.36                                 | 80.75                                 | 507                               |
| 40                                    | 25.677          | 1076.                                                                                 | 1.857                                                            | 116.9                         | 290.4               | 38.94                | 14.17                                 | 71.87                                 | 524                               |
| 42                                    | 29.400          | 1418.                                                                                 | 1.862                                                            | 145.0                         | 343.6               | 39.62                | 13.90                                 | 60.15                                 | 555                               |
| 44                                    | 33.124          | 1761.                                                                                 | 1.865                                                            | 172.6                         | 396.4               | 40.26                | 13.74                                 | 52.88                                 | 584                               |
| 46                                    | 36.851          | 2108.                                                                                 | 1.868                                                            | 200.0                         | 448.9               | 40.87                | 13.64                                 | 47.92                                 | 610                               |
| 48                                    | 40.589          | 2458.                                                                                 | 1.869                                                            | 227.2                         | 501.4               | 41.45                | 13.60                                 | 44.31                                 | 634                               |
| 50                                    | 44.327          | 2809.                                                                                 | 1.869                                                            | 254.4                         | 553.8               | 42.00                | 13.60                                 | 41.60                                 | 657                               |
| 55                                    | 53.671          | 3690.                                                                                 | 1.867                                                            | 322.6                         | 685.2               | 43.30                | 13.71                                 | 37.12                                 | 709                               |
| 60                                    | 62.996          | 4571.                                                                                 | 1.864                                                            | 392.1                         | 817.7               | 44.52                | 13.91                                 | 34.44                                 | 754                               |
| 65                                    | 72.311          | 5454.                                                                                 | 1.859                                                            | 462.5                         | 950.9               | 45.64                | 14.25                                 | 32.80                                 | 794                               |
| 70                                    | 81.599          | 6332.                                                                                 | 1.854                                                            | 534.9                         | 1086.1              | 46.71                | 14.73                                 | 31.84                                 | 829                               |
| 75                                    | 90.847          | 7207.                                                                                 | 1.848                                                            | 610.0                         | 1223.7              | 47.75                | 15.34                                 | 31.35                                 | 860                               |
| 80                                    | 100.069         | 8073.                                                                                 | 1.842                                                            | 688.5                         | 1364.4              | 48.76                | 16.05                                 | 31.20                                 | 888                               |
| 85                                    | 109.265         | 8937.                                                                                 | 1.837                                                            | 770.7                         | 1508.8              | 49.76                | 16.85                                 | 31.31                                 | 913                               |
| 90                                    | 118.439         | 9792.                                                                                 | 1.831                                                            | 857.1                         | 1657.1              | 50.75                | 17.71                                 | 31.58                                 | 937                               |
| 95                                    | 127.589         | 10650.                                                                                | 1.825                                                            | 947.9                         | 1809.7              | 51.73                | 18.60                                 | 31.98                                 | 959                               |
| 100                                   | 136.685         | 11500.                                                                                | 1.819                                                            | 1043.1                        | 1966.4              | 52.71                | 19.50                                 | 32.46                                 | 981                               |
| 0.0155 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.976                              | 12.759          | 0.962                                                                                 | 1.864                                                            | -4.4                          | 79.0                | 35.47                | 19.69                                 |                                       | 351                               |
| 33                                    | 12.801          | 7.005                                                                                 | 1.865                                                            | -3.4                          | 80.2                | 35.50                | 19.71                                 | 24160.64                              | 351                               |
| 34                                    | 14.679          | 125.6                                                                                 | 1.888                                                            | 15.4                          | 111.3               | 36.06                | 17.91                                 | 424.85                                | 387                               |
| 35                                    | 16.578          | 273.4                                                                                 | 1.906                                                            | 32.4                          | 140.8               | 36.55                | 16.17                                 | 212.31                                | 425                               |
| 36                                    | 18.491          | 431.8                                                                                 | 1.918                                                            | 48.2                          | 169.0               | 37.00                | 15.37                                 | 144.76                                | 452                               |
| 37                                    | 20.414          | 595.9                                                                                 | 1.927                                                            | 63.2                          | 196.6               | 37.41                | 14.64                                 | 111.85                                | 478                               |
| 38                                    | 22.345          | 767.7                                                                                 | 1.931                                                            | 77.4                          | 223.4               | 37.79                | 14.56                                 | 92.90                                 | 495                               |
| 39                                    | 24.280          | 937.1                                                                                 | 1.937                                                            | 91.8                          | 250.5               | 38.16                | 14.33                                 | 80.50                                 | 513                               |
| 40                                    | 26.222          | 1104.                                                                                 | 1.941                                                            | 106.0                         | 277.5               | 38.52                | 14.14                                 | 71.70                                 | 531                               |
| 42                                    | 30.118          | 1455.                                                                                 | 1.948                                                            | 134.0                         | 330.9               | 39.20                | 13.88                                 | 60.08                                 | 563                               |
| 44                                    | 34.017          | 1809.                                                                                 | 1.953                                                            | 161.6                         | 384.0               | 39.85                | 13.72                                 | 52.85                                 | 592                               |
| 46                                    | 37.919          | 2168.                                                                                 | 1.956                                                            | 189.0                         | 436.8               | 40.45                | 13.63                                 | 47.92                                 | 619                               |
| 48                                    | 41.834          | 2525.                                                                                 | 1.958                                                            | 216.2                         | 489.7               | 41.03                | 13.59                                 | 44.33                                 | 643                               |
| 50                                    | 45.750          | 2886.                                                                                 | 1.959                                                            | 243.4                         | 542.4               | 41.59                | 13.59                                 | 41.63                                 | 666                               |
| 55                                    | 55.541          | 3791.                                                                                 | 1.957                                                            | 311.6                         | 674.7               | 42.89                | 13.72                                 | 37.16                                 | 718                               |
| 60                                    | 65.313          | 4698.                                                                                 | 1.953                                                            | 381.2                         | 808.1               | 44.10                | 13.92                                 | 34.48                                 | 765                               |
| 65                                    | 75.074          | 5601.                                                                                 | 1.948                                                            | 451.6                         | 942.3               | 45.23                | 14.27                                 | 32.84                                 | 805                               |
| 70                                    | 84.807          | 6502.                                                                                 | 1.942                                                            | 524.1                         | 1078.5              | 46.30                | 14.75                                 | 31.88                                 | 840                               |
| 75                                    | 94.498          | 7400.                                                                                 | 1.936                                                            | 599.3                         | 1217.0              | 47.34                | 15.36                                 | 31.38                                 | 872                               |
| 80                                    | 104.158         | 8287.                                                                                 | 1.930                                                            | 677.8                         | 1358.7              | 48.35                | 16.07                                 | 31.24                                 | 900                               |
| 85                                    | 113.789         | 9168.                                                                                 | 1.924                                                            | 760.2                         | 1504.0              | 49.35                | 16.87                                 | 31.35                                 | 925                               |
| 90                                    | 123.398         | 10049.                                                                                | 1.918                                                            | 846.7                         | 1653.3              | 50.34                | 17.73                                 | 31.62                                 | 949                               |
| 95                                    | 132.982         | 10925.                                                                                | 1.912                                                            | 937.6                         | 1806.9              | 51.32                | 18.63                                 | 32.03                                 | 972                               |
| 100                                   | 142.508         | 11796.                                                                                | 1.906                                                            | 1033.0                        | 1964.6              | 52.30                | 19.53                                 | 32.51                                 | 994                               |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_P$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0160 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                     |                                                               |                               |                     |                      |                                       |                                       |                                   |
| * 32.975                             | 12.757          | 0.433                                                                               | 1.916                                                         | -13.6                         | 67.2                | 35.11                | 19.68                                 |                                       | 350                               |
| 33                                   | 12.803          | 0.620                                                                               | 1.918                                                         | -13.1                         | 68.0                | 35.12                | 19.63                                 | 13288.98                              | 351                               |
| 34                                   | 14.743          | 131.1                                                                               | 1.957                                                         | 5.6                           | 99.0                | 35.68                | 17.75                                 | 410.92                                | 390                               |
| 35                                   | 16.717          | 284.1                                                                               | 1.984                                                         | 22.4                          | 128.2               | 36.17                | 15.79                                 | 207.68                                | 433                               |
| 36                                   | 18.711          | 447.6                                                                               | 2.000                                                         | 37.8                          | 156.3               | 36.60                | 15.10                                 | 142.46                                | 461                               |
| 37                                   | 20.717          | 616.9                                                                               | 2.011                                                         | 52.7                          | 183.9               | 37.01                | 14.57                                 | 110.54                                | 485                               |
| 38                                   | 22.732          | 789.0                                                                               | 2.015                                                         | 66.6                          | 210.6               | 37.38                | 14.44                                 | 91.84                                 | 502                               |
| 39                                   | 24.753          | 963.8                                                                               | 2.022                                                         | 81.0                          | 237.7               | 37.75                | 14.26                                 | 79.76                                 | 520                               |
| 40                                   | 26.783          | 1141.                                                                               | 2.028                                                         | 95.2                          | 264.8               | 38.11                | 14.11                                 | 71.19                                 | 538                               |
| 42                                   | 30.857          | 1507.                                                                               | 2.037                                                         | 123.1                         | 318.5               | 38.79                | 13.87                                 | 59.81                                 | 571                               |
| 44                                   | 34.935          | 1867.                                                                               | 2.044                                                         | 150.7                         | 371.9               | 39.44                | 13.71                                 | 52.67                                 | 600                               |
| 46                                   | 39.018          | 2233.                                                                               | 2.048                                                         | 178.0                         | 425.1               | 40.04                | 13.62                                 | 47.80                                 | 628                               |
| 48                                   | 43.116          | 2603.                                                                               | 2.050                                                         | 205.2                         | 478.3               | 40.62                | 13.59                                 | 44.25                                 | 653                               |
| 50                                   | 47.214          | 2974.                                                                               | 2.051                                                         | 232.4                         | 531.4               | 41.18                | 13.59                                 | 41.58                                 | 676                               |
| 55                                   | 57.464          | 3904.                                                                               | 2.049                                                         | 300.6                         | 664.5               | 42.48                | 13.72                                 | 37.15                                 | 729                               |
| 60                                   | 67.694          | 4833.                                                                               | 2.045                                                         | 370.3                         | 798.9               | 43.69                | 13.93                                 | 34.49                                 | 775                               |
| 65                                   | 77.914          | 5763.                                                                               | 2.039                                                         | 440.7                         | 934.2               | 44.82                | 14.28                                 | 32.85                                 | 816                               |
| 70                                   | 88.104          | 6687.                                                                               | 2.033                                                         | 513.3                         | 1071.3              | 45.89                | 14.77                                 | 31.89                                 | 852                               |
| 75                                   | 98.249          | 7607.                                                                               | 2.026                                                         | 588.6                         | 1210.8              | 46.93                | 15.38                                 | 31.40                                 | 884                               |
| 80                                   | 108.358         | 8516.                                                                               | 2.020                                                         | 667.3                         | 1353.5              | 47.95                | 16.10                                 | 31.26                                 | 912                               |
| 85                                   | 118.435         | 9420.                                                                               | 2.013                                                         | 749.7                         | 1499.8              | 48.95                | 16.90                                 | 31.37                                 | 938                               |
| 90                                   | 128.491         | 10323.                                                                              | 2.006                                                         | 836.3                         | 1650.0              | 49.94                | 17.76                                 | 31.65                                 | 962                               |
| 95                                   | 138.517         | 11218.                                                                              | 2.000                                                         | 927.4                         | 1804.6              | 50.92                | 18.65                                 | 32.06                                 | 985                               |
| 100                                  | 148.484         | 12110.                                                                              | 1.994                                                         | 1022.9                        | 1963.2              | 51.90                | 19.55                                 | 32.55                                 | 1007                              |
| 0.0165 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                     |                                                               |                               |                     |                      |                                       |                                       |                                   |
| * 32.972                             | 12.752          | 3.858                                                                               | 1.970                                                         | -23.5                         | 54.8                | 34.73                | 19.33                                 | 12368.44                              | 352                               |
| 33                                   | 12.806          | 7.611                                                                               | 1.972                                                         | -22.9                         | 55.7                | 34.75                | 19.28                                 | 6297.36                               | 353                               |
| 34                                   | 14.811          | 141.7                                                                               | 2.029                                                         | -4.6                          | 86.4                | 35.30                | 17.50                                 | 385.09                                | 396                               |
| 35                                   | 16.863          | 301.1                                                                               | 2.064                                                         | 12.0                          | 115.6               | 35.78                | 15.63                                 | 200.00                                | 440                               |
| 36                                   | 18.940          | 477.4                                                                               | 2.085                                                         | 27.3                          | 143.6               | 36.21                | 15.00                                 | 138.80                                | 468                               |
| 37                                   | 21.032          | 645.6                                                                               | 2.098                                                         | 42.1                          | 171.2               | 36.61                | 14.50                                 | 108.34                                | 492                               |
| 38                                   | 23.135          | 823.6                                                                               | 2.102                                                         | 56.0                          | 198.1               | 36.99                | 14.37                                 | 90.24                                 | 510                               |
| 39                                   | 25.245          | 1004.                                                                               | 2.111                                                         | 70.3                          | 225.3               | 37.36                | 14.21                                 | 78.60                                 | 528                               |
| 40                                   | 27.364          | 1187.                                                                               | 2.118                                                         | 84.4                          | 252.5               | 37.71                | 14.06                                 | 70.34                                 | 546                               |
| 42                                   | 31.622          | 1559.                                                                               | 2.129                                                         | 112.3                         | 306.5               | 38.39                | 13.83                                 | 59.29                                 | 579                               |
| 44                                   | 35.885          | 1935.                                                                               | 2.137                                                         | 139.8                         | 360.2               | 39.03                | 13.68                                 | 52.32                                 | 610                               |
| 46                                   | 40.154          | 2312.                                                                               | 2.141                                                         | 167.1                         | 413.7               | 39.64                | 13.60                                 | 47.55                                 | 637                               |
| 48                                   | 44.439          | 2693.                                                                               | 2.144                                                         | 194.3                         | 467.2               | 40.22                | 13.58                                 | 44.08                                 | 663                               |
| 50                                   | 48.726          | 3074.                                                                               | 2.145                                                         | 221.5                         | 520.7               | 40.78                | 13.59                                 | 41.45                                 | 686                               |
| 55                                   | 59.446          | 4030.                                                                               | 2.144                                                         | 289.7                         | 654.8               | 42.08                | 13.73                                 | 37.08                                 | 740                               |
| 60                                   | 70.148          | 4984.                                                                               | 2.139                                                         | 359.4                         | 790.2               | 43.29                | 13.95                                 | 34.46                                 | 787                               |
| 65                                   | 80.839          | 5939.                                                                               | 2.133                                                         | 430.0                         | 926.4               | 44.42                | 14.30                                 | 32.83                                 | 828                               |
| 70                                   | 91.496          | 6886.                                                                               | 2.126                                                         | 502.6                         | 1064.5              | 45.50                | 14.79                                 | 31.88                                 | 864                               |
| 75                                   | 102.107         | 7830.                                                                               | 2.119                                                         | 578.0                         | 1205.1              | 46.54                | 15.40                                 | 31.40                                 | 896                               |
| 80                                   | 112.677         | 8762.                                                                               | 2.111                                                         | 656.8                         | 1348.7              | 47.55                | 16.12                                 | 31.27                                 | 924                               |
| 85                                   | 123.212         | 9689.                                                                               | 2.104                                                         | 739.3                         | 1496.0              | 48.55                | 16.92                                 | 31.38                                 | 950                               |
| 90                                   | 133.725         | 10615.                                                                              | 2.097                                                         | 826.1                         | 1647.3              | 49.54                | 17.78                                 | 31.66                                 | 975                               |
| 95                                   | 144.203         | 11529.                                                                              | 2.091                                                         | 917.2                         | 1802.7              | 50.53                | 18.67                                 | 32.08                                 | 998                               |
| 100                                  | 154.621         | 12441.                                                                              | 2.085                                                         | 1012.8                        | 1962.3              | 51.51                | 19.57                                 | 32.57                                 | 1020                              |
| 0.0170 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                     |                                                               |                               |                     |                      |                                       |                                       |                                   |
| * 32.963                             | 12.735          | 9.263                                                                               | 2.028                                                         | -33.3                         | 42.6                | 34.36                | 18.89                                 | 5151.35                               | 356                               |
| 33                                   | 12.811          | 14.57                                                                               | 2.032                                                         | -32.6                         | 43.8                | 34.39                | 18.83                                 | 3297.29                               | 358                               |
| 34                                   | 14.886          | 158.0                                                                               | 2.104                                                         | -14.6                         | 74.2                | 34.92                | 17.18                                 | 351.12                                | 403                               |
| 35                                   | 17.019          | 325.1                                                                               | 2.148                                                         | 1.8                           | 103.2               | 35.40                | 15.46                                 | 189.65                                | 448                               |
| 36                                   | 19.182          | 501.0                                                                               | 2.173                                                         | 16.9                          | 131.3               | 35.82                | 14.89                                 | 133.80                                | 476                               |
| 37                                   | 21.364          | 682.7                                                                               | 2.187                                                         | 31.6                          | 158.9               | 36.23                | 14.43                                 | 105.35                                | 501                               |
| 38                                   | 23.557          | 867.2                                                                               | 2.192                                                         | 45.5                          | 185.9               | 36.60                | 14.30                                 | 88.13                                 | 518                               |
| 39                                   | 25.759          | 1054.                                                                               | 2.202                                                         | 59.7                          | 213.3               | 36.97                | 14.15                                 | 77.06                                 | 537                               |
| 40                                   | 27.971          | 1242.                                                                               | 2.211                                                         | 73.8                          | 240.5               | 37.32                | 14.01                                 | 69.18                                 | 555                               |
| 42                                   | 32.418          | 1626.                                                                               | 2.224                                                         | 101.6                         | 294.8               | 38.00                | 13.80                                 | 58.58                                 | 589                               |
| 44                                   | 36.872          | 2014.                                                                               | 2.232                                                         | 129.0                         | 348.8               | 38.64                | 13.66                                 | 51.82                                 | 620                               |
| 46                                   | 41.333          | 2403.                                                                               | 2.238                                                         | 156.3                         | 402.7               | 39.25                | 13.59                                 | 47.19                                 | 648                               |
| 48                                   | 45.811          | 2795.                                                                               | 2.241                                                         | 183.5                         | 456.5               | 39.83                | 13.57                                 | 43.81                                 | 673                               |
| 50                                   | 50.291          | 3188.                                                                               | 2.243                                                         | 210.6                         | 510.4               | 40.38                | 13.59                                 | 41.25                                 | 697                               |
| 55                                   | 61.495          | 4169.                                                                               | 2.241                                                         | 278.9                         | 645.4               | 41.68                | 13.74                                 | 36.97                                 | 751                               |
| 60                                   | 72.680          | 5150.                                                                               | 2.236                                                         | 348.6                         | 781.8               | 42.90                | 13.96                                 | 34.39                                 | 798                               |
| 65                                   | 83.855          | 6130.                                                                               | 2.229                                                         | 419.2                         | 919.0               | 44.03                | 14.32                                 | 32.79                                 | 840                               |
| 70                                   | 94.993          | 7102.                                                                               | 2.221                                                         | 492.0                         | 1058.2              | 45.10                | 14.81                                 | 31.86                                 | 876                               |
| 75                                   | 106.081         | 8069.                                                                               | 2.213                                                         | 567.5                         | 1199.8              | 46.15                | 15.42                                 | 31.38                                 | 909                               |
| 80                                   | 117.123         | 9024.                                                                               | 2.206                                                         | 646.3                         | 1344.4              | 47.16                | 16.14                                 | 31.26                                 | 937                               |
| 85                                   | 128.127         | 9976.                                                                               | 2.198                                                         | 729.0                         | 1492.7              | 48.17                | 16.94                                 | 31.37                                 | 964                               |
| 90                                   | 139.109         | 10925.                                                                              | 2.191                                                         | 815.9                         | 1645.0              | 49.16                | 17.80                                 | 31.66                                 | 988                               |
| 95                                   | 150.050         | 11859.                                                                              | 2.184                                                         | 907.1                         | 1801.4              | 50.14                | 18.70                                 | 32.09                                 | 1011                              |
| 100                                  | 160.929         | 12792.                                                                              | 2.177                                                         | 1002.8                        | 1962.0              | 51.13                | 19.60                                 | 32.59                                 | 1034                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0175 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.947                             | 12.705          | 17.23                                                                                  | 2.091                                                            | -43.0                         | 30.6                | 34.00                | 18.37                                 | 2783.62                               | 362                               |
| 33                                   | 12.821          | 25.48                                                                                  | 2.097                                                            | -42.0                         | 32.3                | 34.03                | 18.29                                 | 1903.33                               | 365                               |
| 34                                   | 14.970          | 181.0                                                                                  | 2.184                                                            | -24.4                         | 62.3                | 34.56                | 16.81                                 | 313.26                                | 412                               |
| 35                                   | 17.189          | 356.9                                                                                  | 2.236                                                            | -8.4                          | 91.1                | 35.02                | 15.26                                 | 177.48                                | 457                               |
| 36                                   | 19.442          | 540.2                                                                                  | 2.264                                                            | 6.6                           | 119.2               | 35.45                | 14.78                                 | 127.76                                | 485                               |
| 37                                   | 21.717          | 728.9                                                                                  | 2.281                                                            | 21.2                          | 146.9               | 35.85                | 14.35                                 | 101.71                                | 510                               |
| 38                                   | 24.004          | 920.5                                                                                  | 2.286                                                            | 35.1                          | 174.1               | 36.22                | 14.23                                 | 85.58                                 | 527                               |
| 39                                   | 26.301          | 1114.                                                                                  | 2.297                                                            | 49.2                          | 201.5               | 36.58                | 14.08                                 | 75.18                                 | 547                               |
| 40                                   | 28.608          | 1309.                                                                                  | 2.307                                                            | 63.2                          | 228.9               | 36.94                | 13.95                                 | 67.76                                 | 565                               |
| 42                                   | 33.250          | 1704.                                                                                  | 2.321                                                            | 90.9                          | 283.4               | 37.61                | 13.76                                 | 57.69                                 | 599                               |
| 44                                   | 37.902          | 2106.                                                                                  | 2.331                                                            | 118.3                         | 337.8               | 38.25                | 13.63                                 | 51.20                                 | 630                               |
| 46                                   | 42.560          | 2507.                                                                                  | 2.337                                                            | 145.5                         | 391.9               | 38.86                | 13.57                                 | 46.73                                 | 659                               |
| 48                                   | 47.237          | 2910.                                                                                  | 2.341                                                            | 172.7                         | 446.2               | 39.44                | 13.56                                 | 43.47                                 | 685                               |
| 50                                   | 51.916          | 3314.                                                                                  | 2.343                                                            | 199.8                         | 500.4               | 39.99                | 13.58                                 | 40.98                                 | 709                               |
| 55                                   | 63.618          | 4324.                                                                                  | 2.341                                                            | 268.1                         | 636.4               | 41.29                | 13.74                                 | 36.82                                 | 763                               |
| 60                                   | 75.300          | 5331.                                                                                  | 2.336                                                            | 337.8                         | 773.8               | 42.51                | 13.97                                 | 34.29                                 | 811                               |
| 65                                   | 86.971          | 6337.                                                                                  | 2.328                                                            | 408.6                         | 912.1               | 43.64                | 14.33                                 | 32.72                                 | 853                               |
| 70                                   | 98.601          | 7335.                                                                                  | 2.319                                                            | 481.4                         | 1052.3              | 44.72                | 14.82                                 | 31.81                                 | 889                               |
| 75                                   | 110.179         | 8325.                                                                                  | 2.311                                                            | 557.0                         | 1195.0              | 45.76                | 15.44                                 | 31.35                                 | 922                               |
| 80                                   | 121.704         | 9306.                                                                                  | 2.302                                                            | 636.0                         | 1340.6              | 46.78                | 16.16                                 | 31.23                                 | 951                               |
| 85                                   | 133.191         | 10281.                                                                                 | 2.294                                                            | 718.8                         | 1489.9              | 47.78                | 16.96                                 | 31.36                                 | 977                               |
| 90                                   | 144.653         | 11254.                                                                                 | 2.286                                                            | 805.7                         | 1643.2              | 48.78                | 17.82                                 | 31.65                                 | 1002                              |
| 95                                   | 156.065         | 12207.                                                                                 | 2.279                                                            | 897.1                         | 1800.7              | 49.76                | 18.72                                 | 32.09                                 | 1026                              |
| 100                                  | 167.417         | 13162.                                                                                 | 2.272                                                            | 992.9                         | 1962.2              | 50.75                | 19.62                                 | 32.59                                 | 1048                              |
| 0.0180 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.922                             | 12.659          | 28.43                                                                                  | 2.160                                                            | -52.7                         | 18.6                | 33.65                | 17.80                                 | 1708.25                               | 370                               |
| 33                                   | 12.837          | 41.69                                                                                  | 2.171                                                            | -51.2                         | 21.0                | 33.69                | 17.70                                 | 1184.69                               | 374                               |
| 34                                   | 15.068          | 211.8                                                                                  | 2.270                                                            | -34.2                         | 50.6                | 34.20                | 16.41                                 | 275.15                                | 422                               |
| 35                                   | 17.377          | 397.5                                                                                  | 2.328                                                            | -18.5                         | 79.4                | 34.66                | 15.06                                 | 164.29                                | 467                               |
| 36                                   | 19.724          | 588.9                                                                                  | 2.359                                                            | -3.6                          | 107.4               | 35.08                | 14.65                                 | 121.00                                | 494                               |
| 37                                   | 22.095          | 785.3                                                                                  | 2.378                                                            | 10.9                          | 135.2               | 35.47                | 14.27                                 | 97.57                                 | 520                               |
| 38                                   | 24.480          | 984.4                                                                                  | 2.383                                                            | 24.7                          | 162.5               | 35.84                | 14.15                                 | 82.68                                 | 538                               |
| 39                                   | 26.875          | 1185.                                                                                  | 2.395                                                            | 38.8                          | 190.1               | 36.21                | 14.01                                 | 73.05                                 | 557                               |
| 40                                   | 29.282          | 1387.                                                                                  | 2.406                                                            | 52.7                          | 217.6               | 36.56                | 13.89                                 | 66.12                                 | 576                               |
| 42                                   | 34.124          | 1795.                                                                                  | 2.422                                                            | 80.3                          | 272.4               | 37.23                | 13.71                                 | 56.63                                 | 610                               |
| 44                                   | 38.980          | 2210.                                                                                  | 2.433                                                            | 107.6                         | 327.1               | 37.87                | 13.60                                 | 50.45                                 | 642                               |
| 46                                   | 43.842          | 2624.                                                                                  | 2.440                                                            | 134.8                         | 381.6               | 38.47                | 13.55                                 | 46.18                                 | 670                               |
| 48                                   | 48.723          | 3039.                                                                                  | 2.444                                                            | 161.9                         | 436.2               | 39.05                | 13.55                                 | 43.05                                 | 697                               |
| 50                                   | 53.607          | 3455.                                                                                  | 2.446                                                            | 189.0                         | 490.8               | 39.60                | 13.58                                 | 40.65                                 | 721                               |
| 55                                   | 65.822          | 4493.                                                                                  | 2.444                                                            | 257.3                         | 627.8               | 40.91                | 13.75                                 | 36.62                                 | 775                               |
| 60                                   | 78.014          | 5529.                                                                                  | 2.438                                                            | 327.1                         | 766.3               | 42.12                | 13.99                                 | 34.16                                 | 824                               |
| 65                                   | 90.195          | 6561.                                                                                  | 2.429                                                            | 397.9                         | 905.7               | 43.26                | 14.35                                 | 32.63                                 | 866                               |
| 70                                   | 102.330         | 7584.                                                                                  | 2.420                                                            | 470.9                         | 1046.9              | 44.34                | 14.85                                 | 31.75                                 | 903                               |
| 75                                   | 114.409         | 8595.                                                                                  | 2.410                                                            | 546.6                         | 1190.6              | 45.38                | 15.46                                 | 31.31                                 | 935                               |
| 80                                   | 126.431         | 9604.                                                                                  | 2.401                                                            | 625.7                         | 1337.4              | 46.40                | 16.18                                 | 31.20                                 | 965                               |
| 85                                   | 138.412         | 10606.                                                                                 | 2.392                                                            | 708.6                         | 1487.7              | 47.41                | 16.99                                 | 31.33                                 | 992                               |
| 90                                   | 150.366         | 11607.                                                                                 | 2.384                                                            | 795.6                         | 1642.1              | 48.40                | 17.85                                 | 31.63                                 | 1017                              |
| 95                                   | 162.260         | 12576.                                                                                 | 2.376                                                            | 887.1                         | 1800.5              | 49.39                | 18.74                                 | 32.07                                 | 1040                              |
| 100                                  | 174.094         | 13553.                                                                                 | 2.368                                                            | 983.1                         | 1963.1              | 50.37                | 19.64                                 | 32.58                                 | 1063                              |
| 0.0185 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.886                             | 12.592          | 43.67                                                                                  | 2.238                                                            | -62.4                         | 6.6                 | 33.29                | 17.20                                 | 1133.41                               | 380                               |
| 33                                   | 12.864          | 64.94                                                                                  | 2.255                                                            | -60.4                         | 10.1                | 33.35                | 17.08                                 | 782.12                                | 387                               |
| 34                                   | 15.183          | 251.5                                                                                  | 2.362                                                            | -43.9                         | 39.3                | 33.85                | 15.98                                 | 239.38                                | 435                               |
| 35                                   | 17.588          | 448.0                                                                                  | 2.425                                                            | -28.4                         | 67.9                | 34.30                | 14.85                                 | 150.84                                | 478                               |
| 36                                   | 20.033          | 648.3                                                                                  | 2.458                                                            | -13.8                         | 96.0                | 34.71                | 14.51                                 | 113.82                                | 506                               |
| 37                                   | 22.504          | 852.8                                                                                  | 2.479                                                            | 0.6                           | 123.8               | 35.10                | 14.18                                 | 93.09                                 | 530                               |
| 38                                   | 24.990          | 1060.                                                                                  | 2.484                                                            | 14.4                          | 151.3               | 35.47                | 14.06                                 | 79.54                                 | 549                               |
| 39                                   | 27.488          | 1269.                                                                                  | 2.498                                                            | 28.4                          | 179.0               | 35.83                | 13.94                                 | 70.70                                 | 569                               |
| 40                                   | 29.997          | 1477.                                                                                  | 2.509                                                            | 42.3                          | 206.6               | 36.19                | 13.83                                 | 64.30                                 | 587                               |
| 42                                   | 35.047          | 1900.                                                                                  | 2.526                                                            | 69.8                          | 261.7               | 36.86                | 13.67                                 | 55.44                                 | 622                               |
| 44                                   | 40.114          | 2328.                                                                                  | 2.538                                                            | 97.0                          | 316.7               | 37.49                | 13.57                                 | 49.61                                 | 654                               |
| 46                                   | 45.186          | 2755.                                                                                  | 2.545                                                            | 124.1                         | 371.6               | 38.10                | 13.53                                 | 45.55                                 | 683                               |
| 48                                   | 50.278          | 3187.                                                                                  | 2.549                                                            | 151.2                         | 426.6               | 38.67                | 13.54                                 | 42.56                                 | 709                               |
| 50                                   | 55.373          | 3611.                                                                                  | 2.551                                                            | 178.3                         | 481.6               | 39.22                | 13.58                                 | 40.26                                 | 734                               |
| 55                                   | 68.114          | 4680.                                                                                  | 2.550                                                            | 246.6                         | 619.7               | 40.53                | 13.76                                 | 36.38                                 | 789                               |
| 60                                   | 80.831          | 5747.                                                                                  | 2.543                                                            | 316.5                         | 759.2               | 41.74                | 14.00                                 | 34.00                                 | 837                               |
| 65                                   | 93.535          | 6805.                                                                                  | 2.533                                                            | 387.4                         | 899.7               | 42.88                | 14.37                                 | 32.52                                 | 880                               |
| 70                                   | 106.189         | 7857.                                                                                  | 2.523                                                            | 460.4                         | 1042.0              | 43.96                | 14.87                                 | 31.66                                 | 917                               |
| 75                                   | 118.781         | 8897.                                                                                  | 2.513                                                            | 536.3                         | 1186.8              | 45.01                | 15.48                                 | 31.25                                 | 950                               |
| 80                                   | 131.311         | 9922.                                                                                  | 2.502                                                            | 615.4                         | 1334.6              | 46.03                | 16.21                                 | 31.15                                 | 979                               |
| 85                                   | 143.800         | 10950.                                                                                 | 2.493                                                            | 698.5                         | 1486.1              | 47.03                | 17.01                                 | 31.29                                 | 1006                              |
| 90                                   | 156.259         | 11972.                                                                                 | 2.484                                                            | 785.6                         | 1641.5              | 48.03                | 17.87                                 | 31.60                                 | 1031                              |
| 95                                   | 168.645         | 12966.                                                                                 | 2.475                                                            | 877.2                         | 1800.9              | 49.02                | 18.76                                 | 32.05                                 | 1055                              |
| 100                                  | 180.973         | 13965.                                                                                 | 2.467                                                            | 973.3                         | 1964.5              | 50.01                | 19.66                                 | 32.56                                 | 1078                              |
| * TWO-PHASE BOUNDARY                 |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN            | PRESSURE<br>ATM | $(\partial P/\partial p)_T$<br>ISOTHERM<br>OERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_p$<br>ISOCHORE<br>OERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|---------------------------------------|-----------------|------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.0190 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                    |                                                                |                               |                     |                      |                                                |                                                |                                   |
| 32.840                                | 12.507          | 64.55                                                                              | 2.325                                                          | -72.2                         | -5.5                | 32.94                | 16.59                                          | 788.18                                         | 393                               |
| 33                                    | 12.904          | 97.25                                                                              | 2.350                                                          | -69.5                         | -0.7                | 33.02                | 16.45                                          | 542.44                                         | 402                               |
| 34                                    | 15.321          | 301.6                                                                              | 2.462                                                          | -53.5                         | 28.2                | 33.50                | 15.56                                          | 207.33                                         | 449                               |
| 35                                    | 17.827          | 509.7                                                                              | 2.527                                                          | -38.4                         | 56.7                | 33.94                | 14.65                                          | 137.68                                         | 491                               |
| 36                                    | 20.375          | 719.5                                                                              | 2.561                                                          | -23.9                         | 84.8                | 34.35                | 14.37                                          | 106.50                                         | 518                               |
| 37                                    | 22.950          | 932.7                                                                              | 2.584                                                          | -9.6                          | 112.7               | 34.74                | 14.09                                          | 88.41                                          | 542                               |
| 38                                    | 25.542          | 1148.                                                                              | 2.589                                                          | 4.2                           | 140.4               | 35.11                | 13.98                                          | 76.25                                          | 561                               |
| 39                                    | 28.146          | 1365.                                                                              | 2.604                                                          | 18.1                          | 168.2               | 35.47                | 13.87                                          | 68.22                                          | 581                               |
| 40                                    | 30.761          | 1581.                                                                              | 2.616                                                          | 31.9                          | 195.9               | 35.82                | 13.77                                          | 62.35                                          | 600                               |
| 42                                    | 36.026          | 2018.                                                                              | 2.634                                                          | 59.3                          | 251.4               | 36.49                | 13.63                                          | 54.15                                          | 635                               |
| 44                                    | 41.310          | 2461.                                                                              | 2.646                                                          | 86.4                          | 306.8               | 37.12                | 13.54                                          | 48.68                                          | 667                               |
| 46                                    | 46.600          | 2902.                                                                              | 2.654                                                          | 113.5                         | 362.0               | 37.72                | 13.51                                          | 44.84                                          | 696                               |
| 48                                    | 51.909          | 3342.                                                                              | 2.658                                                          | 140.6                         | 417.4               | 38.30                | 13.53                                          | 42.01                                          | 722                               |
| 50                                    | 57.221          | 3784.                                                                              | 2.660                                                          | 167.7                         | 472.8               | 38.85                | 13.57                                          | 39.82                                          | 747                               |
| 55                                    | 70.504          | 4883.                                                                              | 2.658                                                          | 236.0                         | 612.0               | 40.15                | 13.77                                          | 36.10                                          | 802                               |
| 60                                    | 83.760          | 5976.                                                                              | 2.650                                                          | 305.9                         | 752.6               | 41.37                | 14.02                                          | 33.81                                          | 851                               |
| 65                                    | 97.001          | 7063.                                                                              | 2.640                                                          | 376.9                         | 894.2               | 42.51                | 14.39                                          | 32.39                                          | 894                               |
| 70                                    | 110.186         | 8140.                                                                              | 2.629                                                          | 450.0                         | 1037.6              | 43.59                | 14.89                                          | 31.57                                          | 931                               |
| 75                                    | 123.305         | 9205.                                                                              | 2.617                                                          | 526.0                         | 1183.6              | 44.64                | 15.51                                          | 31.18                                          | 964                               |
| 80                                    | 136.356         | 10261.                                                                             | 2.606                                                          | 605.3                         | 1332.5              | 45.66                | 16.23                                          | 31.10                                          | 994                               |
| 85                                    | 149.366         | 11315.                                                                             | 2.596                                                          | 688.4                         | 1485.0              | 46.67                | 17.03                                          | 31.24                                          | 1021                              |
| 90                                    | 162.341         | 12361.                                                                             | 2.586                                                          | 775.7                         | 1641.5              | 47.67                | 17.90                                          | 31.56                                          | 1047                              |
| 95                                    | 175.230         | 13377.                                                                             | 2.576                                                          | 867.4                         | 1801.9              | 48.66                | 18.79                                          | 32.02                                          | 1070                              |
| 100                                   | 188.063         | 14398.                                                                             | 2.567                                                          | 963.6                         | 1966.5              | 49.64                | 19.69                                          | 32.54                                          | 1094                              |
| 0.0195 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                    |                                                                |                               |                     |                      |                                                |                                                |                                   |
| 32.780                                | 12.398          | 91.90                                                                              | 2.422                                                          | -82.1                         | -17.7               | 32.59                | 15.99                                          | 573.42                                         | 407                               |
| 33                                    | 12.963          | 148.9                                                                              | 2.457                                                          | -78.6                         | -11.2               | 32.69                | 15.84                                          | 392.45                                         | 419                               |
| 34                                    | 15.487          | 363.7                                                                              | 2.569                                                          | -63.1                         | 17.4                | 33.16                | 15.15                                          | 179.51                                         | 465                               |
| 35                                    | 18.100          | 584.0                                                                              | 2.634                                                          | -48.3                         | 45.8                | 33.59                | 14.45                                          | 125.24                                         | 504                               |
| 36                                    | 20.755          | 803.9                                                                              | 2.669                                                          | -33.9                         | 73.9                | 33.99                | 14.23                                          | 99.26                                          | 531                               |
| 37                                    | 23.439          | 1028.                                                                              | 2.693                                                          | -19.8                         | 102.0               | 34.38                | 14.00                                          | 83.67                                          | 555                               |
| 38                                    | 26.141          | 1251.                                                                              | 2.699                                                          | -6.0                          | 129.8               | 34.74                | 13.90                                          | 72.87                                          | 574                               |
| 39                                    | 28.856          | 1476.                                                                              | 2.714                                                          | 7.8                           | 157.7               | 35.10                | 13.80                                          | 65.65                                          | 594                               |
| 40                                    | 31.581          | 1701.                                                                              | 2.727                                                          | 21.6                          | 185.7               | 35.45                | 13.71                                          | 60.31                                          | 613                               |
| 42                                    | 37.068          | 2153.                                                                              | 2.745                                                          | 48.8                          | 241.4               | 36.12                | 13.58                                          | 52.77                                          | 648                               |
| 44                                    | 42.577          | 2618.                                                                              | 2.758                                                          | 75.9                          | 297.2               | 36.75                | 13.51                                          | 47.69                                          | 680                               |
| 46                                    | 48.091          | 3065.                                                                              | 2.766                                                          | 102.9                         | 352.8               | 37.35                | 13.49                                          | 44.08                                          | 709                               |
| 48                                    | 53.623          | 3519.                                                                              | 2.770                                                          | 130.0                         | 408.6               | 37.92                | 13.52                                          | 41.41                                          | 736                               |
| 50                                    | 59.160          | 3973.                                                                              | 2.772                                                          | 157.0                         | 464.4               | 38.48                | 13.57                                          | 39.34                                          | 761                               |
| 55                                    | 73.000          | 5104.                                                                              | 2.769                                                          | 225.4                         | 604.7               | 39.78                | 13.78                                          | 35.80                                          | 816                               |
| 60                                    | 86.810          | 6227.                                                                              | 2.761                                                          | 295.4                         | 746.5               | 41.00                | 14.03                                          | 33.60                                          | 866                               |
| 65                                    | 100.602         | 7343.                                                                              | 2.749                                                          | 366.5                         | 889.2               | 42.14                | 14.41                                          | 32.24                                          | 909                               |
| 70                                    | 114.332         | 8447.                                                                              | 2.737                                                          | 439.7                         | 1033.8              | 43.22                | 14.91                                          | 31.46                                          | 946                               |
| 75                                    | 127.989         | 9538.                                                                              | 2.725                                                          | 515.8                         | 1180.8              | 44.27                | 15.53                                          | 31.09                                          | 980                               |
| 80                                    | 141.575         | 10620.                                                                             | 2.713                                                          | 595.2                         | 1330.8              | 45.30                | 16.25                                          | 31.03                                          | 1009                              |
| 85                                    | 155.119         | 11701.                                                                             | 2.701                                                          | 678.5                         | 1484.5              | 46.31                | 17.06                                          | 31.18                                          | 1037                              |
| 90                                    | 168.624         | 12772.                                                                             | 2.690                                                          | 765.9                         | 1642.1              | 47.31                | 17.92                                          | 31.51                                          | 1062                              |
| 95                                    | 182.026         | 13811.                                                                             | 2.680                                                          | 857.7                         | 1803.5              | 48.30                | 18.81                                          | 31.98                                          | 1086                              |
| 100                                   | 195.375         | 14855.                                                                             | 2.670                                                          | 954.0                         | 1969.2              | 49.29                | 19.71                                          | 32.50                                          | 1109                              |
| 0.0200 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                    |                                                                |                               |                     |                      |                                                |                                                |                                   |
| 32.707                                | 12.266          | 127.7                                                                              | 2.530                                                          | -92.2                         | -30.0               | 32.23                | 15.41                                          | 430.67                                         | 424                               |
| 33                                    | 13.047          | 198.4                                                                              | 2.575                                                          | -87.6                         | -21.5               | 32.37                | 15.26                                          | 294.63                                         | 439                               |
| 34                                    | 15.687          | 439.6                                                                              | 2.683                                                          | -72.6                         | 6.8                 | 32.82                | 14.76                                          | 155.82                                         | 483                               |
| 35                                    | 18.414          | 672.5                                                                              | 2.747                                                          | -58.1                         | 35.2                | 33.24                | 14.26                                          | 113.73                                         | 519                               |
| 36                                    | 21.181          | 903.0                                                                              | 2.782                                                          | -44.0                         | 63.4                | 33.64                | 14.09                                          | 92.28                                          | 545                               |
| 37                                    | 23.978          | 1135.                                                                              | 2.807                                                          | -29.9                         | 91.5                | 34.02                | 13.91                                          | 78.98                                          | 569                               |
| 38                                    | 26.795          | 1369.                                                                              | 2.814                                                          | -16.2                         | 119.5               | 34.39                | 13.82                                          | 69.49                                          | 588                               |
| 39                                    | 29.625          | 1603.                                                                              | 2.829                                                          | -2.4                          | 147.6               | 34.74                | 13.73                                          | 63.05                                          | 608                               |
| 40                                    | 32.464          | 1836.                                                                              | 2.842                                                          | 11.2                          | 175.7               | 35.09                | 13.65                                          | 58.22                                          | 627                               |
| 42                                    | 38.182          | 2304.                                                                              | 2.861                                                          | 38.4                          | 231.9               | 35.75                | 13.54                                          | 51.34                                          | 663                               |
| 44                                    | 43.923          | 2776.                                                                              | 2.873                                                          | 65.5                          | 288.0               | 36.38                | 13.48                                          | 46.64                                          | 695                               |
| 46                                    | 49.668          | 3246.                                                                              | 2.881                                                          | 92.4                          | 344.1               | 36.98                | 13.48                                          | 43.28                                          | 724                               |
| 48                                    | 55.431          | 3714.                                                                              | 2.885                                                          | 119.4                         | 400.2               | 37.56                | 13.51                                          | 40.77                                          | 750                               |
| 50                                    | 61.197          | 4181.                                                                              | 2.887                                                          | 146.5                         | 456.5               | 38.11                | 13.57                                          | 38.82                                          | 775                               |
| 55                                    | 75.612          | 5345.                                                                              | 2.884                                                          | 214.8                         | 597.9               | 39.41                | 13.79                                          | 35.46                                          | 831                               |
| 60                                    | 89.991          | 6499.                                                                              | 2.874                                                          | 284.9                         | 740.8               | 40.63                | 14.05                                          | 33.37                                          | 881                               |
| 65                                    | 104.348         | 7643.                                                                              | 2.862                                                          | 356.1                         | 884.7               | 41.77                | 14.43                                          | 32.07                                          | 924                               |
| 70                                    | 118.637         | 8775.                                                                              | 2.849                                                          | 429.4                         | 1030.5              | 42.86                | 14.93                                          | 31.33                                          | 962                               |
| 75                                    | 132.846         | 9892.                                                                              | 2.835                                                          | 505.6                         | 1178.7              | 43.91                | 15.56                                          | 30.99                                          | 995                               |
| 80                                    | 146.980         | 11002.                                                                             | 2.822                                                          | 585.2                         | 1329.8              | 44.94                | 16.28                                          | 30.95                                          | 1025                              |
| 85                                    | 161.071         | 12110.                                                                             | 2.809                                                          | 668.6                         | 1484.6              | 45.95                | 17.08                                          | 31.12                                          | 1053                              |
| 90                                    | 175.117         | 13205.                                                                             | 2.797                                                          | 756.1                         | 1643.3              | 46.95                | 17.95                                          | 31.46                                          | 1079                              |
| 95                                    | 189.045         | 14268.                                                                             | 2.786                                                          | 848.1                         | 1805.8              | 47.94                | 18.84                                          | 31.93                                          | 1102                              |
| 100                                   | 202.921         | 15335.                                                                             | 2.775                                                          | 944.5                         | 1972.6              | 48.93                | 19.74                                          | 32.46                                          | 1126                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMOODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.0205 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 32.620                             | 12.110          | 173.9                                                                                 | 2.651                                                            | -102.4                        | -42.6               | 31.87                | 14.88                                          | 332.64                                         | 442                               |
| 33                                   | 13.164          | 272.3                                                                                 | 2.705                                                            | -96.8                         | -31.7               | 32.04                | 14.75                                          | 228.49                                         | 460                               |
| 34                                   | 15.929          | 531.2                                                                                 | 2.806                                                            | -82.2                         | -3.5                | 32.48                | 14.41                                          | 135.88                                         | 502                               |
| 35                                   | 18.775          | 776.8                                                                                 | 2.866                                                            | -68.0                         | 24.8                | 32.89                | 14.09                                          | 103.29                                         | 535                               |
| 36                                   | 21.661          | 1018.                                                                                 | 2.901                                                            | -53.9                         | 53.1                | 33.28                | 13.96                                          | 85.67                                          | 561                               |
| 37                                   | 24.577          | 1261.                                                                                 | 2.926                                                            | -40.1                         | 81.4                | 33.67                | 13.82                                          | 74.42                                          | 584                               |
| 38                                   | 27.513          | 1504.                                                                                 | 2.933                                                            | -26.3                         | 109.6               | 34.03                | 13.74                                          | 66.16                                          | 603                               |
| 39                                   | 30.462          | 1747.                                                                                 | 2.949                                                            | -12.6                         | 137.9               | 34.39                | 13.66                                          | 60.45                                          | 623                               |
| 40                                   | 33.420          | 1989.                                                                                 | 2.961                                                            | 1.0                           | 166.2               | 34.73                | 13.60                                          | 56.11                                          | 642                               |
| 42                                   | 39.375          | 2473.                                                                                 | 2.980                                                            | 28.1                          | 222.7               | 35.39                | 13.50                                          | 49.86                                          | 678                               |
| 44                                   | 45.356          | 2960.                                                                                 | 2.993                                                            | 55.0                          | 279.2               | 36.02                | 13.46                                          | 45.56                                          | 710                               |
| 46                                   | 51.340          | 3445.                                                                                 | 3.000                                                            | 82.0                          | 335.7               | 36.62                | 13.46                                          | 42.43                                          | 739                               |
| 48                                   | 57.340          | 3927.                                                                                 | 3.004                                                            | 108.9                         | 392.3               | 37.19                | 13.50                                          | 40.10                                          | 766                               |
| 50                                   | 63.344          | 4409.                                                                                 | 3.005                                                            | 136.0                         | 449.1               | 37.75                | 13.57                                          | 38.26                                          | 791                               |
| 55                                   | 78.349          | 5606.                                                                                 | 3.001                                                            | 204.4                         | 591.6               | 39.05                | 13.80                                          | 35.10                                          | 847                               |
| 60                                   | 93.313          | 6792.                                                                                 | 2.991                                                            | 274.5                         | 735.7               | 40.27                | 14.07                                          | 33.12                                          | 896                               |
| 65                                   | 108.249         | 7965.                                                                                 | 2.977                                                            | 345.8                         | 880.8               | 41.41                | 14.45                                          | 31.89                                          | 940                               |
| 70                                   | 123.111         | 9126.                                                                                 | 2.963                                                            | 419.3                         | 1027.7              | 42.50                | 14.96                                          | 31.19                                          | 978                               |
| 75                                   | 137.885         | 10269.                                                                                | 2.948                                                            | 495.6                         | 1177.1              | 43.55                | 15.58                                          | 30.89                                          | 1011                              |
| 80                                   | 152.581         | 11406.                                                                                | 2.934                                                            | 575.2                         | 1329.4              | 44.58                | 16.31                                          | 30.86                                          | 1042                              |
| 85                                   | 167.232         | 12541.                                                                                | 2.920                                                            | 658.8                         | 1485.3              | 45.59                | 17.11                                          | 31.05                                          | 1069                              |
| 90                                   | 181.832         | 13661.                                                                                | 2.907                                                            | 746.5                         | 1645.2              | 46.60                | 17.97                                          | 31.40                                          | 1095                              |
| 95                                   | 196.298         | 14749.                                                                                | 2.894                                                            | 838.6                         | 1808.8              | 47.59                | 18.87                                          | 31.87                                          | 1119                              |
| 100                                  | 210.714         | 15839.                                                                                | 2.882                                                            | 935.2                         | 1976.6              | 48.58                | 19.77                                          | 32.41                                          | 1142                              |
| 0.0210 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 32.517                             | 11.928          | 232.2                                                                                 | 2.784                                                            | -112.9                        | -55.4               | 31.50                | 14.41                                          | 263.83                                         | 462                               |
| 33                                   | 13.322          | 365.2                                                                                 | 2.845                                                            | -106.0                        | -41.7               | 31.72                | 14.30                                          | 182.35                                         | 484                               |
| 34                                   | 16.221          | 640.6                                                                                 | 2.935                                                            | -91.8                         | -13.5               | 32.14                | 14.10                                          | 119.19                                         | 522                               |
| 35                                   | 19.193          | 898.8                                                                                 | 2.990                                                            | -77.8                         | 14.8                | 32.55                | 13.93                                          | 93.93                                          | 552                               |
| 36                                   | 22.202          | 1152.                                                                                 | 3.024                                                            | -63.9                         | 43.2                | 32.94                | 13.83                                          | 79.51                                          | 577                               |
| 37                                   | 25.242          | 1404.                                                                                 | 3.050                                                            | -50.1                         | 71.7                | 33.31                | 13.73                                          | 70.05                                          | 600                               |
| 38                                   | 28.302          | 1657.                                                                                 | 3.058                                                            | -36.5                         | 100.1               | 33.68                | 13.66                                          | 62.92                                          | 619                               |
| 39                                   | 31.376          | 1910.                                                                                 | 3.073                                                            | -22.8                         | 128.6               | 34.03                | 13.60                                          | 57.89                                          | 639                               |
| 40                                   | 34.457          | 2167.                                                                                 | 3.085                                                            | -9.3                          | 157.0               | 34.38                | 13.54                                          | 54.01                                          | 658                               |
| 42                                   | 40.658          | 2663.                                                                                 | 3.104                                                            | 17.7                          | 213.9               | 35.03                | 13.47                                          | 48.38                                          | 693                               |
| 44                                   | 46.886          | 3164.                                                                                 | 3.116                                                            | 44.6                          | 270.9               | 35.66                | 13.43                                          | 44.45                                          | 725                               |
| 46                                   | 53.117          | 3665.                                                                                 | 3.123                                                            | 71.5                          | 327.8               | 36.26                | 13.45                                          | 41.57                                          | 755                               |
| 48                                   | 59.361          | 4167.                                                                                 | 3.126                                                            | 98.5                          | 384.9               | 36.83                | 13.50                                          | 39.40                                          | 781                               |
| 50                                   | 65.610          | 4657.                                                                                 | 3.127                                                            | 125.5                         | 442.1               | 37.39                | 13.57                                          | 37.69                                          | 806                               |
| 55                                   | 81.222          | 5889.                                                                                 | 3.122                                                            | 193.9                         | 585.8               | 38.69                | 13.81                                          | 34.72                                          | 863                               |
| 60                                   | 96.786          | 7106.                                                                                 | 3.110                                                            | 264.2                         | 731.2               | 39.91                | 14.09                                          | 32.85                                          | 913                               |
| 65                                   | 112.317         | 8307.                                                                                 | 3.095                                                            | 335.5                         | 877.5               | 41.05                | 14.47                                          | 31.70                                          | 956                               |
| 70                                   | 127.766         | 9499.                                                                                 | 3.080                                                            | 409.1                         | 1025.6              | 42.15                | 14.98                                          | 31.04                                          | 995                               |
| 75                                   | 143.119         | 10679.                                                                                | 3.064                                                            | 485.6                         | 1176.1              | 43.20                | 15.61                                          | 30.77                                          | 1028                              |
| 80                                   | 158.391         | 11835.                                                                                | 3.048                                                            | 565.4                         | 1329.6              | 44.23                | 16.33                                          | 30.77                                          | 1058                              |
| 85                                   | 173.615         | 12955.                                                                                | 3.033                                                            | 649.0                         | 1486.7              | 45.24                | 17.14                                          | 30.97                                          | 1086                              |
| 90                                   | 188.781         | 14149.                                                                                | 3.019                                                            | 736.9                         | 1647.8              | 46.25                | 18.00                                          | 31.33                                          | 1112                              |
| 95                                   | 203.798         | 15255.                                                                                | 3.005                                                            | 829.1                         | 1812.5              | 47.25                | 18.90                                          | 31.81                                          | 1136                              |
| 100                                  | 218.764         | 16369.                                                                                | 2.991                                                            | 925.9                         | 1981.4              | 48.24                | 19.80                                          | 32.36                                          | 1160                              |
| 0.0215 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 32.397                             | 11.720          | 304.8                                                                                 | 3.032                                                            | -123.9                        | -68.7               | 31.12                | 14.12                                          | 228.29                                         | 498                               |
| 33                                   | 13.533          | 479.7                                                                                 | 3.057                                                            | -115.4                        | -51.6               | 31.38                | 14.03                                          | 154.94                                         | 516                               |
| 34                                   | 16.573          | 769.7                                                                                 | 3.093                                                            | -101.5                        | -23.4               | 31.80                | 13.90                                          | 106.53                                         | 544                               |
| 35                                   | 19.677          | 1041.                                                                                 | 3.123                                                            | -87.6                         | 5.1                 | 32.20                | 13.80                                          | 85.72                                          | 570                               |
| 36                                   | 22.816          | 1305.                                                                                 | 3.148                                                            | -73.8                         | 33.7                | 32.59                | 13.72                                          | 73.65                                          | 593                               |
| 37                                   | 25.984          | 1569.                                                                                 | 3.169                                                            | -60.2                         | 62.3                | 32.96                | 13.65                                          | 65.60                                          | 615                               |
| 38                                   | 29.174          | 1831.                                                                                 | 3.187                                                            | -46.5                         | 90.9                | 33.33                | 13.59                                          | 59.80                                          | 636                               |
| 39                                   | 32.376          | 2093.                                                                                 | 3.202                                                            | -33.0                         | 119.6               | 33.68                | 13.54                                          | 55.40                                          | 656                               |
| 40                                   | 35.585          | 2354.                                                                                 | 3.214                                                            | -19.5                         | 148.2               | 34.02                | 13.49                                          | 51.95                                          | 675                               |
| 42                                   | 42.041          | 2873.                                                                                 | 3.231                                                            | 7.5                           | 205.6               | 34.68                | 13.43                                          | 46.89                                          | 710                               |
| 44                                   | 48.523          | 3399.                                                                                 | 3.243                                                            | 34.3                          | 263.0               | 35.30                | 13.41                                          | 43.33                                          | 742                               |
| 46                                   | 55.009          | 3906.                                                                                 | 3.249                                                            | 61.1                          | 320.4               | 35.90                | 13.43                                          | 40.68                                          | 771                               |
| 48                                   | 61.505          | 4419.                                                                                 | 3.252                                                            | 88.1                          | 377.9               | 36.48                | 13.49                                          | 38.68                                          | 798                               |
| 50                                   | 68.005          | 4929.                                                                                 | 3.252                                                            | 115.1                         | 435.6               | 37.03                | 13.57                                          | 37.09                                          | 823                               |
| 55                                   | 84.241          | 6194.                                                                                 | 3.246                                                            | 183.6                         | 580.6               | 38.33                | 13.82                                          | 34.32                                          | 879                               |
| 60                                   | 100.423         | 7444.                                                                                 | 3.233                                                            | 253.9                         | 727.2               | 39.56                | 14.11                                          | 32.57                                          | 929                               |
| 65                                   | 116.562         | 8677.                                                                                 | 3.217                                                            | 325.4                         | 874.7               | 40.70                | 14.50                                          | 31.49                                          | 973                               |
| 70                                   | 132.614         | 9894.                                                                                 | 3.200                                                            | 399.1                         | 1024.1              | 41.79                | 15.01                                          | 30.88                                          | 1012                              |
| 75                                   | 148.559         | 11095.                                                                                | 3.183                                                            | 475.6                         | 1175.8              | 42.85                | 15.64                                          | 30.65                                          | 1045                              |
| 80                                   | 164.420         | 12289.                                                                                | 3.166                                                            | 555.6                         | 1330.5              | 43.88                | 16.36                                          | 30.66                                          | 1076                              |
| 85                                   | 180.232         | 13475.                                                                                | 3.149                                                            | 639.4                         | 1488.8              | 44.90                | 17.17                                          | 30.88                                          | 1104                              |
| 90                                   | 195.976         | 14644.                                                                                | 3.133                                                            | 727.4                         | 1651.0              | 45.90                | 18.03                                          | 31.26                                          | 1129                              |
| 95                                   | 211.558         | 15787.                                                                                | 3.118                                                            | 819.8                         | 1816.8              | 46.90                | 18.93                                          | 31.75                                          | 1154                              |
| 100                                  | 227.086         | 16924.                                                                                | 3.103                                                            | 916.7                         | 1986.9              | 47.90                | 19.83                                          | 32.30                                          | 1177                              |

\* TWO-PHASE BOUNDARY

TABLE X1. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0220 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.261                             | 11.487          | 394.5                                                                                  | 3.165                                                            | -135.3                        | -82.4               | 30.73                | 13.98                                 | 185.50                                | 513                               |
| 33                                   | 13.806          | 618.1                                                                                  | 3.195                                                            | -125.0                        | -61.4               | 31.05                | 13.89                                 | 128.00                                | 535                               |
| 34                                   | 16.995          | 920.8                                                                                  | 3.230                                                            | -111.2                        | -32.9               | 31.46                | 13.78                                 | 94.45                                 | 563                               |
| 35                                   | 20.237          | 1204.                                                                                  | 3.260                                                            | -97.4                         | -4.2                | 31.86                | 13.70                                 | 78.37                                 | 588                               |
| 36                                   | 23.511          | 1480.                                                                                  | 3.284                                                            | -83.8                         | 24.5                | 32.25                | 13.63                                 | 68.54                                 | 612                               |
| 37                                   | 26.814          | 1754.                                                                                  | 3.304                                                            | -70.2                         | 53.3                | 32.62                | 13.58                                 | 61.80                                 | 633                               |
| 38                                   | 30.137          | 2027.                                                                                  | 3.321                                                            | -56.6                         | 82.2                | 32.98                | 13.53                                 | 56.83                                 | 654                               |
| 39                                   | 33.473          | 2298.                                                                                  | 3.335                                                            | -43.1                         | 111.1               | 33.33                | 13.49                                 | 53.00                                 | 674                               |
| 40                                   | 36.815          | 2569.                                                                                  | 3.347                                                            | -29.6                         | 139.9               | 33.67                | 13.45                                 | 49.95                                 | 693                               |
| 42                                   | 43.535          | 3105.                                                                                  | 3.363                                                            | -2.8                          | 197.7               | 34.33                | 13.40                                 | 45.43                                 | 727                               |
| 44                                   | 50.279          | 3638.                                                                                  | 3.374                                                            | 24.0                          | 255.6               | 34.95                | 13.39                                 | 42.21                                 | 759                               |
| 46                                   | 57.027          | 4171.                                                                                  | 3.379                                                            | 50.8                          | 313.5               | 35.55                | 13.42                                 | 39.79                                 | 788                               |
| 48                                   | 63.783          | 4697.                                                                                  | 3.382                                                            | 77.7                          | 371.5               | 36.12                | 13.49                                 | 37.95                                 | 815                               |
| 50                                   | 70.542          | 5222.                                                                                  | 3.381                                                            | 104.8                         | 429.7               | 36.67                | 13.57                                 | 36.49                                 | 840                               |
| 55                                   | 87.420          | 6524.                                                                                  | 3.373                                                            | 173.3                         | 575.9               | 37.98                | 13.83                                 | 33.91                                 | 896                               |
| 60                                   | 104.234         | 7806.                                                                                  | 3.358                                                            | 243.7                         | 723.7               | 39.20                | 14.13                                 | 32.27                                 | 947                               |
| 65                                   | 120.998         | 9070.                                                                                  | 3.341                                                            | 315.2                         | 872.5               | 40.35                | 14.52                                 | 31.27                                 | 991                               |
| 70                                   | 137.667         | 10319.                                                                                 | 3.323                                                            | 389.1                         | 1023.1              | 41.44                | 15.04                                 | 30.71                                 | 1029                              |
| 75                                   | 154.218         | 11546.                                                                                 | 3.304                                                            | 465.8                         | 1176.1              | 42.50                | 15.66                                 | 30.51                                 | 1063                              |
| 80                                   | 170.683         | 12768.                                                                                 | 3.286                                                            | 545.9                         | 1332.0              | 43.54                | 16.39                                 | 30.55                                 | 1094                              |
| 85                                   | 187.094         | 13979.                                                                                 | 3.268                                                            | 629.9                         | 1491.6              | 44.55                | 17.20                                 | 30.79                                 | 1122                              |
| 90                                   | 203.430         | 15173.                                                                                 | 3.250                                                            | 718.0                         | 1655.0              | 45.56                | 18.07                                 | 31.18                                 | 1147                              |
| 95                                   | 219.590         | 16346.                                                                                 | 3.233                                                            | 810.6                         | 1822.0              | 46.56                | 18.96                                 | 31.68                                 | 1172                              |
| 100                                  | 235.692         | 17506.                                                                                 | 3.217                                                            | 907.7                         | 1993.2              | 47.56                | 19.86                                 | 32.24                                 | 1195                              |
| 0.0225 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 32.106                             | 11.227          | 503.0                                                                                  | 3.304                                                            | -147.0                        | -96.4               | 30.34                | 13.86                                 | 153.36                                | 529                               |
| 33                                   | 14.155          | 783.0                                                                                  | 3.340                                                            | -134.6                        | -70.9               | 30.72                | 13.76                                 | 107.87                                | 555                               |
| 34                                   | 17.498          | 1096.                                                                                  | 3.374                                                            | -120.9                        | -42.1               | 31.12                | 13.67                                 | 84.34                                 | 583                               |
| 35                                   | 20.885          | 1391.                                                                                  | 3.402                                                            | -107.2                        | -13.2               | 31.52                | 13.60                                 | 71.88                                 | 608                               |
| 36                                   | 24.300          | 1679.                                                                                  | 3.425                                                            | -93.7                         | 15.8                | 31.90                | 13.55                                 | 63.89                                 | 631                               |
| 37                                   | 27.742          | 1964.                                                                                  | 3.445                                                            | -80.1                         | 44.8                | 32.27                | 13.51                                 | 58.26                                 | 652                               |
| 38                                   | 31.205          | 2246.                                                                                  | 3.461                                                            | -66.7                         | 73.9                | 32.63                | 13.47                                 | 54.02                                 | 673                               |
| 39                                   | 34.678          | 2527.                                                                                  | 3.474                                                            | -53.2                         | 103.0               | 32.98                | 13.44                                 | 50.70                                 | 692                               |
| 40                                   | 38.159          | 2808.                                                                                  | 3.484                                                            | -39.8                         | 132.1               | 33.32                | 13.41                                 | 48.01                                 | 711                               |
| 42                                   | 45.151          | 3367.                                                                                  | 3.500                                                            | -13.0                         | 190.3               | 33.98                | 13.37                                 | 43.99                                 | 746                               |
| 44                                   | 52.165          | 3911.                                                                                  | 3.509                                                            | 13.7                          | 248.7               | 34.60                | 13.38                                 | 41.10                                 | 777                               |
| 46                                   | 59.184          | 4459.                                                                                  | 3.514                                                            | 40.5                          | 307.1               | 35.20                | 13.42                                 | 38.90                                 | 806                               |
| 48                                   | 66.207          | 5007.                                                                                  | 3.515                                                            | 67.4                          | 365.6               | 35.77                | 13.49                                 | 37.22                                 | 833                               |
| 50                                   | 73.231          | 5551.                                                                                  | 3.514                                                            | 94.5                          | 424.3               | 36.32                | 13.58                                 | 35.87                                 | 858                               |
| 55                                   | 90.769          | 6878.                                                                                  | 3.503                                                            | 163.0                         | 571.8               | 37.63                | 13.85                                 | 33.49                                 | 914                               |
| 60                                   | 108.233         | 8194.                                                                                  | 3.487                                                            | 233.5                         | 720.9               | 38.85                | 14.15                                 | 31.97                                 | 965                               |
| 65                                   | 125.637         | 9489.                                                                                  | 3.468                                                            | 305.2                         | 871.0               | 40.00                | 14.55                                 | 31.04                                 | 1009                              |
| 70                                   | 142.938         | 10769.                                                                                 | 3.448                                                            | 379.2                         | 1022.9              | 41.10                | 15.06                                 | 30.54                                 | 1047                              |
| 75                                   | 160.109         | 12027.                                                                                 | 3.428                                                            | 456.1                         | 1177.1              | 42.16                | 15.69                                 | 30.37                                 | 1081                              |
| 80                                   | 177.192         | 13274.                                                                                 | 3.408                                                            | 536.3                         | 1334.3              | 43.19                | 16.42                                 | 30.44                                 | 1112                              |
| 85                                   | 194.216         | 14511.                                                                                 | 3.389                                                            | 620.4                         | 1495.1              | 44.21                | 17.23                                 | 30.70                                 | 1140                              |
| 90                                   | 211.154         | 15729.                                                                                 | 3.370                                                            | 708.8                         | 1659.6              | 45.22                | 18.10                                 | 31.10                                 | 1166                              |
| 95                                   | 227.908         | 16937.                                                                                 | 3.351                                                            | 801.5                         | 1827.8              | 46.22                | 18.99                                 | 31.61                                 | 1190                              |
| 100                                  | 244.597         | 18116.                                                                                 | 3.333                                                            | 898.7                         | 2000.2              | 47.22                | 19.90                                 | 32.17                                 | 1213                              |
| 0.0230 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 31.934                             | 10.943          | 641.8                                                                                  | 3.445                                                            | -158.8                        | -110.6              | 29.93                | 13.74                                 | 126.86                                | 546                               |
| 32                                   | 11.170          | 662.5                                                                                  | 3.448                                                            | -157.9                        | -108.7              | 29.96                | 13.74                                 | 123.73                                | 548                               |
| 33                                   | 14.594          | 974.3                                                                                  | 3.487                                                            | -144.2                        | -79.9               | 30.38                | 13.64                                 | 92.38                                 | 576                               |
| 34                                   | 18.095          | 1298.                                                                                  | 3.520                                                            | -130.6                        | -50.9               | 30.79                | 13.57                                 | 75.74                                 | 603                               |
| 35                                   | 21.633          | 1604.                                                                                  | 3.547                                                            | -117.1                        | -21.8               | 31.18                | 13.52                                 | 66.11                                 | 628                               |
| 36                                   | 25.195          | 1904.                                                                                  | 3.570                                                            | -103.6                        | 7.4                 | 31.56                | 13.48                                 | 59.64                                 | 651                               |
| 37                                   | 28.782          | 2199.                                                                                  | 3.589                                                            | -90.1                         | 36.7                | 31.93                | 13.45                                 | 54.95                                 | 672                               |
| 38                                   | 32.388          | 2491.                                                                                  | 3.604                                                            | -76.7                         | 66.0                | 32.29                | 13.42                                 | 51.36                                 | 692                               |
| 39                                   | 36.004          | 2787.                                                                                  | 3.616                                                            | -63.3                         | 95.3                | 32.64                | 13.39                                 | 48.51                                 | 712                               |
| 40                                   | 39.628          | 3077.                                                                                  | 3.626                                                            | -49.9                         | 124.7               | 32.97                | 13.37                                 | 46.15                                 | 730                               |
| 42                                   | 46.902          | 3645.                                                                                  | 3.640                                                            | -23.2                         | 183.4               | 33.63                | 13.35                                 | 42.60                                 | 765                               |
| 44                                   | 54.194          | 4205.                                                                                  | 3.648                                                            | 3.5                           | 242.3               | 34.25                | 13.36                                 | 40.01                                 | 796                               |
| 46                                   | 61.491          | 4774.                                                                                  | 3.652                                                            | 30.3                          | 301.2               | 34.84                | 13.41                                 | 38.02                                 | 825                               |
| 48                                   | 68.789          | 5332.                                                                                  | 3.652                                                            | 57.2                          | 360.3               | 35.42                | 13.49                                 | 36.49                                 | 851                               |
| 50                                   | 76.087          | 5886.                                                                                  | 3.650                                                            | 84.3                          | 419.5               | 35.97                | 13.58                                 | 35.26                                 | 876                               |
| 55                                   | 94.303          | 7259.                                                                                  | 3.637                                                            | 152.9                         | 568.3               | 37.28                | 13.87                                 | 33.07                                 | 933                               |
| 60                                   | 112.432         | 8608.                                                                                  | 3.619                                                            | 223.5                         | 718.8               | 38.51                | 14.17                                 | 31.66                                 | 983                               |
| 65                                   | 130.491         | 9934.                                                                                  | 3.598                                                            | 295.3                         | 870.1               | 39.66                | 14.57                                 | 30.80                                 | 1027                              |
| 70                                   | 148.440         | 11245.                                                                                 | 3.577                                                            | 369.4                         | 1023.3              | 40.75                | 15.09                                 | 30.35                                 | 1066                              |
| 75                                   | 166.246         | 12529.                                                                                 | 3.555                                                            | 446.4                         | 1178.8              | 41.82                | 15.72                                 | 30.22                                 | 1100                              |
| 80                                   | 183.962         | 13808.                                                                                 | 3.534                                                            | 526.8                         | 1337.2              | 42.85                | 16.46                                 | 30.31                                 | 1131                              |
| 85                                   | 201.610         | 15070.                                                                                 | 3.513                                                            | 611.1                         | 1499.3              | 43.88                | 17.27                                 | 30.60                                 | 1159                              |
| 90                                   | 219.163         | 16312.                                                                                 | 3.492                                                            | 699.6                         | 1665.1              | 44.89                | 18.13                                 | 31.02                                 | 1184                              |
| 95                                   | 236.527         | 17547.                                                                                 | 3.472                                                            | 792.5                         | 1834.5              | 45.89                | 19.03                                 | 31.53                                 | 1209                              |
| 100                                  | 253.813         | 18755.                                                                                 | 3.453                                                            | 889.9                         | 2008.0              | 46.89                | 19.93                                 | 32.11                                 | 1232                              |
| * TWO-PHASE BOUNDARY                 |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0235 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 31.742                             | 10.634          | 785.3                                                                                  | 3.597                                                            | -170.9                        | -125.1              | 29.52                | 13.63                                 | 109.58                                | 563                               |
| 32                                   | 11.552          | 870.4                                                                                  | 3.608                                                            | -167.4                        | -117.6              | 29.63                | 13.61                                 | 101.41                                | 571                               |
| 33                                   | 15.137          | 1200.                                                                                  | 3.645                                                            | -153.9                        | -88.6               | 30.05                | 13.54                                 | 80.56                                 | 599                               |
| 34                                   | 18.801          | 1529.                                                                                  | 3.676                                                            | -140.3                        | -59.3               | 30.45                | 13.48                                 | 68.61                                 | 625                               |
| 35                                   | 22.494          | 1846.                                                                                  | 3.701                                                            | -126.9                        | -29.9               | 30.84                | 13.44                                 | 61.10                                 | 649                               |
| 36                                   | 26.209          | 2157.                                                                                  | 3.722                                                            | -113.5                        | -0.5                | 31.22                | 13.41                                 | 55.84                                 | 672                               |
| 37                                   | 29.946          | 2462.                                                                                  | 3.739                                                            | -100.1                        | 29.1                | 31.59                | 13.39                                 | 51.94                                 | 693                               |
| 38                                   | 33.701          | 2764.                                                                                  | 3.753                                                            | -86.7                         | 58.6                | 31.94                | 13.37                                 | 48.90                                 | 713                               |
| 39                                   | 37.465          | 3065.                                                                                  | 3.764                                                            | -73.3                         | 88.2                | 32.29                | 13.35                                 | 46.44                                 | 732                               |
| 40                                   | 41.236          | 3365.                                                                                  | 3.773                                                            | -60.0                         | 117.8               | 32.63                | 13.34                                 | 44.39                                 | 750                               |
| 42                                   | 48.800          | 3956.                                                                                  | 3.785                                                            | -33.3                         | 177.1               | 33.28                | 13.33                                 | 41.25                                 | 784                               |
| 44                                   | 56.379          | 4536.                                                                                  | 3.792                                                            | -6.6                          | 236.5               | 33.90                | 13.35                                 | 38.94                                 | 815                               |
| 46                                   | 63.962          | 5117.                                                                                  | 3.794                                                            | 20.1                          | 295.9               | 34.50                | 13.41                                 | 37.15                                 | 844                               |
| 48                                   | 71.544          | 5691.                                                                                  | 3.793                                                            | 47.0                          | 355.5               | 35.07                | 13.49                                 | 35.76                                 | 871                               |
| 50                                   | 79.122          | 6267.                                                                                  | 3.790                                                            | 74.1                          | 415.3               | 35.62                | 13.59                                 | 34.64                                 | 895                               |
| 55                                   | 98.033          | 7669.                                                                                  | 3.775                                                            | 142.8                         | 565.5               | 36.93                | 13.88                                 | 32.63                                 | 952                               |
| 60                                   | 116.846         | 9051.                                                                                  | 3.754                                                            | 213.5                         | 717.3               | 38.16                | 14.19                                 | 31.34                                 | 1002                              |
| 65                                   | 135.576         | 10409.                                                                                 | 3.732                                                            | 285.4                         | 870.0               | 39.31                | 14.60                                 | 30.56                                 | 1046                              |
| 70                                   | 154.187         | 11750.                                                                                 | 3.708                                                            | 359.7                         | 1024.5              | 40.41                | 15.12                                 | 30.16                                 | 1085                              |
| 75                                   | 172.643         | 13065.                                                                                 | 3.685                                                            | 436.8                         | 1181.2              | 41.48                | 15.76                                 | 30.06                                 | 1119                              |
| 80                                   | 191.006         | 14372.                                                                                 | 3.662                                                            | 517.4                         | 1341.0              | 42.52                | 16.49                                 | 30.18                                 | 1150                              |
| 85                                   | 209.290         | 15673.                                                                                 | 3.639                                                            | 601.9                         | 1504.3              | 43.54                | 17.30                                 | 30.49                                 | 1178                              |
| 90                                   | 227.470         | 16924.                                                                                 | 3.617                                                            | 690.5                         | 1671.3              | 44.55                | 18.17                                 | 30.93                                 | 1203                              |
| 95                                   | 245.461         | 18192.                                                                                 | 3.596                                                            | 783.6                         | 1842.0              | 45.56                | 19.07                                 | 31.45                                 | 1228                              |
| 100                                  | 263.356         | 19423.                                                                                 | 3.575                                                            | 881.2                         | 2016.7              | 46.56                | 19.97                                 | 32.04                                 | 1252                              |
| 0.0240 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 31.532                             | 10.303          | 950.1                                                                                  | 3.755                                                            | -183.3                        | -139.8              | 29.10                | 13.53                                 | 95.83                                 | 582                               |
| 32                                   | 12.046          | 1111.                                                                                  | 3.773                                                            | -177.0                        | -126.1              | 29.30                | 13.50                                 | 85.60                                 | 595                               |
| 33                                   | 15.799          | 1456.                                                                                  | 3.808                                                            | -163.5                        | -96.8               | 29.71                | 13.44                                 | 71.24                                 | 623                               |
| 34                                   | 19.629          | 1791.                                                                                  | 3.836                                                            | -150.1                        | -67.2               | 30.11                | 13.40                                 | 62.56                                 | 648                               |
| 35                                   | 23.483          | 2117.                                                                                  | 3.860                                                            | -136.7                        | -37.6               | 30.50                | 13.37                                 | 56.69                                 | 672                               |
| 36                                   | 27.356          | 2439.                                                                                  | 3.879                                                            | -123.3                        | -7.8                | 30.88                | 13.35                                 | 52.41                                 | 694                               |
| 37                                   | 31.249          | 2755.                                                                                  | 3.895                                                            | -110.0                        | 21.9                | 31.24                | 13.34                                 | 49.17                                 | 714                               |
| 38                                   | 35.157          | 3067.                                                                                  | 3.907                                                            | -96.7                         | 51.8                | 31.60                | 13.33                                 | 46.60                                 | 734                               |
| 39                                   | 39.074          | 3377.                                                                                  | 3.917                                                            | -83.3                         | 81.6                | 31.94                | 13.32                                 | 44.49                                 | 753                               |
| 40                                   | 42.998          | 3687.                                                                                  | 3.925                                                            | -70.0                         | 111.5               | 32.28                | 13.31                                 | 42.71                                 | 771                               |
| 42                                   | 50.862          | 4295.                                                                                  | 3.935                                                            | -43.4                         | 171.3               | 32.93                | 13.31                                 | 39.95                                 | 805                               |
| 44                                   | 58.735          | 4897.                                                                                  | 3.940                                                            | -16.7                         | 231.2               | 33.55                | 13.35                                 | 37.90                                 | 836                               |
| 46                                   | 66.612          | 5489.                                                                                  | 3.940                                                            | 10.0                          | 291.3               | 34.15                | 13.41                                 | 36.30                                 | 864                               |
| 48                                   | 74.485          | 6079.                                                                                  | 3.938                                                            | 36.9                          | 351.4               | 34.72                | 13.50                                 | 35.04                                 | 891                               |
| 50                                   | 82.351          | 6663.                                                                                  | 3.933                                                            | 64.0                          | 411.7               | 35.27                | 13.60                                 | 34.02                                 | 915                               |
| 55                                   | 101.976         | 8107.                                                                                  | 3.916                                                            | 132.8                         | 563.3               | 36.58                | 13.90                                 | 32.20                                 | 971                               |
| 60                                   | 121.488         | 9523.                                                                                  | 3.893                                                            | 203.6                         | 716.5               | 37.82                | 14.22                                 | 31.01                                 | 1022                              |
| 65                                   | 140.905         | 10913.                                                                                 | 3.868                                                            | 275.6                         | 870.5               | 38.97                | 14.63                                 | 30.31                                 | 1066                              |
| 70                                   | 160.195         | 12285.                                                                                 | 3.843                                                            | 350.1                         | 1026.4              | 40.07                | 15.15                                 | 29.96                                 | 1105                              |
| 75                                   | 179.316         | 13631.                                                                                 | 3.818                                                            | 427.4                         | 1184.4              | 41.14                | 15.79                                 | 29.90                                 | 1139                              |
| 80                                   | 198.339         | 14967.                                                                                 | 3.793                                                            | 508.1                         | 1345.5              | 42.18                | 16.52                                 | 30.05                                 | 1170                              |
| 85                                   | 217.272         | 16275.                                                                                 | 3.769                                                            | 592.7                         | 1510.0              | 43.21                | 17.34                                 | 30.38                                 | 1197                              |
| 90                                   | 236.092         | 17564.                                                                                 | 3.745                                                            | 681.6                         | 1678.3              | 44.22                | 18.20                                 | 30.84                                 | 1223                              |
| 95                                   | 254.724         | 18867.                                                                                 | 3.722                                                            | 774.8                         | 1850.3              | 45.23                | 19.10                                 | 31.37                                 | 1248                              |
| 100                                  | 273.241         | 20121.                                                                                 | 3.699                                                            | 872.6                         | 2026.2              | 46.23                | 20.01                                 | 31.97                                 | 1271                              |
| 0.0245 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 31.301                             | 9.949           | 1137.                                                                                  | 3.917                                                            | -195.9                        | -154.8              | 28.67                | 13.43                                 | 84.75                                 | 600                               |
| 32                                   | 12.669          | 1388.                                                                                  | 3.944                                                            | -186.5                        | -134.2              | 28.97                | 13.40                                 | 73.94                                 | 620                               |
| 33                                   | 16.598          | 1746.                                                                                  | 3.976                                                            | -173.2                        | -104.5              | 29.38                | 13.35                                 | 63.78                                 | 647                               |
| 34                                   | 20.597          | 2086.                                                                                  | 4.002                                                            | -159.8                        | -74.6               | 29.78                | 13.33                                 | 57.40                                 | 672                               |
| 35                                   | 24.617          | 2422.                                                                                  | 4.024                                                            | -146.5                        | -44.7               | 30.16                | 13.31                                 | 52.80                                 | 695                               |
| 36                                   | 28.653          | 2754.                                                                                  | 4.041                                                            | -133.2                        | -14.7               | 30.54                | 13.30                                 | 49.33                                 | 717                               |
| 37                                   | 32.707          | 3081.                                                                                  | 4.055                                                            | -119.9                        | 15.4                | 30.90                | 13.30                                 | 46.63                                 | 737                               |
| 38                                   | 36.773          | 3402.                                                                                  | 4.066                                                            | -106.6                        | 45.5                | 31.26                | 13.30                                 | 44.47                                 | 756                               |
| 39                                   | 40.847          | 3721.                                                                                  | 4.074                                                            | -93.3                         | 75.6                | 31.60                | 13.29                                 | 42.67                                 | 775                               |
| 40                                   | 44.929          | 4040.                                                                                  | 4.081                                                            | -80.0                         | 105.8               | 31.94                | 13.29                                 | 41.12                                 | 793                               |
| 42                                   | 53.101          | 4666.                                                                                  | 4.089                                                            | -53.4                         | 166.2               | 32.59                | 13.30                                 | 38.70                                 | 826                               |
| 44                                   | 61.276          | 5279.                                                                                  | 4.091                                                            | -26.8                         | 226.6               | 33.21                | 13.34                                 | 36.89                                 | 857                               |
| 46                                   | 69.456          | 5892.                                                                                  | 4.090                                                            | -0.0                          | 287.2               | 33.80                | 13.41                                 | 35.46                                 | 885                               |
| 48                                   | 77.628          | 6498.                                                                                  | 4.086                                                            | 26.9                          | 347.9               | 34.38                | 13.51                                 | 34.33                                 | 911                               |
| 50                                   | 85.790          | 7097.                                                                                  | 4.080                                                            | 54.0                          | 408.8               | 34.93                | 13.62                                 | 33.42                                 | 936                               |
| 55                                   | 106.146         | 8577.                                                                                  | 4.060                                                            | 122.8                         | 561.8               | 36.24                | 13.92                                 | 31.76                                 | 992                               |
| 60                                   | 126.374         | 10026.                                                                                 | 4.035                                                            | 193.8                         | 716.4               | 37.48                | 14.24                                 | 30.69                                 | 1042                              |
| 65                                   | 146.495         | 11449.                                                                                 | 4.008                                                            | 266.0                         | 871.8               | 38.63                | 14.66                                 | 30.05                                 | 1086                              |
| 70                                   | 166.478         | 12852.                                                                                 | 3.981                                                            | 340.5                         | 1029.0              | 39.74                | 15.18                                 | 29.75                                 | 1125                              |
| 75                                   | 186.279         | 14229.                                                                                 | 3.953                                                            | 418.0                         | 1188.4              | 40.80                | 15.82                                 | 29.73                                 | 1159                              |
| 80                                   | 205.978         | 15593.                                                                                 | 3.927                                                            | 498.9                         | 1350.8              | 41.85                | 16.56                                 | 29.91                                 | 1190                              |
| 85                                   | 225.570         | 16924.                                                                                 | 3.901                                                            | 583.7                         | 1516.6              | 42.88                | 17.37                                 | 30.27                                 | 1217                              |
| 90                                   | 245.042         | 18241.                                                                                 | 3.875                                                            | 672.8                         | 1686.2              | 43.89                | 18.24                                 | 30.75                                 | 1243                              |
| 95                                   | 264.332         | 19573.                                                                                 | 3.850                                                            | 766.2                         | 1859.4              | 44.90                | 19.14                                 | 31.29                                 | 1268                              |
| 100                                  | 283.483         | 20851.                                                                                 | 3.826                                                            | 864.2                         | 2036.6              | 45.91                | 20.05                                 | 31.90                                 | 1291                              |
| * TWO-PHASE BOUNDARY                 |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>OEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0250 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| • 31.050                             | 9.574           | 1349.                                                                                 | 4.086                                                            | -208.8                        | -170.0              | 28.23                | 13.34                                 | 75.64                                 | 620                               |
| 32                                   | 13.440          | 1701.                                                                                 | 4.120                                                            | -196.1                        | -141.7              | 28.63                | 13.31                                 | 65.06                                 | 647                               |
| 33                                   | 17.552          | 2072.                                                                                 | 4.149                                                            | -182.8                        | -111.7              | 29.04                | 13.28                                 | 57.72                                 | 673                               |
| 34                                   | 21.721          | 2417.                                                                                 | 4.173                                                            | -169.6                        | -81.5               | 29.44                | 13.26                                 | 52.98                                 | 697                               |
| 35                                   | 25.911          | 2762.                                                                                 | 4.192                                                            | -156.3                        | -51.3               | 29.82                | 13.26                                 | 49.36                                 | 719                               |
| 36                                   | 30.116          | 3104.                                                                                 | 4.208                                                            | -143.1                        | -21.0               | 30.19                | 13.26                                 | 46.54                                 | 740                               |
| 37                                   | 34.335          | 3440.                                                                                 | 4.220                                                            | -129.8                        | 9.4                 | 30.56                | 13.26                                 | 44.31                                 | 760                               |
| 38                                   | 38.565          | 3771.                                                                                 | 4.229                                                            | -116.5                        | 39.8                | 30.91                | 13.27                                 | 42.49                                 | 779                               |
| 39                                   | 42.800          | 4098.                                                                                 | 4.236                                                            | -103.3                        | 70.2                | 31.26                | 13.27                                 | 40.96                                 | 797                               |
| 40                                   | 47.044          | 4427.                                                                                 | 4.241                                                            | -90.0                         | 100.7               | 31.59                | 13.28                                 | 39.63                                 | 815                               |
| 42                                   | 55.533          | 5070.                                                                                 | 4.247                                                            | -63.4                         | 161.7               | 32.24                | 13.30                                 | 37.52                                 | 848                               |
| 44                                   | 64.020          | 5700.                                                                                 | 4.247                                                            | -36.8                         | 222.7               | 32.86                | 13.34                                 | 35.92                                 | 878                               |
| 46                                   | 72.510          | 6328.                                                                                 | 4.244                                                            | -10.0                         | 283.9               | 33.46                | 13.42                                 | 34.65                                 | 906                               |
| 48                                   | 80.989          | 6950.                                                                                 | 4.239                                                            | 16.9                          | 345.2               | 34.03                | 13.52                                 | 33.64                                 | 932                               |
| 50                                   | 89.454          | 7564.                                                                                 | 4.231                                                            | 44.1                          | 406.6               | 34.59                | 13.63                                 | 32.82                                 | 957                               |
| 55                                   | 110.559         | 9079.                                                                                 | 4.208                                                            | 113.0                         | 561.1               | 35.90                | 13.95                                 | 31.33                                 | 1013                              |
| 60                                   | 131.520         | 10567.                                                                                | 4.180                                                            | 184.1                         | 717.1               | 37.14                | 14.27                                 | 30.36                                 | 1063                              |
| 65                                   | 152.360         | 12018.                                                                                | 4.151                                                            | 256.4                         | 873.9               | 38.29                | 14.69                                 | 29.79                                 | 1107                              |
| 70                                   | 173.052         | 13457.                                                                                | 4.121                                                            | 331.1                         | 1032.5              | 39.40                | 15.22                                 | 29.55                                 | 1146                              |
| 75                                   | 193.550         | 14860.                                                                                | 4.092                                                            | 408.8                         | 1193.2              | 40.47                | 15.86                                 | 29.56                                 | 1180                              |
| 80                                   | 213.937         | 16251.                                                                                | 4.063                                                            | 489.9                         | 1357.0              | 41.52                | 16.59                                 | 29.77                                 | 1211                              |
| 85                                   | 234.201         | 17606.                                                                                | 4.035                                                            | 574.9                         | 1524.1              | 42.55                | 17.41                                 | 30.16                                 | 1238                              |
| 90                                   | 254.338         | 18949.                                                                                | 4.008                                                            | 664.1                         | 1694.9              | 43.57                | 18.28                                 | 30.65                                 | 1264                              |
| 95                                   | 274.302         | 20317.                                                                                | 3.981                                                            | 757.7                         | 1869.5              | 44.58                | 19.18                                 | 31.20                                 | 1289                              |
| 100                                  | 294.098         | 21614.                                                                                | 3.955                                                            | 855.9                         | 2047.9              | 45.59                | 20.09                                 | 31.82                                 | 1312                              |
| 0.0255 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| • 30.778                             | 9.180           | 1572.                                                                                 | 4.258                                                            | -221.9                        | -185.4              | 27.78                | 13.26                                 | 68.55                                 | 639                               |
| 31                                   | 10.116          | 1660.                                                                                 | 4.266                                                            | -219.0                        | -178.8              | 27.88                | 13.25                                 | 66.21                                 | 646                               |
| 32                                   | 14.377          | 2054.                                                                                 | 4.299                                                            | -205.7                        | -148.6              | 28.30                | 13.23                                 | 58.09                                 | 673                               |
| 33                                   | 18.677          | 2436.                                                                                 | 4.326                                                            | -192.5                        | -118.3              | 28.70                | 13.21                                 | 52.72                                 | 699                               |
| 34                                   | 23.020          | 2786.                                                                                 | 4.348                                                            | -179.3                        | -87.8               | 29.10                | 13.21                                 | 49.16                                 | 722                               |
| 35                                   | 27.385          | 3139.                                                                                 | 4.365                                                            | -166.1                        | -57.3               | 29.48                | 13.21                                 | 46.31                                 | 744                               |
| 36                                   | 31.764          | 3491.                                                                                 | 4.378                                                            | -152.9                        | -26.7               | 29.85                | 13.22                                 | 44.03                                 | 764                               |
| 37                                   | 36.153          | 3836.                                                                                 | 4.389                                                            | -139.7                        | 4.0                 | 30.22                | 13.23                                 | 42.19                                 | 784                               |
| 38                                   | 40.550          | 4175.                                                                                 | 4.397                                                            | -126.4                        | 34.7                | 30.57                | 13.25                                 | 40.66                                 | 803                               |
| 39                                   | 44.951          | 4512.                                                                                 | 4.402                                                            | -113.2                        | 65.5                | 30.91                | 13.26                                 | 39.36                                 | 821                               |
| 40                                   | 49.361          | 4848.                                                                                 | 4.406                                                            | -99.9                         | 96.2                | 31.25                | 13.26                                 | 38.22                                 | 838                               |
| 42                                   | 58.177          | 5569.                                                                                 | 4.409                                                            | -73.3                         | 157.8               | 31.90                | 13.29                                 | 36.39                                 | 871                               |
| 44                                   | 66.983          | 6156.                                                                                 | 4.407                                                            | -46.7                         | 219.4               | 32.52                | 13.35                                 | 34.98                                 | 901                               |
| 46                                   | 75.791          | 6800.                                                                                 | 4.402                                                            | -19.9                         | 281.2               | 33.11                | 13.43                                 | 33.86                                 | 928                               |
| 48                                   | 84.584          | 7437.                                                                                 | 4.395                                                            | 7.0                           | 343.1               | 33.69                | 13.53                                 | 32.96                                 | 954                               |
| 50                                   | 93.360          | 8066.                                                                                 | 4.386                                                            | 34.2                          | 405.2               | 34.24                | 13.65                                 | 32.23                                 | 978                               |
| 55                                   | 115.231         | 9616.                                                                                 | 4.359                                                            | 103.3                         | 561.1               | 35.56                | 13.97                                 | 30.90                                 | 1034                              |
| 60                                   | 136.942         | 11137.                                                                                | 4.328                                                            | 174.4                         | 718.6               | 36.80                | 14.30                                 | 30.03                                 | 1084                              |
| 65                                   | 158.518         | 12621.                                                                                | 4.296                                                            | 246.9                         | 876.8               | 37.96                | 14.72                                 | 29.53                                 | 1128                              |
| 70                                   | 179.935         | 14088.                                                                                | 4.265                                                            | 321.8                         | 1036.8              | 39.07                | 15.25                                 | 29.34                                 | 1167                              |
| 75                                   | 201.145         | 15528.                                                                                | 4.233                                                            | 399.6                         | 1198.9              | 40.14                | 15.89                                 | 29.38                                 | 1201                              |
| 80                                   | 222.235         | 16944.                                                                                | 4.203                                                            | 480.9                         | 1364.0              | 41.19                | 16.63                                 | 29.63                                 | 1232                              |
| 85                                   | 243.182         | 18324.                                                                                | 4.173                                                            | 566.1                         | 1532.4              | 42.22                | 17.45                                 | 30.03                                 | 1259                              |
| 90                                   | 263.997         | 19694.                                                                                | 4.143                                                            | 655.5                         | 1704.5              | 43.24                | 18.32                                 | 30.55                                 | 1285                              |
| 95                                   | 284.650         | 21084.                                                                                | 4.115                                                            | 749.4                         | 1880.4              | 44.26                | 19.22                                 | 31.11                                 | 1310                              |
| 100                                  | 305.102         | 22409.                                                                                | 4.087                                                            | 847.8                         | 2060.1              | 45.27                | 20.13                                 | 31.75                                 | 1333                              |
| 0.0260 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| • 30.484                             | 8.767           | 1842.                                                                                 | 4.439                                                            | -235.3                        | -201.1              | 27.32                | 13.18                                 | 62.04                                 | 660                               |
| 31                                   | 11.041          | 2049.                                                                                 | 4.457                                                            | -228.5                        | -185.5              | 27.54                | 13.17                                 | 58.22                                 | 675                               |
| 32                                   | 15.501          | 2448.                                                                                 | 4.486                                                            | -215.3                        | -154.9              | 27.96                | 13.16                                 | 52.59                                 | 701                               |
| 33                                   | 19.994          | 2838.                                                                                 | 4.510                                                            | -202.2                        | -124.3              | 28.37                | 13.16                                 | 48.60                                 | 726                               |
| 34                                   | 24.513          | 3195.                                                                                 | 4.529                                                            | -189.0                        | -93.5               | 28.76                | 13.16                                 | 45.88                                 | 748                               |
| 35                                   | 29.057          | 3556.                                                                                 | 4.543                                                            | -175.8                        | -62.6               | 29.14                | 13.17                                 | 43.62                                 | 769                               |
| 36                                   | 33.614          | 3916.                                                                                 | 4.554                                                            | -162.7                        | -31.7               | 29.51                | 13.19                                 | 41.77                                 | 789                               |
| 37                                   | 38.178          | 4270.                                                                                 | 4.563                                                            | -149.5                        | -0.7                | 29.87                | 13.21                                 | 40.25                                 | 809                               |
| 38                                   | 42.747          | 4619.                                                                                 | 4.569                                                            | -136.2                        | 30.3                | 30.23                | 13.23                                 | 38.97                                 | 827                               |
| 39                                   | 47.319          | 4964.                                                                                 | 4.573                                                            | -123.0                        | 61.4                | 30.57                | 13.24                                 | 37.87                                 | 845                               |
| 40                                   | 51.899          | 5308.                                                                                 | 4.575                                                            | -109.8                        | 92.5                | 30.91                | 13.26                                 | 36.90                                 | 862                               |
| 42                                   | 61.049          | 5985.                                                                                 | 4.575                                                            | -83.2                         | 154.7               | 31.55                | 13.30                                 | 35.31                                 | 894                               |
| 44                                   | 70.182          | 6649.                                                                                 | 4.571                                                            | -56.6                         | 216.9               | 32.17                | 13.35                                 | 34.08                                 | 923                               |
| 46                                   | 79.316          | 7308.                                                                                 | 4.564                                                            | -29.7                         | 279.4               | 32.77                | 13.44                                 | 33.09                                 | 951                               |
| 48                                   | 88.432          | 7961.                                                                                 | 4.555                                                            | -2.8                          | 341.9               | 33.35                | 13.55                                 | 32.30                                 | 977                               |
| 50                                   | 97.526          | 8604.                                                                                 | 4.544                                                            | 24.5                          | 404.5               | 33.90                | 13.67                                 | 31.66                                 | 1001                              |
| 55                                   | 120.180         | 10188.                                                                                | 4.514                                                            | 93.6                          | 562.0               | 35.22                | 14.00                                 | 30.48                                 | 1056                              |
| 60                                   | 142.657         | 11737.                                                                                | 4.480                                                            | 164.9                         | 720.9               | 36.46                | 14.33                                 | 29.71                                 | 1106                              |
| 65                                   | 164.987         | 13260.                                                                                | 4.446                                                            | 237.6                         | 880.6               | 37.62                | 14.75                                 | 29.27                                 | 1150                              |
| 70                                   | 187.143         | 14755.                                                                                | 4.411                                                            | 312.6                         | 1042.0              | 38.74                | 15.29                                 | 29.12                                 | 1189                              |
| 75                                   | 209.081         | 16226.                                                                                | 4.378                                                            | 390.6                         | 1205.5              | 39.81                | 15.93                                 | 29.21                                 | 1223                              |
| 80                                   | 230.888         | 17673.                                                                                | 4.345                                                            | 472.1                         | 1371.9              | 40.86                | 16.67                                 | 29.48                                 | 1253                              |
| 85                                   | 252.531         | 19078.                                                                                | 4.313                                                            | 557.5                         | 1541.6              | 41.90                | 17.49                                 | 29.91                                 | 1281                              |
| 90                                   | 274.039         | 20478.                                                                                | 4.281                                                            | 647.1                         | 1715.1              | 42.92                | 18.36                                 | 30.44                                 | 1306                              |
| 95                                   | 295.392         | 21890.                                                                                | 4.251                                                            | 741.2                         | 1892.3              | 43.94                | 19.27                                 | 31.02                                 | 1331                              |
| 100                                  | 316.513         | 23239.                                                                                | 4.221                                                            | 839.8                         | 2073.3              | 44.95                | 20.18                                 | 31.67                                 | 1354                              |
| • TWO-PHASE BOUNDARY                 |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | ( $\partial P/\partial \rho$ ) <sub>T</sub><br>ISOTHERM<br>CM <sup>3</sup> /ATM/GMOLE | ( $\partial P/\partial T$ ) <sub>P</sub><br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.0265 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                            |                               |                     |                      |                                                |                                                |                                   |
| * 30.168                             | 8.339           | 2145.                                                                                 | 4.625                                                                      | -248.9                        | -217.0              | 26.85                | 13.10                                          | 56.50                                          | 682                               |
| 31                                   | 12.172          | 2481.                                                                                 | 4.651                                                                      | -238.0                        | -191.5              | 27.21                | 13.10                                          | 52.10                                          | 704                               |
| 32                                   | 16.832          | 2885.                                                                                 | 4.677                                                                      | -224.9                        | -160.6              | 27.63                | 13.10                                          | 48.11                                          | 730                               |
| 33                                   | 21.522          | 3282.                                                                                 | 4.698                                                                      | -211.8                        | -129.5              | 28.03                | 13.11                                          | 45.13                                          | 754                               |
| 34                                   | 26.222          | 3646.                                                                                 | 4.714                                                                      | -198.7                        | -98.4               | 28.42                | 13.12                                          | 43.02                                          | 775                               |
| 35                                   | 30.948          | 4015.                                                                                 | 4.726                                                                      | -185.6                        | -67.2               | 28.80                | 13.14                                          | 41.23                                          | 796                               |
| 36                                   | 35.687          | 4383.                                                                                 | 4.735                                                                      | -172.4                        | -36.0               | 29.17                | 13.17                                          | 39.73                                          | 815                               |
| 37                                   | 40.430          | 4746.                                                                                 | 4.741                                                                      | -159.2                        | -4.6                | 29.53                | 13.20                                          | 38.48                                          | 834                               |
| 38                                   | 45.175          | 5102.                                                                                 | 4.745                                                                      | -146.0                        | 26.7                | 29.88                | 13.22                                          | 37.41                                          | 852                               |
| 39                                   | 49.922          | 5456.                                                                                 | 4.747                                                                      | -132.8                        | 58.1                | 30.23                | 13.24                                          | 36.48                                          | 869                               |
| 40                                   | 54.675          | 5807.                                                                                 | 4.748                                                                      | -119.5                        | 89.5                | 30.56                | 13.26                                          | 35.66                                          | 886                               |
| 42                                   | 64.168          | 6500.                                                                                 | 4.745                                                                      | -93.0                         | 152.4               | 31.21                | 13.30                                          | 34.29                                          | 918                               |
| 44                                   | 73.639          | 7182.                                                                                 | 4.739                                                                      | -66.3                         | 215.2               | 31.83                | 13.37                                          | 33.22                                          | 947                               |
| 46                                   | 83.105          | 7854.                                                                                 | 4.730                                                                      | -39.5                         | 278.3               | 32.43                | 13.46                                          | 32.36                                          | 974                               |
| 48                                   | 92.551          | 8523.                                                                                 | 4.719                                                                      | -12.5                         | 341.4               | 33.01                | 13.57                                          | 31.66                                          | 1000                              |
| 50                                   | 101.970         | 9181.                                                                                 | 4.706                                                                      | 14.8                          | 404.7               | 33.56                | 13.69                                          | 31.09                                          | 1024                              |
| 55                                   | 125.426         | 10799.                                                                                | 4.672                                                                      | 84.1                          | 563.6               | 34.88                | 14.02                                          | 30.06                                          | 1079                              |
| 60                                   | 148.685         | 12380.                                                                                | 4.635                                                                      | 155.5                         | 724.0               | 36.13                | 14.36                                          | 29.38                                          | 1128                              |
| 65                                   | 171.785         | 13936.                                                                                | 4.598                                                                      | 228.4                         | 885.2               | 37.29                | 14.79                                          | 29.01                                          | 1172                              |
| 70                                   | 194.696         | 15461.                                                                                | 4.561                                                                      | 303.6                         | 1048.0              | 38.41                | 15.32                                          | 28.91                                          | 1211                              |
| 75                                   | 217.377         | 16965.                                                                                | 4.525                                                                      | 381.8                         | 1212.9              | 39.49                | 15.97                                          | 29.03                                          | 1245                              |
| 80                                   | 239.914         | 18438.                                                                                | 4.490                                                                      | 463.4                         | 1380.8              | 40.54                | 16.71                                          | 29.33                                          | 1275                              |
| 85                                   | 262.267         | 19871.                                                                                | 4.455                                                                      | 549.0                         | 1551.8              | 41.58                | 17.53                                          | 29.78                                          | 1303                              |
| 90                                   | 284.483         | 21304.                                                                                | 4.422                                                                      | 638.8                         | 1726.6              | 42.60                | 18.41                                          | 30.32                                          | 1328                              |
| 95                                   | 306.546         | 22732.                                                                                | 4.389                                                                      | 733.1                         | 1905.2              | 43.62                | 19.31                                          | 30.93                                          | 1353                              |
| 100                                  | 328.347         | 24104.                                                                                | 4.357                                                                      | 832.0                         | 2087.4              | 44.64                | 20.22                                          | 31.58                                          | 1376                              |
| 0.0270 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                            |                               |                     |                      |                                                |                                                |                                   |
| * 29.829                             | 7.897           | 2466.                                                                                 | 4.814                                                                      | -262.8                        | -233.2              | 26.37                | 13.03                                          | 52.00                                          | 703                               |
| 30                                   | 8.718           | 2538.                                                                                 | 4.820                                                                      | -260.6                        | -227.8              | 26.45                | 13.03                                          | 51.20                                          | 708                               |
| 31                                   | 13.530          | 2960.                                                                                 | 4.849                                                                      | -247.5                        | -196.8              | 26.87                | 13.04                                          | 47.27                                          | 734                               |
| 32                                   | 18.394          | 3367.                                                                                 | 4.872                                                                      | -234.5                        | -165.5              | 27.29                | 13.05                                          | 44.40                                          | 759                               |
| 33                                   | 23.283          | 3769.                                                                                 | 4.889                                                                      | -221.4                        | -134.1              | 27.69                | 13.07                                          | 42.16                                          | 782                               |
| 34                                   | 28.167          | 4142.                                                                                 | 4.902                                                                      | -208.3                        | -102.6              | 28.08                | 13.09                                          | 40.51                                          | 803                               |
| 35                                   | 33.080          | 4518.                                                                                 | 4.912                                                                      | -195.2                        | -71.1               | 28.46                | 13.12                                          | 39.10                                          | 823                               |
| 36                                   | 38.004          | 4894.                                                                                 | 4.919                                                                      | -182.1                        | -39.5               | 28.83                | 13.15                                          | 37.89                                          | 842                               |
| 37                                   | 42.931          | 5264.                                                                                 | 4.923                                                                      | -168.9                        | -7.8                | 29.19                | 13.18                                          | 36.86                                          | 860                               |
| 38                                   | 47.856          | 5629.                                                                                 | 4.925                                                                      | -155.7                        | 23.9                | 29.54                | 13.21                                          | 35.97                                          | 878                               |
| 39                                   | 52.781          | 5990.                                                                                 | 4.925                                                                      | -142.5                        | 55.6                | 29.89                | 13.24                                          | 35.19                                          | 895                               |
| 40                                   | 57.712          | 6348.                                                                                 | 4.924                                                                      | -129.3                        | 87.3                | 30.22                | 13.26                                          | 34.50                                          | 911                               |
| 42                                   | 67.555          | 7056.                                                                                 | 4.919                                                                      | -102.7                        | 150.8               | 30.87                | 13.31                                          | 33.33                                          | 942                               |
| 44                                   | 77.371          | 7755.                                                                                 | 4.910                                                                      | -76.0                         | 214.3               | 31.49                | 13.38                                          | 32.39                                          | 971                               |
| 46                                   | 87.177          | 8442.                                                                                 | 4.899                                                                      | -49.1                         | 278.0               | 32.09                | 13.47                                          | 31.65                                          | 998                               |
| 48                                   | 96.962          | 9125.                                                                                 | 4.886                                                                      | -22.1                         | 341.8               | 32.67                | 13.59                                          | 31.04                                          | 1024                              |
| 50                                   | 106.713         | 9797.                                                                                 | 4.872                                                                      | 5.2                           | 405.7               | 33.22                | 13.71                                          | 30.55                                          | 1047                              |
| 55                                   | 130.986         | 11448.                                                                                | 4.833                                                                      | 74.6                          | 566.2               | 34.55                | 14.05                                          | 29.65                                          | 1102                              |
| 60                                   | 155.044         | 13063.                                                                                | 4.793                                                                      | 146.3                         | 728.1               | 35.79                | 14.39                                          | 29.06                                          | 1151                              |
| 65                                   | 178.930         | 14652.                                                                                | 4.753                                                                      | 219.3                         | 890.7               | 36.96                | 14.82                                          | 28.75                                          | 1195                              |
| 70                                   | 202.611         | 16206.                                                                                | 4.714                                                                      | 294.7                         | 1055.0              | 38.08                | 15.36                                          | 28.70                                          | 1234                              |
| 75                                   | 226.052         | 17742.                                                                                | 4.675                                                                      | 373.1                         | 1221.4              | 39.16                | 16.01                                          | 28.85                                          | 1268                              |
| 80                                   | 249.332         | 19241.                                                                                | 4.637                                                                      | 454.9                         | 1390.6              | 40.22                | 16.75                                          | 29.18                                          | 1298                              |
| 85                                   | 272.409         | 20707.                                                                                | 4.601                                                                      | 540.7                         | 1563.0              | 41.26                | 17.57                                          | 29.65                                          | 1325                              |
| 90                                   | 295.351         | 22176.                                                                                | 4.565                                                                      | 630.7                         | 1739.1              | 42.28                | 18.45                                          | 30.20                                          | 1351                              |
| 95                                   | 318.129         | 23610.                                                                                | 4.530                                                                      | 725.2                         | 1919.1              | 43.31                | 19.36                                          | 30.83                                          | 1375                              |
| 100                                  | 340.623         | 25006.                                                                                | 4.495                                                                      | 824.3                         | 2102.6              | 44.32                | 20.27                                          | 31.50                                          | 1398                              |
| 0.0275 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                            |                               |                     |                      |                                                |                                                |                                   |
| * 29.466                             | 7.442           | 2828.                                                                                 | 5.009                                                                      | -276.9                        | -249.5              | 25.88                | 12.96                                          | 47.99                                          | 725                               |
| 30                                   | 10.115          | 3057.                                                                                 | 5.025                                                                      | -270.0                        | -232.7              | 26.11                | 12.97                                          | 46.17                                          | 740                               |
| 31                                   | 15.140          | 3484.                                                                                 | 5.051                                                                      | -257.0                        | -201.2              | 26.54                | 12.99                                          | 43.38                                          | 765                               |
| 32                                   | 20.208          | 3897.                                                                                 | 5.070                                                                      | -244.0                        | -169.6              | 26.95                | 13.01                                          | 41.30                                          | 788                               |
| 33                                   | 25.298          | 4301.                                                                                 | 5.085                                                                      | -231.0                        | -137.8              | 27.35                | 13.04                                          | 39.62                                          | 810                               |
| 34                                   | 30.371          | 4684.                                                                                 | 5.096                                                                      | -217.9                        | -106.0              | 27.74                | 13.07                                          | 38.32                                          | 831                               |
| 35                                   | 35.474          | 5068.                                                                                 | 5.103                                                                      | -204.9                        | -74.2               | 28.12                | 13.10                                          | 37.20                                          | 850                               |
| 36                                   | 40.588          | 5450.                                                                                 | 5.107                                                                      | -191.7                        | -42.2               | 28.49                | 13.14                                          | 36.23                                          | 869                               |
| 37                                   | 45.701          | 5827.                                                                                 | 5.109                                                                      | -178.6                        | -10.2               | 28.85                | 13.18                                          | 35.39                                          | 887                               |
| 38                                   | 50.811          | 6200.                                                                                 | 5.110                                                                      | -165.4                        | 21.8                | 29.20                | 13.21                                          | 34.65                                          | 904                               |
| 39                                   | 55.919          | 6568.                                                                                 | 5.108                                                                      | -152.2                        | 53.9                | 29.54                | 13.24                                          | 34.00                                          | 921                               |
| 40                                   | 61.031          | 6933.                                                                                 | 5.106                                                                      | -138.9                        | 86.0                | 29.88                | 13.26                                          | 33.41                                          | 937                               |
| 42                                   | 71.231          | 7656.                                                                                 | 5.097                                                                      | -112.3                        | 150.1               | 30.53                | 13.32                                          | 32.42                                          | 968                               |
| 44                                   | 81.401          | 8371.                                                                                 | 5.085                                                                      | -85.6                         | 214.3               | 31.15                | 13.40                                          | 31.61                                          | 996                               |
| 46                                   | 91.554          | 9072.                                                                                 | 5.072                                                                      | -58.7                         | 278.6               | 31.75                | 13.50                                          | 30.97                                          | 1023                              |
| 48                                   | 101.683         | 9769.                                                                                 | 5.056                                                                      | -31.6                         | 343.1               | 32.33                | 13.61                                          | 30.45                                          | 1048                              |
| 50                                   | 111.775         | 10456.                                                                                | 5.040                                                                      | -4.2                          | 407.6               | 32.88                | 13.74                                          | 30.02                                          | 1071                              |
| 55                                   | 136.881         | 12139.                                                                                | 4.998                                                                      | 65.3                          | 569.7               | 34.21                | 14.08                                          | 29.25                                          | 1126                              |
| 60                                   | 161.755         | 13786.                                                                                | 4.954                                                                      | 137.1                         | 733.1               | 35.46                | 14.43                                          | 28.74                                          | 1175                              |
| 65                                   | 186.443         | 15408.                                                                                | 4.911                                                                      | 210.3                         | 897.2               | 36.63                | 14.86                                          | 28.49                                          | 1219                              |
| 70                                   | 210.909         | 16991.                                                                                | 4.869                                                                      | 285.9                         | 1063.0              | 37.75                | 15.40                                          | 28.49                                          | 1257                              |
| 75                                   | 235.126         | 18558.                                                                                | 4.828                                                                      | 364.5                         | 1230.8              | 38.84                | 16.05                                          | 28.67                                          | 1291                              |
| 80                                   | 259.162         | 20084.                                                                                | 4.789                                                                      | 446.5                         | 1401.4              | 39.89                | 16.79                                          | 29.03                                          | 1321                              |
| 85                                   | 282.981         | 21586.                                                                                | 4.750                                                                      | 532.5                         | 1575.2              | 40.94                | 17.62                                          | 29.52                                          | 1348                              |
| 90                                   | 306.667         | 23096.                                                                                | 4.713                                                                      | 622.8                         | 1752.7              | 41.97                | 18.49                                          | 30.09                                          | 1374                              |
| 95                                   | 330.162         | 24526.                                                                                | 4.676                                                                      | 717.5                         | 1934.0              | 42.99                | 19.40                                          | 30.75                                          | 1398                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN            | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCHORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|---------------------------------------|-----------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0280 GMCLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                        |                                                                   |                               |                     |                      |                                       |                                       |                                   |
| * 29.080                              | 6.980           | 3229.                                                                                  | 5.212                                                             | -291.3                        | -266.0              | 25.37                | 12.90                                 | 44.52                                 | 748                               |
| 30                                    | 11.783          | 3628.                                                                                  | 5.237                                                             | -279.4                        | -236.8              | 25.77                | 12.92                                 | 42.23                                 | 772                               |
| 31                                    | 17.024          | 4061.                                                                                  | 5.258                                                             | -266.5                        | -204.9              | 26.20                | 12.94                                 | 40.22                                 | 796                               |
| 32                                    | 22.298          | 4475.                                                                                  | 5.274                                                             | -253.5                        | -172.8              | 26.61                | 12.98                                 | 38.68                                 | 819                               |
| 33                                    | 27.592          | 4881.                                                                                  | 5.285                                                             | -240.5                        | -140.7              | 27.01                | 13.01                                 | 37.42                                 | 840                               |
| 34                                    | 32.859          | 5275.                                                                                  | 5.292                                                             | -227.5                        | -108.6              | 27.40                | 13.05                                 | 36.38                                 | 860                               |
| 35                                    | 38.155          | 5666.                                                                                  | 5.297                                                             | -214.4                        | -76.3               | 27.78                | 13.09                                 | 35.49                                 | 879                               |
| 36                                    | 43.462          | 6054.                                                                                  | 5.299                                                             | -201.3                        | -44.0               | 28.15                | 13.14                                 | 34.71                                 | 897                               |
| 37                                    | 48.766          | 6438.                                                                                  | 5.299                                                             | -188.1                        | -11.7               | 28.51                | 13.18                                 | 34.03                                 | 914                               |
| 38                                    | 54.064          | 6818.                                                                                  | 5.297                                                             | -174.9                        | 20.7                | 28.86                | 13.22                                 | 33.43                                 | 931                               |
| 39                                    | 59.357          | 7193.                                                                                  | 5.294                                                             | -161.7                        | 53.1                | 29.20                | 13.25                                 | 32.88                                 | 947                               |
| 40                                    | 64.653          | 7564.                                                                                  | 5.289                                                             | -148.4                        | 85.5                | 29.54                | 13.27                                 | 32.40                                 | 963                               |
| 42                                    | 75.218          | 8300.                                                                                  | 5.278                                                             | -121.8                        | 150.4               | 30.19                | 13.34                                 | 31.55                                 | 993                               |
| 44                                    | 85.749          | 9032.                                                                                  | 5.264                                                             | -95.1                         | 215.2               | 30.81                | 13.42                                 | 30.86                                 | 1022                              |
| 46                                    | 96.256          | 9746.                                                                                  | 5.248                                                             | -68.1                         | 280.2               | 31.41                | 13.52                                 | 30.32                                 | 1048                              |
| 48                                    | 106.738         | 10457.                                                                                 | 5.231                                                             | -41.0                         | 345.3               | 31.99                | 13.64                                 | 29.87                                 | 1073                              |
| 50                                    | 117.176         | 11158.                                                                                 | 5.213                                                             | -13.6                         | 410.5               | 32.55                | 13.77                                 | 29.51                                 | 1096                              |
| 55                                    | 143.132         | 12873.                                                                                 | 5.166                                                             | 56.1                          | 574.1               | 33.88                | 14.12                                 | 28.85                                 | 1150                              |
| 60                                    | 168.837         | 14552.                                                                                 | 5.119                                                             | 128.1                         | 739.1               | 35.13                | 14.46                                 | 28.43                                 | 1199                              |
| 65                                    | 194.345         | 16206.                                                                                 | 5.073                                                             | 201.5                         | 904.8               | 36.30                | 14.90                                 | 28.24                                 | 1243                              |
| 70                                    | 219.609         | 17818.                                                                                 | 5.028                                                             | 277.3                         | 1072.0              | 37.43                | 15.44                                 | 28.28                                 | 1281                              |
| 75                                    | 244.617         | 19415.                                                                                 | 4.985                                                             | 356.0                         | 1241.2              | 38.51                | 16.09                                 | 28.49                                 | 1315                              |
| 80                                    | 269.423         | 20968.                                                                                 | 4.942                                                             | 438.3                         | 1413.3              | 39.57                | 16.83                                 | 28.88                                 | 1345                              |
| 85                                    | 294.004         | 22514.                                                                                 | 4.901                                                             | 524.5                         | 1588.4              | 40.62                | 17.66                                 | 29.38                                 | 1372                              |
| 90                                    | 318.456         | 24071.                                                                                 | 4.861                                                             | 615.0                         | 1767.4              | 41.65                | 18.54                                 | 29.96                                 | 1398                              |
| 95                                    | 342.661         | 25480.                                                                                 | 4.822                                                             | 710.0                         | 1950.0              | 42.68                | 19.45                                 | 30.65                                 | 1421                              |
| 0.0285 GMCLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                        |                                                                   |                               |                     |                      |                                       |                                       |                                   |
| * 28.668                              | 6.509           | 3697.                                                                                  | 5.419                                                             | -305.9                        | -282.8              | 24.85                | 12.84                                 | 41.24                                 | 773                               |
| 29                                    | 8.317           | 3836.                                                                                  | 5.428                                                             | -301.6                        | -272.1              | 25.00                | 12.85                                 | 40.63                                 | 781                               |
| 30                                    | 13.751          | 4257.                                                                                  | 5.451                                                             | -288.8                        | -239.9              | 25.43                | 12.87                                 | 39.02                                 | 805                               |
| 31                                    | 19.209          | 4688.                                                                                  | 5.468                                                             | -275.9                        | -207.6              | 25.86                | 12.91                                 | 37.57                                 | 828                               |
| 32                                    | 24.691          | 5104.                                                                                  | 5.480                                                             | -262.9                        | -175.2              | 26.27                | 12.96                                 | 36.44                                 | 849                               |
| 33                                    | 30.187          | 5511.                                                                                  | 5.488                                                             | -250.0                        | -142.6              | 26.67                | 13.00                                 | 35.49                                 | 870                               |
| 34                                    | 35.654          | 5917.                                                                                  | 5.492                                                             | -236.9                        | -110.2              | 27.05                | 13.04                                 | 34.67                                 | 889                               |
| 35                                    | 41.148          | 6314.                                                                                  | 5.494                                                             | -223.9                        | -77.6               | 27.43                | 13.09                                 | 33.96                                 | 907                               |
| 36                                    | 46.650          | 6708.                                                                                  | 5.494                                                             | -210.8                        | -44.9               | 27.80                | 13.14                                 | 33.34                                 | 925                               |
| 37                                    | 52.147          | 7098.                                                                                  | 5.491                                                             | -197.6                        | -12.2               | 28.16                | 13.18                                 | 32.79                                 | 942                               |
| 38                                    | 57.637          | 7485.                                                                                  | 5.488                                                             | -184.4                        | 20.5                | 28.52                | 13.23                                 | 32.30                                 | 958                               |
| 39                                    | 63.120          | 7867.                                                                                  | 5.483                                                             | -171.2                        | 53.3                | 28.86                | 13.26                                 | 31.85                                 | 975                               |
| 40                                    | 68.602          | 8247.                                                                                  | 5.477                                                             | -157.9                        | 86.0                | 29.20                | 13.29                                 | 31.45                                 | 990                               |
| 42                                    | 79.540          | 8993.                                                                                  | 5.462                                                             | -131.2                        | 151.5               | 29.85                | 13.36                                 | 30.74                                 | 1020                              |
| 44                                    | 90.440          | 9739.                                                                                  | 5.445                                                             | -104.4                        | 217.1               | 30.47                | 13.44                                 | 30.15                                 | 1048                              |
| 46                                    | 101.307         | 10466.                                                                                 | 5.427                                                             | -77.4                         | 282.7               | 31.07                | 13.55                                 | 29.69                                 | 1074                              |
| 48                                    | 112.148         | 11191.                                                                                 | 5.408                                                             | -50.2                         | 348.5               | 31.65                | 13.67                                 | 29.32                                 | 1098                              |
| 50                                    | 122.940         | 11905.                                                                                 | 5.388                                                             | -22.8                         | 414.3               | 32.21                | 13.80                                 | 29.01                                 | 1122                              |
| 55                                    | 149.761         | 13651.                                                                                 | 5.338                                                             | 47.1                          | 579.5               | 33.54                | 14.15                                 | 28.47                                 | 1175                              |
| 60                                    | 176.314         | 15363.                                                                                 | 5.287                                                             | 119.2                         | 746.1               | 34.80                | 14.50                                 | 28.12                                 | 1224                              |
| 65                                    | 202.656         | 17048.                                                                                 | 5.238                                                             | 192.8                         | 913.3               | 35.98                | 14.93                                 | 27.99                                 | 1267                              |
| 70                                    | 228.734         | 18688.                                                                                 | 5.191                                                             | 268.8                         | 1082.0              | 37.10                | 15.48                                 | 28.07                                 | 1305                              |
| 75                                    | 254.548         | 20314.                                                                                 | 5.144                                                             | 347.8                         | 1252.7              | 38.19                | 16.13                                 | 28.32                                 | 1339                              |
| 80                                    | 280.137         | 21897.                                                                                 | 5.100                                                             | 430.3                         | 1426.2              | 39.26                | 16.88                                 | 28.73                                 | 1369                              |
| 85                                    | 305.503         | 23497.                                                                                 | 5.056                                                             | 516.7                         | 1602.8              | 40.30                | 17.70                                 | 29.24                                 | 1397                              |
| 90                                    | 330.747         | 25104.                                                                                 | 5.014                                                             | 607.4                         | 1783.3              | 41.34                | 18.59                                 | 29.83                                 | 1423                              |
| 0.0290 GMCLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                        |                                                                   |                               |                     |                      |                                       |                                       |                                   |
| * 28.229                              | 6.033           | 4176.                                                                                  | 5.625                                                             | -320.8                        | -299.7              | 24.31                | 12.77                                 | 38.54                                 | 796                               |
| 29                                    | 10.400          | 4506.                                                                                  | 5.645                                                             | -310.9                        | -274.6              | 24.66                | 12.80                                 | 37.52                                 | 815                               |
| 30                                    | 16.046          | 4934.                                                                                  | 5.665                                                             | -298.1                        | -242.0              | 25.09                | 12.84                                 | 36.35                                 | 838                               |
| 31                                    | 21.721          | 5369.                                                                                  | 5.679                                                             | -285.2                        | -209.3              | 25.51                | 12.89                                 | 35.32                                 | 860                               |
| 32                                    | 27.412          | 5787.                                                                                  | 5.688                                                             | -272.3                        | -176.5              | 25.92                | 12.94                                 | 34.49                                 | 881                               |
| 33                                    | 33.111          | 6194.                                                                                  | 5.693                                                             | -259.3                        | -143.6              | 26.32                | 12.99                                 | 33.79                                 | 900                               |
| 34                                    | 38.784          | 6611.                                                                                  | 5.695                                                             | -246.3                        | -110.8              | 26.71                | 13.04                                 | 33.14                                 | 919                               |
| 35                                    | 44.478          | 7015.                                                                                  | 5.695                                                             | -233.3                        | -77.9               | 27.09                | 13.09                                 | 32.59                                 | 937                               |
| 36                                    | 50.178          | 7417.                                                                                  | 5.692                                                             | -220.1                        | -44.8               | 27.46                | 13.14                                 | 32.10                                 | 954                               |
| 37                                    | 55.872          | 7809.                                                                                  | 5.688                                                             | -207.0                        | -11.8               | 27.82                | 13.19                                 | 31.66                                 | 971                               |
| 38                                    | 61.557          | 8207.                                                                                  | 5.682                                                             | -193.8                        | 21.3                | 28.17                | 13.24                                 | 31.26                                 | 987                               |
| 39                                    | 67.233          | 8591.                                                                                  | 5.675                                                             | -180.5                        | 54.4                | 28.52                | 13.27                                 | 30.89                                 | 1002                              |
| 40                                    | 72.904          | 8977.                                                                                  | 5.668                                                             | -167.2                        | 87.5                | 28.85                | 13.31                                 | 30.56                                 | 1018                              |
| 42                                    | 84.219          | 9734.                                                                                  | 5.650                                                             | -140.5                        | 153.7               | 29.50                | 13.38                                 | 29.97                                 | 1047                              |
| 44                                    | 95.497          | 10495.                                                                                 | 5.630                                                             | -113.7                        | 220.0               | 30.13                | 13.47                                 | 29.48                                 | 1075                              |
| 46                                    | 106.731         | 11235.                                                                                 | 5.610                                                             | -86.6                         | 286.3               | 30.73                | 13.57                                 | 29.10                                 | 1100                              |
| 48                                    | 117.937         | 11977.                                                                                 | 5.588                                                             | -59.4                         | 352.7               | 31.31                | 13.70                                 | 28.78                                 | 1124                              |
| 50                                    | 129.089         | 12699.                                                                                 | 5.566                                                             | -31.8                         | 419.2               | 31.87                | 13.83                                 | 28.53                                 | 1147                              |
| 55                                    | 156.791         | 14477.                                                                                 | 5.512                                                             | 38.2                          | 586.0               | 33.21                | 14.19                                 | 28.09                                 | 1200                              |
| 60                                    | 184.208         | 16220.                                                                                 | 5.458                                                             | 110.5                         | 754.2               | 34.47                | 14.54                                 | 27.81                                 | 1249                              |
| 65                                    | 211.400         | 17935.                                                                                 | 5.406                                                             | 184.3                         | 922.9               | 35.65                | 14.97                                 | 27.74                                 | 1292                              |
| 70                                    | 238.305         | 19607.                                                                                 | 5.356                                                             | 260.5                         | 1093.1              | 36.78                | 15.52                                 | 27.86                                 | 1330                              |
| 75                                    | 264.938         | 21256.                                                                                 | 5.308                                                             | 339.7                         | 1265.3              | 37.87                | 16.17                                 | 28.15                                 | 1364                              |
| 80                                    | 291.324         | 22862.                                                                                 | 5.262                                                             | 422.4                         | 1440.2              | 38.94                | 16.92                                 | 28.59                                 | 1393                              |
| 85                                    | 317.506         | 24526.                                                                                 | 5.217                                                             | 509.0                         | 1618.4              | 39.99                | 17.75                                 | 29.11                                 | 1422                              |
| 90                                    | 343.571         | 26202.                                                                                 | 5.173                                                             | 600.0                         | 1800.4              | 41.03                | 18.63                                 | 29.71                                 | 1449                              |
| * TWO-PHASE BOUNDARY                  |                 |                                                                                        |                                                                   |                               |                     |                      |                                       |                                       |                                   |

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN          | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>v</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|-------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.0295 GMOL/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| 27.764                              | 5.555           | 4692.                                                                                 | 5.847                                                            | -335.8                        | -316.8              | 23.76                | 12.71                                          | 36.26                                          | 820                               |
| 28                                  | 6.950           | 4796.                                                                                 | 5.853                                                            | -332.8                        | -309.0              | 23.87                | 12.72                                          | 36.01                                          | 826                               |
| 29                                  | 12.833          | 5235.                                                                                 | 5.873                                                            | -320.1                        | -276.0              | 24.32                | 12.77                                          | 35.01                                          | 849                               |
| 30                                  | 18.695          | 5672.                                                                                 | 5.886                                                            | -307.3                        | -243.1              | 24.75                | 12.82                                          | 34.15                                          | 872                               |
| 31                                  | 24.587          | 6105.                                                                                 | 5.895                                                            | -294.5                        | -210.0              | 25.17                | 12.87                                          | 33.42                                          | 893                               |
| 32                                  | 30.487          | 6525.                                                                                 | 5.899                                                            | -281.6                        | -176.8              | 25.58                | 12.93                                          | 32.80                                          | 912                               |
| 33                                  | 36.391          | 6934.                                                                                 | 5.901                                                            | -268.6                        | -143.6              | 25.98                | 12.98                                          | 32.28                                          | 931                               |
| 34                                  | 42.274          | 7360.                                                                                 | 5.900                                                            | -255.6                        | -110.4              | 26.37                | 13.04                                          | 31.76                                          | 949                               |
| 35                                  | 48.172          | 7769.                                                                                 | 5.897                                                            | -242.5                        | -77.1               | 26.75                | 13.10                                          | 31.33                                          | 967                               |
| 36                                  | 54.072          | 8173.                                                                                 | 5.892                                                            | -229.4                        | -43.7               | 27.12                | 13.15                                          | 30.95                                          | 983                               |
| 37                                  | 59.965          | 8573.                                                                                 | 5.885                                                            | -216.2                        | -10.3               | 27.48                | 13.21                                          | 30.61                                          | 999                               |
| 38                                  | 65.849          | 8973.                                                                                 | 5.878                                                            | -203.0                        | 23.2                | 27.83                | 13.25                                          | 30.29                                          | 1015                              |
| 39                                  | 71.720          | 9367.                                                                                 | 5.869                                                            | -189.7                        | 56.6                | 28.18                | 13.29                                          | 29.99                                          | 1031                              |
| 40                                  | 77.584          | 9754.                                                                                 | 5.860                                                            | -176.4                        | 90.1                | 28.51                | 13.33                                          | 29.72                                          | 1046                              |
| 42                                  | 89.283          | 10528.                                                                                | 5.840                                                            | -149.7                        | 157.0               | 29.16                | 13.40                                          | 29.25                                          | 1074                              |
| 44                                  | 100.944         | 11302.                                                                                | 5.818                                                            | -122.8                        | 223.9               | 29.79                | 13.49                                          | 28.84                                          | 1102                              |
| 46                                  | 112.551         | 12054.                                                                                | 5.796                                                            | -95.7                         | 290.9               | 30.40                | 13.60                                          | 28.53                                          | 1127                              |
| 48                                  | 124.128         | 12802.                                                                                | 5.773                                                            | -68.3                         | 358.0               | 30.98                | 13.73                                          | 28.28                                          | 1151                              |
| 50                                  | 135.647         | 13543.                                                                                | 5.749                                                            | -40.7                         | 425.2               | 31.54                | 13.87                                          | 28.07                                          | 1174                              |
| 55                                  | 164.246         | 15350.                                                                                | 5.691                                                            | 29.5                          | 593.6               | 32.88                | 14.22                                          | 27.73                                          | 1226                              |
| 60                                  | 192.542         | 17124.                                                                                | 5.633                                                            | 102.0                         | 763.3               | 34.14                | 14.58                                          | 27.52                                          | 1275                              |
| 65                                  | 220.599         | 18869.                                                                                | 5.577                                                            | 175.9                         | 933.6               | 35.32                | 15.02                                          | 27.49                                          | 1318                              |
| 70                                  | 248.345         | 20564.                                                                                | 5.523                                                            | 252.3                         | 1105.3              | 36.46                | 15.56                                          | 27.65                                          | 1355                              |
| 75                                  | 275.811         | 22247.                                                                                | 5.471                                                            | 331.7                         | 1279.1              | 37.55                | 16.22                                          | 27.97                                          | 1389                              |
| 80                                  | 303.006         | 23876.                                                                                | 5.420                                                            | 414.7                         | 1455.4              | 38.62                | 16.97                                          | 28.43                                          | 1418                              |
| 85                                  | 330.040         | 25624.                                                                                | 5.370                                                            | 501.5                         | 1635.1              | 39.67                | 17.80                                          | 28.94                                          | 1447                              |
| 0.0300 GMOL/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| 27.270                              | 5.077           | 5263.                                                                                 | 6.060                                                            | -351.2                        | -334.0              | 23.19                | 12.64                                          | 34.06                                          | 844                               |
| 28                                  | 9.543           | 5584.                                                                                 | 6.076                                                            | -341.9                        | -309.7              | 23.53                | 12.68                                          | 33.53                                          | 861                               |
| 29                                  | 15.645          | 6024.                                                                                 | 6.093                                                            | -329.2                        | -276.4              | 23.97                | 12.74                                          | 32.86                                          | 884                               |
| 30                                  | 21.727          | 6464.                                                                                 | 6.104                                                            | -316.4                        | -243.1              | 24.41                | 12.80                                          | 32.26                                          | 905                               |
| 31                                  | 27.835          | 6894.                                                                                 | 6.110                                                            | -303.6                        | -209.6              | 24.83                | 12.86                                          | 31.75                                          | 925                               |
| 32                                  | 33.946          | 7324.                                                                                 | 6.112                                                            | -290.7                        | -176.1              | 25.24                | 12.93                                          | 31.31                                          | 944                               |
| 33                                  | 40.055          | 7731.                                                                                 | 6.111                                                            | -277.8                        | -142.5              | 25.64                | 12.99                                          | 30.93                                          | 962                               |
| 34                                  | 46.153          | 8165.                                                                                 | 6.108                                                            | -264.7                        | -108.9              | 26.02                | 13.05                                          | 30.54                                          | 980                               |
| 35                                  | 52.257          | 8584.                                                                                 | 6.102                                                            | -251.7                        | -75.2               | 26.40                | 13.11                                          | 30.21                                          | 997                               |
| 36                                  | 58.360          | 8987.                                                                                 | 6.095                                                            | -238.5                        | -41.4               | 26.77                | 13.17                                          | 29.92                                          | 1013                              |
| 37                                  | 64.454          | 9397.                                                                                 | 6.087                                                            | -225.3                        | -7.6                | 27.14                | 13.22                                          | 29.66                                          | 1029                              |
| 38                                  | 70.539          | 9798.                                                                                 | 6.078                                                            | -212.1                        | 26.2                | 27.49                | 13.27                                          | 29.40                                          | 1044                              |
| 39                                  | 76.609          | 10198.                                                                                | 6.068                                                            | -198.8                        | 60.0                | 27.83                | 13.31                                          | 29.16                                          | 1060                              |
| 40                                  | 82.668          | 10591.                                                                                | 6.057                                                            | -185.5                        | 93.7                | 28.17                | 13.35                                          | 28.95                                          | 1074                              |
| 42                                  | 94.756          | 11375.                                                                                | 6.034                                                            | -158.7                        | 161.4               | 28.82                | 13.43                                          | 28.56                                          | 1103                              |
| 44                                  | 106.807         | 12164.                                                                                | 6.009                                                            | -131.7                        | 229.0               | 29.45                | 13.52                                          | 28.23                                          | 1130                              |
| 46                                  | 118.793         | 12924.                                                                                | 5.984                                                            | -104.6                        | 296.7               | 30.06                | 13.64                                          | 27.98                                          | 1155                              |
| 48                                  | 130.748         | 13684.                                                                                | 5.959                                                            | -77.2                         | 364.4               | 30.64                | 13.77                                          | 27.79                                          | 1178                              |
| 50                                  | 142.640         | 14437.                                                                                | 5.933                                                            | -49.5                         | 432.3               | 31.21                | 13.90                                          | 27.63                                          | 1201                              |
| 55                                  | 172.149         | 16274.                                                                                | 5.871                                                            | 20.9                          | 602.3               | 32.55                | 14.26                                          | 27.37                                          | 1253                              |
| 60                                  | 201.340         | 18079.                                                                                | 5.810                                                            | 93.6                          | 773.6               | 33.81                | 14.62                                          | 27.23                                          | 1301                              |
| 65                                  | 230.277         | 19857.                                                                                | 5.751                                                            | 167.8                         | 945.5               | 35.00                | 15.06                                          | 27.25                                          | 1344                              |
| 70                                  | 258.877         | 21574.                                                                                | 5.695                                                            | 244.4                         | 1118.7              | 36.14                | 15.61                                          | 27.45                                          | 1381                              |
| 75                                  | 287.188         | 23273.                                                                                | 5.641                                                            | 324.0                         | 1294.0              | 37.23                | 16.26                                          | 27.81                                          | 1414                              |
| 80                                  | 315.207         | 24936.                                                                                | 5.589                                                            | 407.2                         | 1471.8              | 38.31                | 17.01                                          | 28.30                                          | 1444                              |
| 85                                  | 343.136         | 26777.                                                                                | 5.538                                                            | 494.3                         | 1653.2              | 39.36                | 17.85                                          | 28.80                                          | 1474                              |
| 0.0305 GMOL/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| 26.747                              | 4.603           | 5915.                                                                                 | 6.295                                                            | -366.7                        | -351.4              | 22.61                | 12.57                                          | 32.09                                          | 871                               |
| 27                                  | 6.210           | 6024.                                                                                 | 6.299                                                            | -363.5                        | -342.9              | 22.73                | 12.59                                          | 31.98                                          | 877                               |
| 28                                  | 12.545          | 6435.                                                                                 | 6.314                                                            | -350.9                        | -309.2              | 23.19                | 12.66                                          | 31.55                                          | 898                               |
| 29                                  | 18.867          | 6875.                                                                                 | 6.322                                                            | -338.2                        | -275.6              | 23.63                | 12.73                                          | 31.09                                          | 919                               |
| 30                                  | 25.173          | 7324.                                                                                 | 6.327                                                            | -325.5                        | -241.8              | 24.06                | 12.79                                          | 30.65                                          | 939                               |
| 31                                  | 31.495          | 7751.                                                                                 | 6.327                                                            | -312.6                        | -208.0              | 24.48                | 12.86                                          | 30.30                                          | 958                               |
| 32                                  | 37.817          | 8175.                                                                                 | 6.325                                                            | -299.8                        | -174.1              | 24.89                | 12.93                                          | 29.99                                          | 976                               |
| 33                                  | 44.133          | 8590.                                                                                 | 6.321                                                            | -286.8                        | -140.2              | 25.29                | 12.99                                          | 29.71                                          | 994                               |
| 34                                  | 50.449          | 9028.                                                                                 | 6.315                                                            | -273.8                        | -106.2              | 25.68                | 13.06                                          | 29.42                                          | 1011                              |
| 35                                  | 56.761          | 9448.                                                                                 | 6.307                                                            | -260.7                        | -72.1               | 26.06                | 13.12                                          | 29.17                                          | 1027                              |
| 36                                  | 63.069          | 9860.                                                                                 | 6.298                                                            | -247.5                        | -38.0               | 26.43                | 13.18                                          | 28.96                                          | 1043                              |
| 37                                  | 69.367          | 10269.                                                                                | 6.288                                                            | -234.3                        | -3.9                | 26.79                | 13.24                                          | 28.76                                          | 1059                              |
| 38                                  | 75.656          | 10680.                                                                                | 6.278                                                            | -221.0                        | 30.3                | 27.15                | 13.30                                          | 28.57                                          | 1074                              |
| 39                                  | 81.927          | 11084.                                                                                | 6.266                                                            | -207.7                        | 64.4                | 27.49                | 13.34                                          | 28.39                                          | 1089                              |
| 40                                  | 88.183          | 11487.                                                                                | 6.254                                                            | -194.4                        | 98.6                | 27.83                | 13.38                                          | 28.22                                          | 1103                              |
| 42                                  | 100.667         | 12277.                                                                                | 6.230                                                            | -167.5                        | 166.9               | 28.49                | 13.46                                          | 27.92                                          | 1131                              |
| 44                                  | 113.113         | 13077.                                                                                | 6.204                                                            | -140.5                        | 235.3               | 29.11                | 13.55                                          | 27.66                                          | 1158                              |
| 46                                  | 125.483         | 13847.                                                                                | 6.177                                                            | -113.3                        | 303.6               | 29.72                | 13.67                                          | 27.47                                          | 1183                              |
| 48                                  | 137.821         | 14617.                                                                                | 6.150                                                            | -85.8                         | 372.0               | 30.31                | 13.80                                          | 27.33                                          | 1206                              |
| 50                                  | 150.093         | 15387.                                                                                | 6.124                                                            | -58.1                         | 440.6               | 30.87                | 13.94                                          | 27.21                                          | 1229                              |
| 55                                  | 180.528         | 17249.                                                                                | 6.057                                                            | 12.5                          | 612.2               | 32.22                | 14.30                                          | 27.04                                          | 1280                              |
| 60                                  | 210.629         | 19084.                                                                                | 5.991                                                            | 85.4                          | 785.2               | 33.49                | 14.66                                          | 26.95                                          | 1328                              |
| 65                                  | 240.459         | 20887.                                                                                | 5.927                                                            | 159.8                         | 958.6               | 34.68                | 15.10                                          | 27.01                                          | 1370                              |
| 70                                  | 269.927         | 22637.                                                                                | 5.864                                                            | 236.6                         | 1133.3              | 35.82                | 15.65                                          | 27.23                                          | 1407                              |
| 75                                  | 299.092         | 24354.                                                                                | 5.803                                                            | 316.5                         | 1310.1              | 36.92                | 16.31                                          | 27.61                                          | 1439                              |
| 80                                  | 327.950         | 26047.                                                                                | 5.742                                                            | 399.9                         | 1489.4              | 37.99                | 17.06                                          | 28.10                                          | 1468                              |

• TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>OERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>OERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GPOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0310 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 26.194                             | 4.137           | 6581.                                                                                 | 6.515                                                            | -382.5                        | -369.0              | 22.00                | 12.51                                 | 30.32                                 | 895                               |
| 27                                   | 9.444           | 6924.                                                                                 | 6.528                                                            | -372.4                        | -341.5              | 22.38                | 12.57                                 | 30.09                                 | 913                               |
| 28                                   | 15.988          | 7349.                                                                                 | 6.539                                                            | -359.8                        | -307.5              | 22.84                | 12.64                                 | 29.82                                 | 933                               |
| 29                                   | 22.531          | 7789.                                                                                 | 6.544                                                            | -347.1                        | -273.5              | 23.29                | 12.72                                 | 29.53                                 | 953                               |
| 30                                   | 29.061          | 8249.                                                                                 | 6.546                                                            | -334.4                        | -239.4              | 23.72                | 12.79                                 | 29.24                                 | 973                               |
| 31                                   | 35.597          | 8684.                                                                                 | 6.544                                                            | -321.5                        | -205.2              | 24.14                | 12.86                                 | 29.02                                 | 991                               |
| 32                                   | 42.131          | 9091.                                                                                 | 6.540                                                            | -308.6                        | -170.9              | 24.55                | 12.94                                 | 28.81                                 | 1009                              |
| 33                                   | 48.655          | 9511.                                                                                 | 6.533                                                            | -295.7                        | -136.6              | 24.95                | 13.00                                 | 28.62                                 | 1026                              |
| 34                                   | 55.191          | 9951.                                                                                 | 6.525                                                            | -282.6                        | -102.2              | 25.34                | 13.07                                 | 28.41                                 | 1043                              |
| 35                                   | 61.715          | 10375.                                                                                | 6.516                                                            | -269.5                        | -67.8               | 25.72                | 13.14                                 | 28.24                                 | 1059                              |
| 36                                   | 68.229          | 10791.                                                                                | 6.505                                                            | -256.4                        | -33.3               | 26.09                | 13.20                                 | 28.09                                 | 1074                              |
| 37                                   | 74.733          | 11204.                                                                                | 6.494                                                            | -243.1                        | 1.1                 | 26.45                | 13.26                                 | 27.95                                 | 1089                              |
| 38                                   | 81.229          | 11619.                                                                                | 6.482                                                            | -229.8                        | 35.7                | 26.80                | 13.32                                 | 27.81                                 | 1104                              |
| 39                                   | 87.703          | 12028.                                                                                | 6.469                                                            | -216.5                        | 70.2                | 27.15                | 13.36                                 | 27.67                                 | 1119                              |
| 40                                   | 94.160          | 12432.                                                                                | 6.456                                                            | -203.1                        | 104.7               | 27.49                | 13.40                                 | 27.54                                 | 1133                              |
| 42                                   | 107.043         | 13236.                                                                                | 6.429                                                            | -176.2                        | 173.7               | 28.15                | 13.49                                 | 27.32                                 | 1161                              |
| 44                                   | 119.889         | 14039.                                                                                | 6.401                                                            | -149.1                        | 242.7               | 28.78                | 13.59                                 | 27.12                                 | 1187                              |
| 46                                   | 132.649         | 14826.                                                                                | 6.372                                                            | -121.8                        | 311.7               | 29.39                | 13.70                                 | 26.99                                 | 1211                              |
| 48                                   | 145.374         | 15605.                                                                                | 6.343                                                            | -94.3                         | 380.9               | 29.97                | 13.84                                 | 26.89                                 | 1235                              |
| 50                                   | 158.031         | 16382.                                                                                | 6.315                                                            | -66.5                         | 450.0               | 30.54                | 13.97                                 | 26.81                                 | 1257                              |
| 55                                   | 189.408         | 18278.                                                                                | 6.244                                                            | 4.3                           | 623.4               | 31.89                | 14.34                                 | 26.71                                 | 1308                              |
| 60                                   | 220.433         | 20142.                                                                                | 6.174                                                            | 77.4                          | 797.9               | 33.16                | 14.70                                 | 26.67                                 | 1355                              |
| 65                                   | 251.169         | 21965.                                                                                | 6.106                                                            | 152.0                         | 972.9               | 34.35                | 15.15                                 | 26.78                                 | 1397                              |
| 70                                   | 281.519         | 23744.                                                                                | 6.039                                                            | 229.1                         | 1149.2              | 35.50                | 15.70                                 | 27.03                                 | 1434                              |
| 75                                   | 311.546         | 25473.                                                                                | 5.974                                                            | 309.2                         | 1327.5              | 36.60                | 16.36                                 | 27.44                                 | 1465                              |
| 80                                   | 341.258         | 27198.                                                                                | 5.910                                                            | 392.8                         | 1508.2              | 37.68                | 17.12                                 | 27.95                                 | 1494                              |
| 0.0315 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 25.608                             | 3.680           | 7291.                                                                                 | 6.743                                                            | -398.5                        | -386.7              | 21.38                | 12.44                                 | 28.75                                 | 920                               |
| 26                                   | 6.349           | 7461.                                                                                 | 6.749                                                            | -393.6                        | -373.2              | 21.57                | 12.47                                 | 28.68                                 | 929                               |
| 27                                   | 13.145          | 7894.                                                                                 | 6.760                                                            | -381.1                        | -338.8              | 22.04                | 12.55                                 | 28.52                                 | 949                               |
| 28                                   | 19.905          | 8328.                                                                                 | 6.766                                                            | -368.5                        | -304.5              | 22.50                | 12.64                                 | 28.36                                 | 969                               |
| 29                                   | 26.667          | 8767.                                                                                 | 6.768                                                            | -355.9                        | -270.1              | 22.94                | 12.72                                 | 28.19                                 | 988                               |
| 30                                   | 33.423          | 9219.                                                                                 | 6.766                                                            | -343.1                        | -235.6              | 23.37                | 12.79                                 | 28.00                                 | 1007                              |
| 31                                   | 40.172          | 9643.                                                                                 | 6.762                                                            | -330.3                        | -201.1              | 23.79                | 12.87                                 | 27.88                                 | 1025                              |
| 32                                   | 46.919          | 10071.                                                                                | 6.755                                                            | -317.4                        | -166.4              | 24.20                | 12.95                                 | 27.75                                 | 1042                              |
| 33                                   | 53.654          | 10497.                                                                                | 6.746                                                            | -304.4                        | -131.8              | 24.60                | 13.02                                 | 27.63                                 | 1058                              |
| 34                                   | 60.410          | 10935.                                                                                | 6.736                                                            | -291.3                        | -97.0               | 24.99                | 13.09                                 | 27.50                                 | 1075                              |
| 35                                   | 67.147          | 11363.                                                                                | 6.725                                                            | -278.2                        | -62.2               | 25.37                | 13.16                                 | 27.38                                 | 1090                              |
| 36                                   | 73.870          | 11782.                                                                                | 6.713                                                            | -265.0                        | -27.4               | 25.74                | 13.22                                 | 27.29                                 | 1105                              |
| 37                                   | 80.581          | 12198.                                                                                | 6.701                                                            | -251.8                        | 7.4                 | 26.11                | 13.29                                 | 27.19                                 | 1120                              |
| 38                                   | 87.285          | 12618.                                                                                | 6.687                                                            | -238.4                        | 42.3                | 26.46                | 13.35                                 | 27.10                                 | 1135                              |
| 39                                   | 93.965          | 13031.                                                                                | 6.673                                                            | -225.1                        | 77.2                | 26.81                | 13.39                                 | 27.00                                 | 1149                              |
| 40                                   | 100.626         | 13441.                                                                                | 6.659                                                            | -211.7                        | 112.0               | 27.15                | 13.43                                 | 26.91                                 | 1163                              |
| 42                                   | 113.912         | 14253.                                                                                | 6.630                                                            | -184.7                        | 181.7               | 27.81                | 13.52                                 | 26.75                                 | 1190                              |
| 44                                   | 127.162         | 15063.                                                                                | 6.600                                                            | -157.6                        | 251.5               | 28.44                | 13.62                                 | 26.61                                 | 1216                              |
| 46                                   | 140.319         | 15861.                                                                                | 6.570                                                            | -130.2                        | 321.2               | 29.05                | 13.74                                 | 26.52                                 | 1241                              |
| 48                                   | 153.435         | 16648.                                                                                | 6.539                                                            | -102.6                        | 391.0               | 29.64                | 13.87                                 | 26.46                                 | 1263                              |
| 50                                   | 166.484         | 17436.                                                                                | 6.509                                                            | -74.7                         | 460.8               | 30.21                | 14.01                                 | 26.42                                 | 1285                              |
| 55                                   | 198.815         | 19369.                                                                                | 6.433                                                            | -3.7                          | 635.8               | 31.56                | 14.38                                 | 26.39                                 | 1336                              |
| 60                                   | 230.779         | 21257.                                                                                | 6.359                                                            | 69.6                          | 811.9               | 32.84                | 14.74                                 | 26.40                                 | 1383                              |
| 65                                   | 262.432         | 23098.                                                                                | 6.286                                                            | 144.4                         | 988.6               | 34.03                | 15.19                                 | 26.55                                 | 1424                              |
| 70                                   | 293.680         | 24908.                                                                                | 6.215                                                            | 221.7                         | 1166.4              | 35.18                | 15.75                                 | 26.83                                 | 1460                              |
| 75                                   | 324.572         | 26647.                                                                                | 6.145                                                            | 302.1                         | 1346.1              | 36.29                | 16.41                                 | 27.27                                 | 1492                              |
| 0.0320 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 24.988                             | 3.237           | 8036.                                                                                 | 6.970                                                            | -414.8                        | -404.5              | 20.73                | 12.37                                 | 27.32                                 | 944                               |
| 25                                   | 3.327           | 8041.                                                                                 | 6.970                                                            | -414.6                        | -404.1              | 20.73                | 12.37                                 | 27.32                                 | 945                               |
| 26                                   | 10.337          | 8509.                                                                                 | 6.983                                                            | -402.2                        | -369.5              | 21.22                | 12.46                                 | 27.21                                 | 966                               |
| 27                                   | 17.349          | 8937.                                                                                 | 6.990                                                            | -389.7                        | -334.8              | 21.69                | 12.54                                 | 27.16                                 | 986                               |
| 28                                   | 24.327          | 9377.                                                                                 | 6.992                                                            | -377.1                        | -300.1              | 22.15                | 12.63                                 | 27.09                                 | 1005                              |
| 29                                   | 31.309          | 9819.                                                                                 | 6.990                                                            | -364.4                        | -265.3              | 22.59                | 12.72                                 | 27.01                                 | 1023                              |
| 30                                   | 38.290          | 10269.                                                                                | 6.986                                                            | -351.7                        | -230.4              | 23.03                | 12.80                                 | 26.92                                 | 1041                              |
| 31                                   | 45.251          | 10686.                                                                                | 6.979                                                            | -338.8                        | -195.6              | 23.45                | 12.88                                 | 26.86                                 | 1058                              |
| 32                                   | 52.213          | 11116.                                                                                | 6.970                                                            | -325.9                        | -160.6              | 23.86                | 12.96                                 | 26.80                                 | 1075                              |
| 33                                   | 59.163          | 11548.                                                                                | 6.960                                                            | -312.9                        | -125.6              | 24.26                | 13.04                                 | 26.73                                 | 1091                              |
| 34                                   | 66.137          | 11987.                                                                                | 6.949                                                            | -299.8                        | -90.4               | 24.65                | 13.11                                 | 26.67                                 | 1107                              |
| 35                                   | 73.088          | 12413.                                                                                | 6.936                                                            | -286.7                        | -55.3               | 25.03                | 13.18                                 | 26.60                                 | 1122                              |
| 36                                   | 80.022          | 12835.                                                                                | 6.923                                                            | -273.5                        | -20.1               | 25.40                | 13.25                                 | 26.55                                 | 1137                              |
| 37                                   | 86.941          | 13255.                                                                                | 6.909                                                            | -260.2                        | 15.1                | 25.77                | 13.31                                 | 26.50                                 | 1151                              |
| 38                                   | 93.856          | 13677.                                                                                | 6.895                                                            | -246.9                        | 50.3                | 26.12                | 13.37                                 | 26.44                                 | 1166                              |
| 39                                   | 100.744         | 14094.                                                                                | 6.880                                                            | -233.5                        | 85.5                | 26.47                | 13.42                                 | 26.38                                 | 1180                              |
| 40                                   | 107.611         | 14519.                                                                                | 6.865                                                            | -220.0                        | 120.7               | 26.81                | 13.46                                 | 26.32                                 | 1194                              |
| 42                                   | 121.306         | 15337.                                                                                | 6.834                                                            | -193.0                        | 191.1               | 27.47                | 13.55                                 | 26.21                                 | 1221                              |
| 44                                   | 134.962         | 16145.                                                                                | 6.802                                                            | -165.8                        | 261.5               | 28.10                | 13.65                                 | 26.13                                 | 1246                              |
| 46                                   | 148.520         | 16953.                                                                                | 6.770                                                            | -138.4                        | 331.9               | 28.71                | 13.77                                 | 26.08                                 | 1270                              |
| 48                                   | 162.032         | 17748.                                                                                | 6.738                                                            | -110.7                        | 402.4               | 29.30                | 13.91                                 | 26.06                                 | 1293                              |
| 50                                   | 175.477         | 18547.                                                                                | 6.706                                                            | -82.7                         | 472.9               | 29.87                | 14.05                                 | 26.05                                 | 1315                              |
| 55                                   | 208.777         | 20498.                                                                                | 6.626                                                            | -11.5                         | 649.5               | 31.23                | 14.42                                 | 26.08                                 | 1365                              |
| 60                                   | 241.694         | 22416.                                                                                | 6.547                                                            | 62.0                          | 827.3               | 32.51                | 14.79                                 | 26.14                                 | 1411                              |
| 65                                   | 274.276         | 24284.                                                                                | 6.470                                                            | 137.1                         | 1005.5              | 33.71                | 15.24                                 | 26.33                                 | 1452                              |
| 70                                   | 306.437         | 26127.                                                                                | 6.393                                                            | 214.6                         | 1184.9              | 34.86                | 15.80                                 | 26.64                                 | 1488                              |
| 75                                   | 338.196         | 27859.                                                                                | 6.317                                                            | 295.3                         | 1366.1              | 35.97                | 16.47                                 | 27.10                                 | 1518                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0325 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 24.334                             | 2.812           | 8865.                                                                                 | 7.185                                                            | -431.2                        | -422.4              | 20.06                | 12.29                                 | 25.89                                 | 969                               |
| 25                                   | 7.625           | 9167.                                                                                 | 7.196                                                            | -423.0                        | -399.2              | 20.39                | 12.35                                 | 25.91                                 | 983                               |
| 26                                   | 14.861          | 9608.                                                                                 | 7.207                                                            | -410.6                        | -364.2              | 20.87                | 12.45                                 | 25.93                                 | 1003                              |
| 27                                   | 22.088          | 10038.                                                                                | 7.213                                                            | -398.1                        | -329.2              | 21.35                | 12.54                                 | 25.96                                 | 1022                              |
| 28                                   | 29.288          | 10482.                                                                                | 7.214                                                            | -385.5                        | -294.2              | 21.80                | 12.63                                 | 25.97                                 | 1041                              |
| 29                                   | 36.489          | 10920.                                                                                | 7.211                                                            | -372.8                        | -259.1              | 22.25                | 12.73                                 | 25.97                                 | 1058                              |
| 30                                   | 43.694          | 11366.                                                                                | 7.205                                                            | -360.0                        | -223.8              | 22.68                | 12.81                                 | 25.95                                 | 1076                              |
| 31                                   | 50.868          | 11794.                                                                                | 7.197                                                            | -347.2                        | -188.6              | 23.10                | 12.89                                 | 25.95                                 | 1092                              |
| 32                                   | 58.046          | 12226.                                                                                | 7.187                                                            | -334.3                        | -153.3              | 23.51                | 12.98                                 | 25.94                                 | 1108                              |
| 33                                   | 65.213          | 12665.                                                                                | 7.175                                                            | -321.2                        | -117.9              | 23.91                | 13.05                                 | 25.92                                 | 1124                              |
| 34                                   | 72.403          | 13094.                                                                                | 7.163                                                            | -308.2                        | -82.4               | 24.31                | 13.13                                 | 25.91                                 | 1140                              |
| 35                                   | 79.570          | 13526.                                                                                | 7.149                                                            | -295.0                        | -46.9               | 24.69                | 13.20                                 | 25.89                                 | 1155                              |
| 36                                   | 86.716          | 13952.                                                                                | 7.135                                                            | -281.7                        | -11.4               | 25.06                | 13.27                                 | 25.87                                 | 1169                              |
| 37                                   | 93.846          | 14374.                                                                                | 7.120                                                            | -268.4                        | 24.1                | 25.42                | 13.34                                 | 25.86                                 | 1183                              |
| 38                                   | 100.973         | 14798.                                                                                | 7.104                                                            | -255.1                        | 59.7                | 25.78                | 13.40                                 | 25.83                                 | 1197                              |
| 39                                   | 108.069         | 15218.                                                                                | 7.088                                                            | -241.6                        | 95.3                | 26.13                | 13.45                                 | 25.80                                 | 1211                              |
| 40                                   | 115.146         | 15640.                                                                                | 7.072                                                            | -228.2                        | 130.8               | 26.47                | 13.49                                 | 25.76                                 | 1225                              |
| 42                                   | 129.253         | 16469.                                                                                | 7.039                                                            | -201.1                        | 201.9               | 27.13                | 13.59                                 | 25.71                                 | 1252                              |
| 44                                   | 143.317         | 17286.                                                                                | 7.006                                                            | -173.8                        | 273.0               | 27.77                | 13.69                                 | 25.67                                 | 1276                              |
| 46                                   | 157.281         | 18104.                                                                                | 6.972                                                            | -146.3                        | 344.0               | 28.38                | 13.81                                 | 25.66                                 | 1300                              |
| 48                                   | 171.193         | 18907.                                                                                | 6.938                                                            | -118.5                        | 415.2               | 28.97                | 13.95                                 | 25.67                                 | 1322                              |
| 50                                   | 185.040         | 19714.                                                                                | 6.905                                                            | -90.5                         | 486.4               | 29.54                | 14.09                                 | 25.69                                 | 1344                              |
| 55                                   | 219.323         | 21693.                                                                                | 6.821                                                            | -19.1                         | 664.7               | 30.90                | 14.47                                 | 25.78                                 | 1394                              |
| 60                                   | 253.205         | 23634.                                                                                | 6.738                                                            | 54.7                          | 844.1               | 32.19                | 14.84                                 | 25.89                                 | 1440                              |
| 65                                   | 286.725         | 25521.                                                                                | 6.657                                                            | 129.9                         | 1023.9              | 33.39                | 15.29                                 | 26.12                                 | 1480                              |
| 70                                   | 319.816         | 27402.                                                                                | 6.577                                                            | 207.8                         | 1204.9              | 34.55                | 15.85                                 | 26.45                                 | 1516                              |
| 0.0330 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 24.642                             | 2.406           | 9731.                                                                                 | 7.401                                                            | -447.8                        | -440.4              | 19.36                | 12.20                                 | 24.58                                 | 993                               |
| 24                                   | 5.059           | 9894.                                                                                 | 7.409                                                            | -443.4                        | -427.9              | 19.54                | 12.24                                 | 24.63                                 | 1000                              |
| 25                                   | 12.500          | 10350.                                                                                | 7.424                                                            | -431.1                        | -392.7              | 20.04                | 12.34                                 | 24.73                                 | 1021                              |
| 26                                   | 19.956          | 10785.                                                                                | 7.433                                                            | -418.7                        | -357.5              | 20.53                | 12.44                                 | 24.83                                 | 1040                              |
| 27                                   | 27.398          | 11214.                                                                                | 7.437                                                            | -406.3                        | -322.1              | 21.00                | 12.54                                 | 24.93                                 | 1059                              |
| 28                                   | 34.820          | 11660.                                                                                | 7.436                                                            | -393.7                        | -286.8              | 21.46                | 12.64                                 | 24.99                                 | 1077                              |
| 29                                   | 42.240          | 12096.                                                                                | 7.431                                                            | -381.0                        | -251.3              | 21.90                | 12.73                                 | 25.05                                 | 1094                              |
| 30                                   | 49.668          | 12538.                                                                                | 7.424                                                            | -368.2                        | -215.7              | 22.34                | 12.82                                 | 25.09                                 | 1111                              |
| 31                                   | 57.056          | 12970.                                                                                | 7.414                                                            | -355.3                        | -180.2              | 22.76                | 12.91                                 | 25.13                                 | 1127                              |
| 32                                   | 64.451          | 13404.                                                                                | 7.403                                                            | -342.4                        | -144.5              | 23.17                | 12.99                                 | 25.17                                 | 1142                              |
| 33                                   | 71.839          | 13848.                                                                                | 7.391                                                            | -329.4                        | -108.8              | 23.57                | 13.07                                 | 25.18                                 | 1158                              |
| 34                                   | 79.241          | 14271.                                                                                | 7.377                                                            | -316.2                        | -72.9               | 23.96                | 13.15                                 | 25.22                                 | 1173                              |
| 35                                   | 86.625          | 14703.                                                                                | 7.362                                                            | -303.1                        | -37.1               | 24.34                | 13.23                                 | 25.23                                 | 1187                              |
| 36                                   | 93.984          | 15132.                                                                                | 7.347                                                            | -289.8                        | -1.2                | 24.72                | 13.30                                 | 25.25                                 | 1202                              |
| 37                                   | 101.326         | 15556.                                                                                | 7.331                                                            | -276.5                        | 34.7                | 25.08                | 13.37                                 | 25.26                                 | 1216                              |
| 38                                   | 108.665         | 15983.                                                                                | 7.315                                                            | -263.1                        | 70.6                | 25.44                | 13.43                                 | 25.27                                 | 1229                              |
| 39                                   | 115.973         | 16405.                                                                                | 7.298                                                            | -249.6                        | 106.5               | 25.79                | 13.48                                 | 25.26                                 | 1243                              |
| 40                                   | 123.261         | 16832.                                                                                | 7.281                                                            | -236.1                        | 142.4               | 26.13                | 13.53                                 | 25.25                                 | 1257                              |
| 42                                   | 137.785         | 17662.                                                                                | 7.247                                                            | -209.0                        | 214.1               | 26.79                | 13.62                                 | 25.23                                 | 1283                              |
| 44                                   | 152.257         | 18487.                                                                                | 7.212                                                            | -181.6                        | 285.9               | 27.43                | 13.72                                 | 25.24                                 | 1307                              |
| 46                                   | 166.634         | 19316.                                                                                | 7.176                                                            | -154.0                        | 357.6               | 28.05                | 13.85                                 | 25.26                                 | 1331                              |
| 48                                   | 180.948         | 20124.                                                                                | 7.141                                                            | -126.2                        | 429.4               | 28.64                | 13.99                                 | 25.30                                 | 1353                              |
| 50                                   | 195.201         | 20942.                                                                                | 7.106                                                            | -98.1                         | 501.3               | 29.21                | 14.13                                 | 25.35                                 | 1374                              |
| 55                                   | 230.479         | 22942.                                                                                | 7.018                                                            | -26.5                         | 681.2               | 30.58                | 14.51                                 | 25.50                                 | 1423                              |
| 60                                   | 265.337         | 24905.                                                                                | 6.931                                                            | 47.5                          | 862.2               | 31.86                | 14.88                                 | 25.65                                 | 1469                              |
| 65                                   | 299.805         | 26811.                                                                                | 6.846                                                            | 123.1                         | 1043.6              | 33.07                | 15.34                                 | 25.92                                 | 1509                              |
| 70                                   | 333.848         | 28734.                                                                                | 6.762                                                            | 201.1                         | 1226.2              | 34.23                | 15.91                                 | 26.27                                 | 1544                              |
| 0.0335 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 22.912                             | 2.026           | 10623.                                                                                | 7.607                                                            | -464.6                        | -458.4              | 18.63                | 12.09                                 | 23.36                                 | 1016                              |
| 23                                   | 2.688           | 10664.                                                                                | 7.609                                                            | -463.5                        | -455.4              | 18.68                | 12.10                                 | 23.38                                 | 1018                              |
| 24                                   | 10.320          | 11167.                                                                                | 7.633                                                            | -451.3                        | -420.1              | 19.20                | 12.22                                 | 23.53                                 | 1039                              |
| 25                                   | 17.986          | 11606.                                                                                | 7.648                                                            | -439.1                        | -384.7              | 19.70                | 12.33                                 | 23.70                                 | 1059                              |
| 26                                   | 25.658          | 12033.                                                                                | 7.656                                                            | -426.7                        | -349.1              | 20.18                | 12.43                                 | 23.86                                 | 1078                              |
| 27                                   | 33.314          | 12460.                                                                                | 7.658                                                            | -414.2                        | -313.4              | 20.65                | 12.54                                 | 24.01                                 | 1095                              |
| 28                                   | 40.959          | 12904.                                                                                | 7.656                                                            | -401.6                        | -277.7              | 21.11                | 12.64                                 | 24.12                                 | 1113                              |
| 29                                   | 48.596          | 13341.                                                                                | 7.650                                                            | -388.9                        | -241.9              | 21.56                | 12.74                                 | 24.23                                 | 1129                              |
| 30                                   | 56.244          | 13777.                                                                                | 7.642                                                            | -376.1                        | -206.0              | 21.99                | 12.83                                 | 24.31                                 | 1145                              |
| 31                                   | 63.850          | 14214.                                                                                | 7.632                                                            | -363.3                        | -170.1              | 22.41                | 12.92                                 | 24.39                                 | 1161                              |
| 32                                   | 71.461          | 14650.                                                                                | 7.620                                                            | -350.3                        | -134.2              | 22.83                | 13.01                                 | 24.46                                 | 1177                              |
| 33                                   | 79.073          | 15097.                                                                                | 7.606                                                            | -337.2                        | -98.1               | 23.23                | 13.09                                 | 24.51                                 | 1192                              |
| 34                                   | 86.685          | 15514.                                                                                | 7.592                                                            | -324.1                        | -61.9               | 23.62                | 13.17                                 | 24.58                                 | 1206                              |
| 35                                   | 94.284          | 15946.                                                                                | 7.577                                                            | -310.9                        | -25.7               | 24.00                | 13.25                                 | 24.63                                 | 1220                              |
| 36                                   | 101.859         | 16377.                                                                                | 7.560                                                            | -297.6                        | 10.5                | 24.38                | 13.33                                 | 24.67                                 | 1234                              |
| 37                                   | 109.413         | 16804.                                                                                | 7.544                                                            | -284.2                        | 46.7                | 24.74                | 13.40                                 | 24.71                                 | 1248                              |
| 38                                   | 116.966         | 17231.                                                                                | 7.527                                                            | -270.8                        | 83.0                | 25.10                | 13.46                                 | 24.74                                 | 1262                              |
| 39                                   | 124.485         | 17656.                                                                                | 7.509                                                            | -257.3                        | 119.2               | 25.45                | 13.51                                 | 24.76                                 | 1275                              |
| 40                                   | 131.989         | 18088.                                                                                | 7.491                                                            | -243.8                        | 155.4               | 25.79                | 13.56                                 | 24.76                                 | 1289                              |
| 42                                   | 146.932         | 18930.                                                                                | 7.455                                                            | -216.6                        | 227.8               | 26.46                | 13.65                                 | 24.79                                 | 1314                              |
| 44                                   | 161.814         | 19750.                                                                                | 7.419                                                            | -189.2                        | 300.3               | 27.09                | 13.76                                 | 24.83                                 | 1338                              |
| 46                                   | 176.607         | 20588.                                                                                | 7.382                                                            | -161.5                        | 372.7               | 27.71                | 13.89                                 | 24.88                                 | 1362                              |
| 48                                   | 191.327         | 21402.                                                                                | 7.345                                                            | -133.6                        | 445.1               | 28.31                | 14.03                                 | 24.95                                 | 1383                              |
| 50                                   | 205.990         | 22225.                                                                                | 7.309                                                            | -105.4                        | 517.6               | 28.88                | 14.17                                 | 25.02                                 | 1404                              |
| 55                                   | 242.275         | 24250.                                                                                | 7.217                                                            | -33.6                         | 699.2               | 30.25                | 14.56                                 | 25.22                                 | 1453                              |
| 60                                   | 278.119         | 26228.                                                                                | 7.127                                                            | 40.7                          | 881.9               | 31.54                | 14.93                                 | 25.42                                 | 1498                              |
| 65                                   | 313.544         | 28152.                                                                                | 7.038                                                            | 116.4                         | 1064.8              | 32.76                | 15.39                                 | 25.72                                 | 1538                              |
| 70                                   | 348.560         | 30127.                                                                                | 6.951                                                            | 194.8                         | 1249.1              | 33.92                | 15.96                                 | 26.10                                 | 1573                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0340 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 22.141                             | 1.672           | 11658.                                                                                | 7.809                                                            | -481.5                        | -476.5              | 17.88                | 11.97                                 | 22.12                                 | 1041                              |
| 23                                   | 8.364           | 12046.                                                                                | 7.835                                                            | -471.2                        | -446.2              | 18.34                | 12.08                                 | 22.35                                 | 1059                              |
| 24                                   | 16.232          | 12498.                                                                                | 7.855                                                            | -459.0                        | -410.6              | 18.85                | 12.20                                 | 22.58                                 | 1078                              |
| 25                                   | 24.118          | 12931.                                                                                | 7.868                                                            | -446.8                        | -374.9              | 19.35                | 12.31                                 | 22.80                                 | 1097                              |
| 26                                   | 32.001          | 13351.                                                                                | 7.874                                                            | -434.4                        | -339.0              | 19.84                | 12.43                                 | 23.01                                 | 1115                              |
| 27                                   | 39.870          | 13777.                                                                                | 7.875                                                            | -421.9                        | -303.1              | 20.31                | 12.54                                 | 23.19                                 | 1132                              |
| 28                                   | 47.738          | 14221.                                                                                | 7.873                                                            | -409.3                        | -267.0              | 20.77                | 12.65                                 | 23.34                                 | 1149                              |
| 29                                   | 55.592          | 14654.                                                                                | 7.867                                                            | -396.6                        | -230.9              | 21.21                | 12.75                                 | 23.48                                 | 1165                              |
| 30                                   | 63.456          | 15084.                                                                                | 7.858                                                            | -383.8                        | -194.7              | 21.65                | 12.84                                 | 23.61                                 | 1180                              |
| 31                                   | 71.282          | 15526.                                                                                | 7.848                                                            | -370.9                        | -158.5              | 22.07                | 12.94                                 | 23.72                                 | 1196                              |
| 32                                   | 79.112          | 15963.                                                                                | 7.835                                                            | -357.9                        | -122.2              | 22.48                | 13.03                                 | 23.82                                 | 1211                              |
| 33                                   | 86.947          | 16412.                                                                                | 7.822                                                            | -344.9                        | -85.8               | 22.88                | 13.12                                 | 23.90                                 | 1226                              |
| 34                                   | 94.766          | 16824.                                                                                | 7.807                                                            | -331.7                        | -49.3               | 23.28                | 13.20                                 | 23.99                                 | 1240                              |
| 35                                   | 102.582         | 17255.                                                                                | 7.792                                                            | -318.5                        | -12.8               | 23.66                | 13.28                                 | 24.07                                 | 1254                              |
| 36                                   | 110.373         | 17689.                                                                                | 7.775                                                            | -305.2                        | 23.8                | 24.04                | 13.35                                 | 24.14                                 | 1268                              |
| 37                                   | 118.141         | 18118.                                                                                | 7.758                                                            | -291.8                        | 60.3                | 24.40                | 13.42                                 | 24.20                                 | 1281                              |
| 38                                   | 125.907         | 18544.                                                                                | 7.741                                                            | -278.3                        | 96.9                | 24.76                | 13.49                                 | 24.25                                 | 1294                              |
| 39                                   | 133.639         | 18972.                                                                                | 7.723                                                            | -264.8                        | 133.5               | 25.11                | 13.54                                 | 24.29                                 | 1308                              |
| 40                                   | 141.360         | 19407.                                                                                | 7.705                                                            | -251.2                        | 170.0               | 25.46                | 13.59                                 | 24.31                                 | 1321                              |
| 42                                   | 156.725         | 20254.                                                                                | 7.667                                                            | -224.0                        | 243.1               | 26.12                | 13.69                                 | 24.37                                 | 1346                              |
| 44                                   | 172.018         | 21076.                                                                                | 7.629                                                            | -196.5                        | 316.2               | 26.76                | 13.80                                 | 24.45                                 | 1370                              |
| 46                                   | 187.232         | 21921.                                                                                | 7.591                                                            | -168.7                        | 389.2               | 27.38                | 13.92                                 | 24.52                                 | 1393                              |
| 48                                   | 202.361         | 22741.                                                                                | 7.552                                                            | -140.7                        | 462.3               | 27.97                | 14.07                                 | 24.62                                 | 1414                              |
| 50                                   | 217.436         | 23570.                                                                                | 7.513                                                            | -112.5                        | 535.5               | 28.55                | 14.22                                 | 24.71                                 | 1435                              |
| 55                                   | 254.738         | 25612.                                                                                | 7.416                                                            | -40.4                         | 718.7               | 29.92                | 14.60                                 | 24.96                                 | 1483                              |
| 60                                   | 291.574         | 27600.                                                                                | 7.319                                                            | 34.1                          | 903.0               | 31.22                | 14.98                                 | 25.19                                 | 1527                              |
| 65                                   | 327.965         | 29547.                                                                                | 7.222                                                            | 110.1                         | 1087.5              | 32.44                | 15.45                                 | 25.51                                 | 1566                              |
| 0.0345 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 21.327                             | 1.350           | 12756.                                                                                | 7.987                                                            | -498.5                        | -494.5              | 17.09                | 11.81                                 | 20.89                                 | 1065                              |
| 22                                   | 6.732           | 13046.                                                                                | 8.016                                                            | -490.5                        | -470.8              | 17.46                | 11.91                                 | 21.13                                 | 1079                              |
| 23                                   | 14.743          | 13477.                                                                                | 8.048                                                            | -478.5                        | -435.2              | 17.99                | 12.05                                 | 21.46                                 | 1098                              |
| 24                                   | 22.830          | 13902.                                                                                | 8.070                                                            | -466.4                        | -399.4              | 18.51                | 12.18                                 | 21.75                                 | 1117                              |
| 25                                   | 30.929          | 14325.                                                                                | 8.083                                                            | -454.2                        | -363.3              | 19.01                | 12.30                                 | 22.01                                 | 1135                              |
| 26                                   | 39.021          | 14741.                                                                                | 8.090                                                            | -441.8                        | -327.2              | 19.49                | 12.42                                 | 22.25                                 | 1152                              |
| 27                                   | 47.102          | 15165.                                                                                | 8.092                                                            | -429.3                        | -291.0              | 19.96                | 12.54                                 | 22.46                                 | 1169                              |
| 28                                   | 55.191          | 15605.                                                                                | 8.089                                                            | -416.7                        | -254.7              | 20.42                | 12.65                                 | 22.65                                 | 1185                              |
| 29                                   | 63.262          | 16037.                                                                                | 8.084                                                            | -404.0                        | -218.2              | 20.87                | 12.76                                 | 22.82                                 | 1201                              |
| 30                                   | 71.339          | 16461.                                                                                | 8.075                                                            | -391.2                        | -181.7              | 21.30                | 12.86                                 | 22.97                                 | 1216                              |
| 31                                   | 79.387          | 16908.                                                                                | 8.064                                                            | -378.3                        | -145.2              | 21.73                | 12.95                                 | 23.10                                 | 1231                              |
| 32                                   | 87.436          | 17345.                                                                                | 8.052                                                            | -365.3                        | -108.5              | 22.14                | 13.05                                 | 23.23                                 | 1246                              |
| 33                                   | 95.495          | 17791.                                                                                | 8.038                                                            | -352.2                        | -71.8               | 22.54                | 13.14                                 | 23.34                                 | 1260                              |
| 34                                   | 103.520         | 18203.                                                                                | 8.023                                                            | -339.1                        | -35.0               | 22.93                | 13.22                                 | 23.46                                 | 1274                              |
| 35                                   | 111.551         | 18632.                                                                                | 8.007                                                            | -325.8                        | 1.8                 | 23.32                | 13.30                                 | 23.55                                 | 1288                              |
| 36                                   | 119.559         | 19067.                                                                                | 7.990                                                            | -312.5                        | 38.7                | 23.69                | 13.38                                 | 23.64                                 | 1301                              |
| 37                                   | 127.542         | 19497.                                                                                | 7.973                                                            | -299.0                        | 75.5                | 24.06                | 13.45                                 | 23.72                                 | 1315                              |
| 38                                   | 135.522         | 19921.                                                                                | 7.955                                                            | -285.6                        | 112.5               | 24.42                | 13.52                                 | 23.79                                 | 1328                              |
| 39                                   | 143.468         | 20357.                                                                                | 7.936                                                            | -272.0                        | 149.3               | 24.77                | 13.57                                 | 23.85                                 | 1341                              |
| 40                                   | 151.407         | 20789.                                                                                | 7.917                                                            | -258.4                        | 186.3               | 25.12                | 13.62                                 | 23.89                                 | 1354                              |
| 42                                   | 167.196         | 21640.                                                                                | 7.879                                                            | -231.1                        | 260.0               | 25.79                | 13.72                                 | 23.98                                 | 1379                              |
| 44                                   | 182.901         | 22465.                                                                                | 7.840                                                            | -203.5                        | 333.7               | 26.43                | 13.83                                 | 24.08                                 | 1402                              |
| 46                                   | 198.539         | 23317.                                                                                | 7.800                                                            | -175.7                        | 407.4               | 27.05                | 13.96                                 | 24.18                                 | 1425                              |
| 48                                   | 214.079         | 24147.                                                                                | 7.759                                                            | -147.6                        | 481.1               | 27.64                | 14.11                                 | 24.30                                 | 1446                              |
| 50                                   | 229.570         | 24974.                                                                                | 7.719                                                            | -119.3                        | 555.0               | 28.22                | 14.26                                 | 24.41                                 | 1466                              |
| 55                                   | 267.896         | 27028.                                                                                | 7.618                                                            | -47.0                         | 739.8               | 29.60                | 14.65                                 | 24.70                                 | 1513                              |
| 60                                   | 305.726         | 29019.                                                                                | 7.516                                                            | 27.7                          | 925.6               | 30.90                | 15.03                                 | 24.98                                 | 1557                              |
| 65                                   | 343.095         | 30983.                                                                                | 7.415                                                            | 104.0                         | 1111.7              | 32.12                | 15.50                                 | 25.32                                 | 1595                              |
| 0.0350 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 20.469                             | 1.061           | 13821.                                                                                | 8.168                                                            | -515.6                        | -512.5              | 16.27                | 11.62                                 | 19.79                                 | 1088                              |
| 21                                   | 5.378           | 14058.                                                                                | 8.195                                                            | -509.4                        | -493.8              | 16.57                | 11.71                                 | 20.01                                 | 1099                              |
| 22                                   | 13.615          | 14504.                                                                                | 8.236                                                            | -497.6                        | -458.2              | 17.12                | 11.88                                 | 20.39                                 | 1119                              |
| 23                                   | 21.851          | 14966.                                                                                | 8.266                                                            | -485.6                        | -422.4              | 17.65                | 12.03                                 | 20.71                                 | 1138                              |
| 24                                   | 30.146          | 15375.                                                                                | 8.285                                                            | -473.6                        | -386.3              | 18.17                | 12.16                                 | 21.03                                 | 1156                              |
| 25                                   | 38.454          | 15789.                                                                                | 8.298                                                            | -461.3                        | -350.0              | 18.66                | 12.29                                 | 21.31                                 | 1173                              |
| 26                                   | 46.754          | 16204.                                                                                | 8.304                                                            | -449.0                        | -313.6              | 19.15                | 12.42                                 | 21.57                                 | 1189                              |
| 27                                   | 55.047          | 16626.                                                                                | 8.306                                                            | -436.5                        | -277.1              | 19.62                | 12.54                                 | 21.80                                 | 1205                              |
| 28                                   | 63.355          | 17061.                                                                                | 8.303                                                            | -423.9                        | -240.5              | 20.08                | 12.66                                 | 22.02                                 | 1221                              |
| 29                                   | 71.641          | 17490.                                                                                | 8.298                                                            | -411.2                        | -203.8              | 20.52                | 12.77                                 | 22.21                                 | 1237                              |
| 30                                   | 79.929          | 17909.                                                                                | 8.290                                                            | -398.4                        | -167.0              | 20.96                | 12.87                                 | 22.39                                 | 1251                              |
| 31                                   | 88.201          | 18359.                                                                                | 8.279                                                            | -385.4                        | -130.1              | 21.38                | 12.97                                 | 22.54                                 | 1266                              |
| 32                                   | 96.468          | 18794.                                                                                | 8.267                                                            | -372.4                        | -93.1               | 21.80                | 13.07                                 | 22.69                                 | 1281                              |
| 33                                   | 104.749         | 19236.                                                                                | 8.254                                                            | -359.3                        | -56.1               | 22.20                | 13.16                                 | 22.82                                 | 1295                              |
| 34                                   | 112.980         | 19650.                                                                                | 8.239                                                            | -346.1                        | -19.0               | 22.59                | 13.24                                 | 22.96                                 | 1308                              |
| 35                                   | 121.225         | 20077.                                                                                | 8.223                                                            | -332.8                        | 18.1                | 22.98                | 13.32                                 | 23.07                                 | 1322                              |
| 36                                   | 129.451         | 20513.                                                                                | 8.206                                                            | -319.5                        | 55.3                | 23.36                | 13.40                                 | 23.18                                 | 1335                              |
| 37                                   | 137.649         | 20944.                                                                                | 8.188                                                            | -306.0                        | 92.5                | 23.72                | 13.48                                 | 23.28                                 | 1348                              |
| 38                                   | 145.842         | 21369.                                                                                | 8.170                                                            | -292.5                        | 129.7               | 24.08                | 13.55                                 | 23.37                                 | 1361                              |
| 39                                   | 154.003         | 21799.                                                                                | 8.151                                                            | -278.9                        | 166.9               | 24.44                | 13.60                                 | 23.44                                 | 1374                              |
| 40                                   | 162.160         | 22235.                                                                                | 8.132                                                            | -265.3                        | 204.1               | 24.78                | 13.65                                 | 23.49                                 | 1387                              |
| 42                                   | 178.376         | 23090.                                                                                | 8.093                                                            | -237.9                        | 278.5               | 25.45                | 13.76                                 | 23.61                                 | 1411                              |
| 44                                   | 194.494         | 23918.                                                                                | 8.052                                                            | -210.3                        | 352.8               | 26.09                | 13.87                                 | 23.74                                 | 1434                              |
| 46                                   | 210.559         | 24775.                                                                                | 8.010                                                            | -182.4                        | 427.2               | 26.71                | 14.00                                 | 23.86                                 | 1457                              |
| 48                                   | 226.513         | 25605.                                                                                | 7.968                                                            | -154.2                        | 501.5               | 27.31                | 14.15                                 | 23.99                                 | 1477                              |
| 50                                   | 242.420         | 26438.                                                                                | 7.925                                                            | -125.8                        | 576.0               | 27.89                | 14.30                                 | 24.13                                 | 1497                              |
| 55                                   | 281.775         | 28496.                                                                                | 7.816                                                            | -53.3                         | 762.5               | 29.28                | 14.70                                 | 24.45                                 | 1544                              |
| 60                                   | 320.600         | 30480.                                                                                | 7.706                                                            | 21.7                          | 949.8               | 30.58                | 15.09                                 | 24.76                                 | 1585                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMOODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN            | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|---------------------------------------|-----------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0355 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 19.564                              | 0.807           | 15050.                                                                                | 8.324                                                            | -532.7                        | -530.4              | 15.42                | 11.40                                 | 18.64                                 | 1112                              |
| 20                                    | 4.452           | 15228.                                                                                | 8.354                                                            | -527.7                        | -515.0              | 15.67                | 11.49                                 | 18.85                                 | 1121                              |
| 21                                    | 12.799          | 15636.                                                                                | 8.408                                                            | -516.1                        | -479.6              | 16.23                | 11.67                                 | 19.31                                 | 1140                              |
| 22                                    | 21.250          | 16049.                                                                                | 8.448                                                            | -504.4                        | -443.7              | 16.78                | 11.85                                 | 19.71                                 | 1159                              |
| 23                                    | 29.719          | 16515.                                                                                | 8.477                                                            | -492.4                        | -407.6              | 17.31                | 12.00                                 | 20.05                                 | 1178                              |
| 24                                    | 38.217          | 16918.                                                                                | 8.497                                                            | -480.4                        | -371.3              | 17.82                | 12.15                                 | 20.38                                 | 1194                              |
| 25                                    | 46.730          | 17324.                                                                                | 8.510                                                            | -468.2                        | -334.8              | 18.32                | 12.28                                 | 20.69                                 | 1211                              |
| 26                                    | 55.237          | 17738.                                                                                | 8.516                                                            | -455.8                        | -298.1              | 18.81                | 12.41                                 | 20.96                                 | 1227                              |
| 27                                    | 63.741          | 18160.                                                                                | 8.518                                                            | -443.3                        | -261.4              | 19.28                | 12.54                                 | 21.21                                 | 1243                              |
| 28                                    | 72.264          | 18588.                                                                                | 8.517                                                            | -430.7                        | -224.5              | 19.74                | 12.66                                 | 21.45                                 | 1258                              |
| 29                                    | 80.764          | 19015.                                                                                | 8.512                                                            | -418.0                        | -187.5              | 20.18                | 12.78                                 | 21.66                                 | 1273                              |
| 30                                    | 89.261          | 19430.                                                                                | 8.504                                                            | -405.2                        | -150.4              | 20.62                | 12.88                                 | 21.86                                 | 1287                              |
| 31                                    | 97.758          | 19879.                                                                                | 8.494                                                            | -392.3                        | -113.2              | 21.04                | 12.98                                 | 22.03                                 | 1302                              |
| 32                                    | 106.242         | 20312.                                                                                | 8.482                                                            | -379.2                        | -76.0               | 21.45                | 13.08                                 | 22.20                                 | 1316                              |
| 33                                    | 114.742         | 20745.                                                                                | 8.469                                                            | -366.1                        | -38.6               | 21.86                | 13.17                                 | 22.35                                 | 1330                              |
| 34                                    | 123.182         | 21167.                                                                                | 8.454                                                            | -352.9                        | -1.3                | 22.25                | 13.26                                 | 22.49                                 | 1343                              |
| 35                                    | 131.640         | 21597.                                                                                | 8.438                                                            | -339.6                        | 36.2                | 22.64                | 13.35                                 | 22.63                                 | 1356                              |
| 36                                    | 140.083         | 22027.                                                                                | 8.421                                                            | -326.2                        | 73.7                | 23.02                | 13.43                                 | 22.75                                 | 1369                              |
| 37                                    | 148.497         | 22459.                                                                                | 8.403                                                            | -312.7                        | 111.1               | 23.39                | 13.51                                 | 22.86                                 | 1382                              |
| 38                                    | 156.901         | 22881.                                                                                | 8.385                                                            | -299.2                        | 148.7               | 23.75                | 13.58                                 | 22.96                                 | 1395                              |
| 39                                    | 165.278         | 23313.                                                                                | 8.366                                                            | -285.6                        | 186.2               | 24.10                | 13.63                                 | 23.05                                 | 1407                              |
| 40                                    | 173.653         | 23746.                                                                                | 8.346                                                            | -271.9                        | 223.7               | 24.45                | 13.69                                 | 23.12                                 | 1420                              |
| 42                                    | 190.296         | 24602.                                                                                | 8.306                                                            | -244.4                        | 298.7               | 25.12                | 13.79                                 | 23.26                                 | 1444                              |
| 44                                    | 206.829         | 25436.                                                                                | 8.264                                                            | -216.7                        | 373.6               | 25.76                | 13.91                                 | 23.41                                 | 1467                              |
| 46                                    | 223.324         | 26296.                                                                                | 8.221                                                            | -188.8                        | 448.7               | 26.38                | 14.04                                 | 23.55                                 | 1489                              |
| 48                                    | 239.694         | 27130.                                                                                | 8.176                                                            | -160.5                        | 523.6               | 26.98                | 14.19                                 | 23.70                                 | 1509                              |
| 50                                    | 256.018         | 27967.                                                                                | 8.132                                                            | -132.0                        | 598.8               | 27.57                | 14.35                                 | 23.85                                 | 1529                              |
| 55                                    | 296.400         | 30017.                                                                                | 8.018                                                            | -59.2                         | 786.8               | 28.95                | 14.75                                 | 24.22                                 | 1574                              |
| 60                                    | 336.212         | 31977.                                                                                | 7.901                                                            | 16.0                          | 975.6               | 30.26                | 15.14                                 | 24.56                                 | 1615                              |
| 0.0360 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 18.612                              | 0.590           | 16187.                                                                                | 8.490                                                            | -549.8                        | -548.1              | 14.52                | 11.13                                 | 17.61                                 | 1134                              |
| 19                                    | 3.880           | 16359.                                                                                | 8.519                                                            | -545.4                        | -534.5              | 14.75                | 11.22                                 | 17.81                                 | 1142                              |
| 20                                    | 12.456          | 16817.                                                                                | 8.580                                                            | -534.1                        | -499.0              | 15.33                | 11.44                                 | 18.29                                 | 1162                              |
| 21                                    | 21.026          | 17287.                                                                                | 8.626                                                            | -522.6                        | -463.4              | 15.89                | 11.64                                 | 18.71                                 | 1182                              |
| 22                                    | 29.678          | 17679.                                                                                | 8.662                                                            | -510.8                        | -427.3              | 16.44                | 11.82                                 | 19.12                                 | 1199                              |
| 23                                    | 38.378          | 18131.                                                                                | 8.688                                                            | -498.9                        | -390.9              | 16.97                | 11.98                                 | 19.47                                 | 1217                              |
| 24                                    | 47.076          | 18537.                                                                                | 8.706                                                            | -486.9                        | -354.4              | 17.48                | 12.13                                 | 19.81                                 | 1233                              |
| 25                                    | 55.791          | 18933.                                                                                | 8.718                                                            | -474.7                        | -317.6              | 17.98                | 12.28                                 | 20.12                                 | 1249                              |
| 26                                    | 64.505          | 19348.                                                                                | 8.725                                                            | -462.3                        | -280.8              | 18.46                | 12.41                                 | 20.41                                 | 1265                              |
| 27                                    | 73.219          | 19766.                                                                                | 8.728                                                            | -449.8                        | -243.8              | 18.94                | 12.54                                 | 20.67                                 | 1280                              |
| 28                                    | 81.954          | 20187.                                                                                | 8.727                                                            | -437.2                        | -206.6              | 19.39                | 12.66                                 | 20.92                                 | 1295                              |
| 29                                    | 90.668          | 20617.                                                                                | 8.723                                                            | -424.5                        | -169.3              | 19.84                | 12.78                                 | 21.15                                 | 1309                              |
| 30                                    | 99.371          | 21025.                                                                                | 8.716                                                            | -411.7                        | -132.0              | 20.28                | 12.89                                 | 21.36                                 | 1323                              |
| 31                                    | 108.092         | 21469.                                                                                | 8.707                                                            | -398.7                        | -94.5               | 20.70                | 13.00                                 | 21.55                                 | 1338                              |
| 32                                    | 116.791         | 21899.                                                                                | 8.696                                                            | -385.7                        | -57.0               | 21.11                | 13.10                                 | 21.74                                 | 1352                              |
| 33                                    | 125.506         | 22322.                                                                                | 8.683                                                            | -372.5                        | -19.3               | 21.52                | 13.19                                 | 21.91                                 | 1365                              |
| 34                                    | 134.159         | 22753.                                                                                | 8.669                                                            | -359.3                        | 18.3                | 21.91                | 13.28                                 | 22.06                                 | 1378                              |
| 35                                    | 142.829         | 23176.                                                                                | 8.654                                                            | -346.0                        | 56.0                | 22.30                | 13.37                                 | 22.21                                 | 1391                              |
| 36                                    | 151.489         | 23609.                                                                                | 8.637                                                            | -332.6                        | 93.8                | 22.68                | 13.45                                 | 22.35                                 | 1404                              |
| 37                                    | 160.119         | 24047.                                                                                | 8.619                                                            | -319.1                        | 131.6               | 23.05                | 13.53                                 | 22.47                                 | 1417                              |
| 38                                    | 168.734         | 24467.                                                                                | 8.601                                                            | -305.5                        | 169.4               | 23.41                | 13.60                                 | 22.59                                 | 1429                              |
| 39                                    | 177.327         | 24895.                                                                                | 8.582                                                            | -291.9                        | 207.2               | 23.76                | 13.66                                 | 22.68                                 | 1441                              |
| 40                                    | 185.917         | 25321.                                                                                | 8.562                                                            | -278.2                        | 245.1               | 24.11                | 13.72                                 | 22.77                                 | 1453                              |
| 42                                    | 202.988         | 26179.                                                                                | 8.520                                                            | -250.6                        | 320.7               | 24.78                | 13.83                                 | 22.93                                 | 1477                              |
| 44                                    | 219.941         | 27029.                                                                                | 8.476                                                            | -222.9                        | 396.2               | 25.43                | 13.95                                 | 23.09                                 | 1500                              |
| 46                                    | 236.865         | 27879.                                                                                | 8.431                                                            | -194.8                        | 471.9               | 26.05                | 14.08                                 | 23.25                                 | 1521                              |
| 48                                    | 253.653         | 28719.                                                                                | 8.384                                                            | -166.5                        | 547.4               | 26.66                | 14.24                                 | 23.42                                 | 1541                              |
| 50                                    | 270.393         | 29549.                                                                                | 8.336                                                            | -137.9                        | 623.2               | 27.24                | 14.39                                 | 23.59                                 | 1560                              |
| 55                                    | 311.795         | 31579.                                                                                | 8.212                                                            | -64.9                         | 812.7               | 28.63                | 14.80                                 | 23.99                                 | 1604                              |
| 0.0365 GMOLE/CM <sup>3</sup> ISOCHORE |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 17.609                              | 0.412           | 17457.                                                                                | 8.652                                                            | -566.7                        | -565.6              | 13.58                | 10.82                                 | 16.56                                 | 1159                              |
| 18                                    | 3.784           | 17644.                                                                                | 8.681                                                            | -562.5                        | -552.0              | 13.82                | 10.92                                 | 16.77                                 | 1167                              |
| 19                                    | 12.501          | 18136.                                                                                | 8.747                                                            | -551.4                        | -516.7              | 14.42                | 11.18                                 | 17.27                                 | 1187                              |
| 20                                    | 21.285          | 18524.                                                                                | 8.799                                                            | -540.1                        | -481.1              | 15.00                | 11.40                                 | 17.76                                 | 1204                              |
| 21                                    | 30.094          | 19009.                                                                                | 8.839                                                            | -528.6                        | -445.1              | 15.56                | 11.61                                 | 18.17                                 | 1223                              |
| 22                                    | 38.942          | 19389.                                                                                | 8.871                                                            | -516.9                        | -408.8              | 16.10                | 11.79                                 | 18.58                                 | 1239                              |
| 23                                    | 47.862          | 19817.                                                                                | 8.895                                                            | -505.1                        | -372.2              | 16.63                | 11.96                                 | 18.95                                 | 1256                              |
| 24                                    | 56.761          | 20219.                                                                                | 8.913                                                            | -493.0                        | -335.5              | 17.14                | 12.12                                 | 19.29                                 | 1272                              |
| 25                                    | 65.675          | 20615.                                                                                | 8.925                                                            | -480.8                        | -298.5              | 17.64                | 12.27                                 | 19.61                                 | 1287                              |
| 26                                    | 74.596          | 21029.                                                                                | 8.933                                                            | -468.5                        | -261.4              | 18.12                | 12.40                                 | 19.91                                 | 1302                              |
| 27                                    | 83.519          | 21447.                                                                                | 8.936                                                            | -456.0                        | -224.2              | 18.60                | 12.54                                 | 20.18                                 | 1317                              |
| 28                                    | 92.463          | 21869.                                                                                | 8.936                                                            | -443.4                        | -186.7              | 19.05                | 12.67                                 | 20.45                                 | 1332                              |
| 29                                    | 101.389         | 22287.                                                                                | 8.933                                                            | -430.7                        | -149.2              | 19.50                | 12.79                                 | 20.69                                 | 1346                              |
| 30                                    | 110.298         | 22694.                                                                                | 8.927                                                            | -417.8                        | -111.7              | 19.94                | 12.90                                 | 20.91                                 | 1360                              |
| 31                                    | 119.239         | 23130.                                                                                | 8.919                                                            | -404.9                        | -73.9               | 20.36                | 13.01                                 | 21.11                                 | 1374                              |
| 32                                    | 128.152         | 23554.                                                                                | 8.909                                                            | -391.8                        | -36.1               | 20.77                | 13.11                                 | 21.31                                 | 1387                              |
| 33                                    | 137.075         | 23968.                                                                                | 8.897                                                            | -378.7                        | 1.9                 | 21.18                | 13.21                                 | 21.50                                 | 1400                              |
| 34                                    | 145.947         | 24411.                                                                                | 8.883                                                            | -365.4                        | 39.7                | 21.58                | 13.30                                 | 21.66                                 | 1413                              |
| 35                                    | 154.828         | 24832.                                                                                | 8.868                                                            | -352.1                        | 77.7                | 21.96                | 13.39                                 | 21.82                                 | 1426                              |
| 36                                    | 163.704         | 25262.                                                                                | 8.852                                                            | -338.6                        | 115.8               | 22.34                | 13.48                                 | 21.97                                 | 1439                              |
| 37                                    | 172.550         | 25693.                                                                                | 8.834                                                            | -325.1                        | 153.9               | 22.71                | 13.56                                 | 22.11                                 | 1451                              |
| 38                                    | 181.374         | 26111.                                                                                | 8.816                                                            | -311.5                        | 192.0               | 23.07                | 13.63                                 | 22.23                                 | 1463                              |
| 39                                    | 190.184         | 26545.                                                                                | 8.796                                                            | -297.9                        | 230.1               | 23.43                | 13.69                                 | 22.34                                 | 1475                              |
| 40                                    | 198.985         | 26963.                                                                                | 8.776                                                            | -284.1                        | 268.3               | 23.78                | 13.75                                 | 22.44                                 | 1487                              |
| 42                                    | 216.484         | 27819.                                                                                | 8.734                                                            | -256.5                        | 344.4               | 24.45                | 13.86                                 | 22.62                                 | 1510                              |
| 44                                    | 233.860         | 28670.                                                                                | 8.688                                                            | -228.7                        | 420.5               | 25.10                | 13.99                                 | 22.80                                 | 1533                              |
| 46                                    | 251.213         | 29523.                                                                                | 8.641                                                            | -200.5                        | 496.8               | 25.72                | 14.13                                 | 22.97                                 | 1553                              |
| 48                                    | 268.422         | 30369.                                                                                | 8.592                                                            | -172.1                        | 573.0               | 26.33                | 14.28                                 | 23.16                                 | 1573                              |
| 50                                    | 285.574         | 31187.                                                                                | 8.541                                                            | -143.4                        | 649.3               | 26.92                | 14.44                                 | 23.34                                 | 1592                              |
| 55                                    | 327.981         | 33176.                                                                                | 8.410                                                            | -70.2                         | 840.3               | 28.31                | 14.86                                 | 23.78                                 | 1633                              |
| * TWO-PHASE BOUNDARY                  |                 |                                                                                       |                                                                  |                               |                     |                      |                                       |                                       |                                   |

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0370 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 16.556                             | 0.271           | 18951.                                                                                 | 8.820                                                            | -583.5                        | -582.8              | 12.60                | 10.46                                 | 15.49                                 | 1188                              |
| 17                                   | 4.207           | 19142.                                                                                 | 8.850                                                            | -578.9                        | -567.3              | 12.88                | 10.59                                 | 15.74                                 | 1196                              |
| 18                                   | 13.087          | 19571.                                                                                 | 8.912                                                            | -568.1                        | -532.3              | 13.49                | 10.88                                 | 16.29                                 | 1213                              |
| 19                                   | 22.027          | 19979.                                                                                 | 8.965                                                            | -557.1                        | -496.8              | 14.09                | 11.14                                 | 16.79                                 | 1231                              |
| 20                                   | 30.998          | 20342.                                                                                 | 9.009                                                            | -545.8                        | -461.0              | 14.66                | 11.37                                 | 17.27                                 | 1246                              |
| 21                                   | 40.038          | 20789.                                                                                 | 9.045                                                            | -534.4                        | -424.7              | 15.22                | 11.58                                 | 17.69                                 | 1264                              |
| 22                                   | 49.081          | 21179.                                                                                 | 9.074                                                            | -522.7                        | -388.3              | 15.77                | 11.77                                 | 18.10                                 | 1279                              |
| 23                                   | 58.207          | 21577.                                                                                 | 9.098                                                            | -510.8                        | -351.4              | 16.29                | 11.95                                 | 18.47                                 | 1295                              |
| 24                                   | 67.306          | 21978.                                                                                 | 9.115                                                            | -498.8                        | -314.5              | 16.80                | 12.11                                 | 18.82                                 | 1310                              |
| 25                                   | 76.418          | 22373.                                                                                 | 9.128                                                            | -486.6                        | -277.4              | 17.30                | 12.26                                 | 19.15                                 | 1325                              |
| 26                                   | 85.546          | 22786.                                                                                 | 9.137                                                            | -474.3                        | -240.0              | 17.79                | 12.40                                 | 19.45                                 | 1340                              |
| 27                                   | 94.679          | 23202.                                                                                 | 9.142                                                            | -461.8                        | -202.6              | 18.26                | 12.53                                 | 19.73                                 | 1355                              |
| 28                                   | 103.827         | 23609.                                                                                 | 9.143                                                            | -449.2                        | -164.9              | 18.71                | 12.67                                 | 20.01                                 | 1369                              |
| 29                                   | 112.964         | 24028.                                                                                 | 9.141                                                            | -436.5                        | -127.1              | 19.16                | 12.79                                 | 20.26                                 | 1383                              |
| 30                                   | 122.078         | 24440.                                                                                 | 9.137                                                            | -423.7                        | -89.3               | 19.60                | 12.90                                 | 20.49                                 | 1397                              |
| 31                                   | 131.234         | 24862.                                                                                 | 9.130                                                            | -410.7                        | -51.3               | 20.02                | 13.02                                 | 20.71                                 | 1410                              |
| 32                                   | 140.357         | 25279.                                                                                 | 9.121                                                            | -397.6                        | -13.3               | 20.44                | 13.12                                 | 20.92                                 | 1423                              |
| 33                                   | 149.485         | 25686.                                                                                 | 9.110                                                            | -384.4                        | 24.9                | 20.84                | 13.22                                 | 21.12                                 | 1436                              |
| 34                                   | 158.582         | 26139.                                                                                 | 9.097                                                            | -371.2                        | 63.1                | 21.24                | 13.32                                 | 21.29                                 | 1449                              |
| 35                                   | 167.673         | 26560.                                                                                 | 9.082                                                            | -357.8                        | 101.4               | 21.63                | 13.41                                 | 21.46                                 | 1461                              |
| 36                                   | 176.762         | 26984.                                                                                 | 9.066                                                            | -344.3                        | 139.7               | 22.00                | 13.50                                 | 21.62                                 | 1474                              |
| 37                                   | 185.824         | 27415.                                                                                 | 9.049                                                            | -330.8                        | 178.1               | 22.38                | 13.58                                 | 21.76                                 | 1486                              |
| 38                                   | 194.857         | 27830.                                                                                 | 9.031                                                            | -317.2                        | 216.4               | 22.74                | 13.66                                 | 21.90                                 | 1498                              |
| 39                                   | 203.884         | 28264.                                                                                 | 9.011                                                            | -303.5                        | 254.8               | 23.09                | 13.72                                 | 22.01                                 | 1510                              |
| 40                                   | 212.891         | 28672.                                                                                 | 8.990                                                            | -289.7                        | 293.3               | 23.44                | 13.78                                 | 22.13                                 | 1521                              |
| 42                                   | 230.817         | 29524.                                                                                 | 8.946                                                            | -262.1                        | 370.0               | 24.12                | 13.90                                 | 22.33                                 | 1544                              |
| 44                                   | 248.622         | 30387.                                                                                 | 8.899                                                            | -234.1                        | 446.7               | 24.77                | 14.03                                 | 22.51                                 | 1566                              |
| 46                                   | 266.399         | 31229.                                                                                 | 8.850                                                            | -205.9                        | 523.6               | 25.40                | 14.17                                 | 22.71                                 | 1586                              |
| 48                                   | 284.032         | 32081.                                                                                 | 8.798                                                            | -177.4                        | 600.4               | 26.00                | 14.33                                 | 22.90                                 | 1605                              |
| 50                                   | 301.590         | 32886.                                                                                 | 8.744                                                            | -148.6                        | 677.3               | 26.59                | 14.49                                 | 23.10                                 | 1623                              |
| 55                                   | 344.977         | 34809.                                                                                 | 8.603                                                            | -75.1                         | 869.6               | 27.99                | 14.92                                 | 23.57                                 | 1663                              |
| 0.0375 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 15.451                             | 0.165           | 20739.                                                                                 | 9.036                                                            | -600.1                        | -599.6              | 11.56                | 10.06                                 | 14.45                                 | 1223                              |
| 16                                   | 5.209           | 20881.                                                                                 | 9.054                                                            | -594.5                        | -580.4              | 11.92                | 10.25                                 | 14.77                                 | 1230                              |
| 17                                   | 14.275          | 21139.                                                                                 | 9.092                                                            | -584.1                        | -545.5              | 12.55                | 10.56                                 | 15.35                                 | 1243                              |
| 18                                   | 23.360          | 21525.                                                                                 | 9.132                                                            | -573.4                        | -510.3              | 13.16                | 10.85                                 | 15.87                                 | 1258                              |
| 19                                   | 32.491          | 21889.                                                                                 | 9.171                                                            | -562.4                        | -474.6              | 13.75                | 11.11                                 | 16.37                                 | 1273                              |
| 20                                   | 41.642          | 22250.                                                                                 | 9.208                                                            | -551.2                        | -438.7              | 14.33                | 11.34                                 | 16.83                                 | 1288                              |
| 21                                   | 50.895          | 22652.                                                                                 | 9.240                                                            | -539.7                        | -402.2              | 14.89                | 11.55                                 | 17.26                                 | 1304                              |
| 22                                   | 60.134          | 23044.                                                                                 | 9.268                                                            | -528.1                        | -365.6              | 15.43                | 11.75                                 | 17.66                                 | 1319                              |
| 23                                   | 69.451          | 23414.                                                                                 | 9.292                                                            | -516.2                        | -328.6              | 15.96                | 11.93                                 | 18.04                                 | 1334                              |
| 24                                   | 78.751          | 23814.                                                                                 | 9.311                                                            | -504.2                        | -291.4              | 16.47                | 12.09                                 | 18.39                                 | 1349                              |
| 25                                   | 88.060          | 24208.                                                                                 | 9.325                                                            | -492.0                        | -254.1              | 16.97                | 12.25                                 | 18.72                                 | 1364                              |
| 26                                   | 97.394          | 24618.                                                                                 | 9.336                                                            | -479.7                        | -216.6              | 17.45                | 12.39                                 | 19.02                                 | 1378                              |
| 27                                   | 106.734         | 25033.                                                                                 | 9.343                                                            | -467.3                        | -178.9              | 17.92                | 12.53                                 | 19.32                                 | 1393                              |
| 28                                   | 116.084         | 25433.                                                                                 | 9.347                                                            | -454.7                        | -141.0              | 18.38                | 12.67                                 | 19.60                                 | 1406                              |
| 29                                   | 125.429         | 25848.                                                                                 | 9.348                                                            | -441.9                        | -103.0              | 18.82                | 12.79                                 | 19.86                                 | 1420                              |
| 30                                   | 134.750         | 26267.                                                                                 | 9.345                                                            | -429.1                        | -65.0               | 19.26                | 12.91                                 | 20.10                                 | 1433                              |
| 31                                   | 144.113         | 26668.                                                                                 | 9.340                                                            | -416.1                        | -26.7               | 19.68                | 13.02                                 | 20.33                                 | 1446                              |
| 32                                   | 153.443         | 27078.                                                                                 | 9.332                                                            | -403.0                        | 11.6                | 20.10                | 13.14                                 | 20.55                                 | 1459                              |
| 33                                   | 162.774         | 27487.                                                                                 | 9.323                                                            | -389.8                        | 50.0                | 20.51                | 13.24                                 | 20.76                                 | 1472                              |
| 34                                   | 172.098         | 27940.                                                                                 | 9.311                                                            | -376.6                        | 88.4                | 20.90                | 13.34                                 | 20.94                                 | 1485                              |
| 35                                   | 181.400         | 28360.                                                                                 | 9.297                                                            | -363.2                        | 127.0               | 21.29                | 13.43                                 | 21.12                                 | 1497                              |
| 36                                   | 190.700         | 28779.                                                                                 | 9.281                                                            | -349.7                        | 165.6               | 21.67                | 13.52                                 | 21.29                                 | 1509                              |
| 37                                   | 199.977         | 29206.                                                                                 | 9.264                                                            | -336.1                        | 204.2               | 22.04                | 13.61                                 | 21.44                                 | 1521                              |
| 38                                   | 209.216         | 29619.                                                                                 | 9.245                                                            | -322.5                        | 242.8               | 22.41                | 13.69                                 | 21.59                                 | 1532                              |
| 39                                   | 218.460         | 30053.                                                                                 | 9.225                                                            | -308.8                        | 281.5               | 22.76                | 13.75                                 | 21.71                                 | 1544                              |
| 40                                   | 227.669         | 30453.                                                                                 | 9.204                                                            | -295.0                        | 320.2               | 23.11                | 13.81                                 | 21.83                                 | 1555                              |
| 42                                   | 246.020         | 31300.                                                                                 | 9.158                                                            | -267.2                        | 397.5               | 23.79                | 13.93                                 | 22.04                                 | 1578                              |
| 44                                   | 264.259         | 32172.                                                                                 | 9.108                                                            | -239.2                        | 474.8               | 24.44                | 14.07                                 | 22.24                                 | 1599                              |
| 46                                   | 282.452         | 32995.                                                                                 | 9.055                                                            | -210.9                        | 552.2               | 25.07                | 14.21                                 | 22.45                                 | 1618                              |
| 48                                   | 300.514         | 33856.                                                                                 | 8.999                                                            | -182.4                        | 629.6               | 25.68                | 14.38                                 | 22.65                                 | 1637                              |
| 50                                   | 318.469         | 34641.                                                                                 | 8.940                                                            | -153.4                        | 707.1               | 26.27                | 14.54                                 | 22.86                                 | 1654                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_p$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0380 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                     |                                                               |                               |                     |                      |                                       |                                       |                                   |
| * 14.295                             | 0.092           | 22443.                                                                              | 9.324                                                         | -616.3                        | -616.1              | 10.47                | 9.66                                  | 13.55                                 | 1258                              |
| 15                                   | 6.734           | 22613.                                                                              | 9.297                                                         | -609.4                        | -591.5              | 10.94                | 9.91                                  | 13.93                                 | 1264                              |
| 16                                   | 16.138          | 22855.                                                                              | 9.290                                                         | -599.3                        | -556.3              | 11.59                | 10.24                                 | 14.48                                 | 1275                              |
| 17                                   | 25.354          | 23185.                                                                              | 9.305                                                         | -588.9                        | -521.3              | 12.22                | 10.54                                 | 15.00                                 | 1288                              |
| 18                                   | 34.619          | 23517.                                                                              | 9.332                                                         | -578.3                        | -486.0              | 12.83                | 10.83                                 | 15.50                                 | 1301                              |
| 19                                   | 43.927          | 23867.                                                                              | 9.363                                                         | -567.3                        | -450.2              | 13.42                | 11.08                                 | 15.98                                 | 1315                              |
| 20                                   | 53.261          | 24237.                                                                              | 9.396                                                         | -556.1                        | -414.1              | 14.00                | 11.32                                 | 16.43                                 | 1330                              |
| 21                                   | 62.703          | 24591.                                                                              | 9.427                                                         | -544.7                        | -377.5              | 14.56                | 11.53                                 | 16.86                                 | 1344                              |
| 22                                   | 72.138          | 24984.                                                                              | 9.456                                                         | -533.0                        | -340.7              | 15.10                | 11.73                                 | 17.25                                 | 1359                              |
| 23                                   | 81.635          | 25332.                                                                              | 9.481                                                         | -521.2                        | -303.5              | 15.62                | 11.91                                 | 17.64                                 | 1373                              |
| 24                                   | 91.133          | 25728.                                                                              | 9.502                                                         | -509.2                        | -266.2              | 16.13                | 12.08                                 | 17.99                                 | 1388                              |
| 25                                   | 100.639         | 26127.                                                                              | 9.520                                                         | -497.1                        | -228.7              | 16.63                | 12.23                                 | 18.32                                 | 1402                              |
| 26                                   | 110.177         | 26527.                                                                              | 9.533                                                         | -484.8                        | -191.0              | 17.11                | 12.38                                 | 18.63                                 | 1416                              |
| 27                                   | 119.724         | 26938.                                                                              | 9.543                                                         | -472.3                        | -153.1              | 17.58                | 12.52                                 | 18.93                                 | 1430                              |
| 28                                   | 129.273         | 27334.                                                                              | 9.549                                                         | -459.7                        | -115.0              | 18.04                | 12.66                                 | 19.22                                 | 1444                              |
| 29                                   | 138.824         | 27745.                                                                              | 9.552                                                         | -447.0                        | -76.8               | 18.49                | 12.79                                 | 19.49                                 | 1457                              |
| 30                                   | 148.353         | 28160.                                                                              | 9.552                                                         | -434.1                        | -38.6               | 18.92                | 12.91                                 | 19.73                                 | 1471                              |
| 31                                   | 157.915         | 28550.                                                                              | 9.548                                                         | -421.2                        | -0.1                | 19.35                | 13.03                                 | 19.98                                 | 1483                              |
| 32                                   | 167.448         | 28954.                                                                              | 9.542                                                         | -408.1                        | 38.4                | 19.76                | 13.15                                 | 20.21                                 | 1496                              |
| 33                                   | 176.980         | 29358.                                                                              | 9.534                                                         | -394.9                        | 77.0                | 20.17                | 13.25                                 | 20.42                                 | 1508                              |
| 34                                   | 186.534         | 29814.                                                                              | 9.523                                                         | -381.6                        | 115.8               | 20.57                | 13.35                                 | 20.61                                 | 1521                              |
| 35                                   | 196.045         | 30235.                                                                              | 9.509                                                         | -368.2                        | 154.6               | 20.96                | 13.45                                 | 20.79                                 | 1533                              |
| 36                                   | 205.553         | 30646.                                                                              | 9.494                                                         | -354.7                        | 193.4               | 21.34                | 13.54                                 | 20.97                                 | 1544                              |
| 37                                   | 215.043         | 31070.                                                                              | 9.477                                                         | -341.1                        | 232.3               | 21.71                | 13.63                                 | 21.14                                 | 1556                              |
| 38                                   | 224.488         | 31482.                                                                              | 9.459                                                         | -327.4                        | 271.2               | 22.07                | 13.71                                 | 21.29                                 | 1567                              |
| 39                                   | 233.949         | 31914.                                                                              | 9.438                                                         | -313.7                        | 310.1               | 22.43                | 13.78                                 | 21.42                                 | 1579                              |
| 40                                   | 243.357         | 32310.                                                                              | 9.416                                                         | -299.9                        | 349.0               | 22.78                | 13.84                                 | 21.55                                 | 1590                              |
| 42                                   | 262.130         | 33151.                                                                              | 9.369                                                         | -272.0                        | 426.9               | 23.46                | 13.97                                 | 21.77                                 | 1611                              |
| 44                                   | 280.806         | 34027.                                                                              | 9.317                                                         | -244.0                        | 504.8               | 24.11                | 14.11                                 | 21.98                                 | 1632                              |
| 46                                   | 299.403         | 34820.                                                                              | 9.260                                                         | -215.6                        | 582.8               | 24.74                | 14.26                                 | 22.21                                 | 1651                              |
| 48                                   | 317.898         | 35691.                                                                              | 9.201                                                         | -186.9                        | 660.8               | 25.35                | 14.43                                 | 22.42                                 | 1669                              |
| 50                                   | 336.239         | 36448.                                                                              | 9.138                                                         | -157.9                        | 738.7               | 25.95                | 14.60                                 | 22.64                                 | 1685                              |
| 0.0385 GMCLE/CM <sup>3</sup> ISOCORE |                 |                                                                                     |                                                               |                               |                     |                      |                                       |                                       |                                   |
| * 14.155                             | 10.556          | 24648.                                                                              | 9.445                                                         | -622.1                        | -594.3              | 10.05                | 9.64                                  | 13.14                                 | 1300                              |
| 15                                   | 18.577          | 24780.                                                                              | 9.424                                                         | -613.8                        | -564.9              | 10.62                | 9.91                                  | 13.59                                 | 1307                              |
| 16                                   | 28.081          | 24936.                                                                              | 9.431                                                         | -603.8                        | -529.9              | 11.27                | 10.23                                 | 14.13                                 | 1316                              |
| 17                                   | 37.468          | 25279.                                                                              | 9.457                                                         | -593.4                        | -494.8              | 11.90                | 10.53                                 | 14.64                                 | 1329                              |
| 18                                   | 46.885          | 25554.                                                                              | 9.494                                                         | -582.7                        | -459.3              | 12.51                | 10.80                                 | 15.14                                 | 1342                              |
| 19                                   | 56.368          | 25909.                                                                              | 9.533                                                         | -571.8                        | -423.4              | 13.10                | 11.06                                 | 15.62                                 | 1356                              |
| 20                                   | 65.888          | 26284.                                                                              | 9.572                                                         | -560.6                        | -387.2              | 13.67                | 11.29                                 | 16.06                                 | 1371                              |
| 21                                   | 75.499          | 26607.                                                                              | 9.609                                                         | -549.2                        | -350.5              | 14.23                | 11.51                                 | 16.49                                 | 1384                              |
| 22                                   | 85.130          | 26994.                                                                              | 9.642                                                         | -537.6                        | -313.6              | 14.77                | 11.71                                 | 16.89                                 | 1399                              |
| 23                                   | 94.797          | 27333.                                                                              | 9.671                                                         | -525.8                        | -276.3              | 15.29                | 11.89                                 | 17.27                                 | 1413                              |
| 24                                   | 104.492         | 27727.                                                                              | 9.696                                                         | -513.8                        | -238.8              | 15.80                | 12.06                                 | 17.62                                 | 1427                              |
| 25                                   | 114.195         | 28115.                                                                              | 9.716                                                         | -501.7                        | -201.1              | 16.30                | 12.22                                 | 17.96                                 | 1441                              |
| 26                                   | 123.934         | 28514.                                                                              | 9.732                                                         | -489.4                        | -163.2              | 16.78                | 12.37                                 | 18.27                                 | 1455                              |
| 27                                   | 133.685         | 28921.                                                                              | 9.744                                                         | -476.9                        | -125.1              | 17.25                | 12.52                                 | 18.58                                 | 1469                              |
| 28                                   | 143.431         | 29317.                                                                              | 9.752                                                         | -464.4                        | -86.9               | 17.71                | 12.66                                 | 18.87                                 | 1482                              |
| 29                                   | 153.187         | 29711.                                                                              | 9.756                                                         | -451.6                        | -48.5               | 18.15                | 12.79                                 | 19.14                                 | 1495                              |
| 30                                   | 162.924         | 30134.                                                                              | 9.757                                                         | -438.8                        | -10.0               | 18.59                | 12.91                                 | 19.39                                 | 1508                              |
| 31                                   | 172.677         | 30511.                                                                              | 9.755                                                         | -425.8                        | 28.7                | 19.01                | 13.04                                 | 19.64                                 | 1520                              |
| 32                                   | 182.410         | 30910.                                                                              | 9.749                                                         | -412.7                        | 67.4                | 19.43                | 13.15                                 | 19.88                                 | 1532                              |
| 33                                   | 192.147         | 31321.                                                                              | 9.741                                                         | -399.5                        | 106.2               | 19.84                | 13.26                                 | 20.10                                 | 1544                              |
| 34                                   | 201.925         | 31767.                                                                              | 9.731                                                         | -386.2                        | 145.2               | 20.23                | 13.37                                 | 20.29                                 | 1557                              |
| 35                                   | 211.647         | 32184.                                                                              | 9.718                                                         | -372.8                        | 184.2               | 20.62                | 13.47                                 | 20.49                                 | 1569                              |
| 36                                   | 221.359         | 32589.                                                                              | 9.703                                                         | -359.3                        | 223.3               | 21.00                | 13.56                                 | 20.67                                 | 1580                              |
| 37                                   | 231.059         | 33008.                                                                              | 9.686                                                         | -345.6                        | 262.5               | 21.38                | 13.65                                 | 20.84                                 | 1591                              |
| 38                                   | 240.711         | 33420.                                                                              | 9.667                                                         | -331.9                        | 301.6               | 21.74                | 13.74                                 | 21.00                                 | 1602                              |
| 39                                   | 250.386         | 33848.                                                                              | 9.647                                                         | -318.2                        | 340.8               | 22.10                | 13.81                                 | 21.14                                 | 1614                              |
| 40                                   | 259.993         | 34250.                                                                              | 9.625                                                         | -304.3                        | 379.9               | 22.45                | 13.87                                 | 21.27                                 | 1624                              |
| 42                                   | 279.185         | 35085.                                                                              | 9.577                                                         | -276.5                        | 458.3               | 23.13                | 14.01                                 | 21.51                                 | 1646                              |
| 44                                   | 298.297         | 35951.                                                                              | 9.523                                                         | -248.3                        | 536.8               | 23.79                | 14.15                                 | 21.74                                 | 1666                              |
| 46                                   | 317.282         | 36703.                                                                              | 9.466                                                         | -219.8                        | 615.2               | 24.42                | 14.31                                 | 21.98                                 | 1684                              |
| 48                                   | 336.214         | 37584.                                                                              | 9.405                                                         | -191.0                        | 693.8               | 25.03                | 14.48                                 | 22.20                                 | 1702                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | C <sub>p</sub> , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|------------------------------------------------|------------------------------------------------|-----------------------------------|
| 0.0390 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 14.759                             | 29.213          | 27057.                                                                                 | 9.499                                                            | -620.2                        | -544.3              | 10.14                | 9.84                                           | 13.12                                          | 1346                              |
| 15                                   | 31.533          | 27067.                                                                                 | 9.504                                                            | -617.8                        | -535.9              | 10.30                | 9.91                                           | 13.24                                          | 1348                              |
| 16                                   | 41.092          | 27127.                                                                                 | 9.539                                                            | -607.7                        | -501.0              | 10.95                | 10.21                                          | 13.79                                          | 1357                              |
| 17                                   | 50.640          | 27416.                                                                                 | 9.587                                                            | -597.4                        | -465.8              | 11.58                | 10.50                                          | 14.30                                          | 1370                              |
| 18                                   | 60.185          | 27657.                                                                                 | 9.639                                                            | -586.7                        | -430.4              | 12.18                | 10.78                                          | 14.80                                          | 1382                              |
| 19                                   | 69.848          | 28023.                                                                                 | 9.691                                                            | -575.8                        | -394.4              | 12.77                | 11.03                                          | 15.27                                          | 1396                              |
| 20                                   | 79.557          | 28396.                                                                                 | 9.741                                                            | -564.7                        | -358.0              | 13.35                | 11.26                                          | 15.72                                          | 1411                              |
| 21                                   | 89.323          | 28702.                                                                                 | 9.786                                                            | -553.3                        | -321.2              | 13.90                | 11.48                                          | 16.15                                          | 1424                              |
| 22                                   | 99.146          | 29081.                                                                                 | 9.826                                                            | -541.7                        | -284.1              | 14.44                | 11.68                                          | 16.55                                          | 1439                              |
| 23                                   | 108.982         | 29418.                                                                                 | 9.860                                                            | -529.9                        | -246.8              | 14.96                | 11.87                                          | 16.93                                          | 1452                              |
| 24                                   | 118.869         | 29799.                                                                                 | 9.889                                                            | -518.0                        | -209.2              | 15.47                | 12.04                                          | 17.29                                          | 1466                              |
| 25                                   | 128.768         | 30190.                                                                                 | 9.912                                                            | -505.9                        | -171.3              | 15.97                | 12.20                                          | 17.62                                          | 1480                              |
| 26                                   | 138.704         | 30580.                                                                                 | 9.931                                                            | -493.6                        | -133.2              | 16.45                | 12.36                                          | 17.94                                          | 1494                              |
| 27                                   | 148.657         | 30980.                                                                                 | 9.945                                                            | -481.2                        | -94.9               | 16.92                | 12.51                                          | 18.25                                          | 1507                              |
| 28                                   | 158.599         | 31371.                                                                                 | 9.954                                                            | -468.6                        | -56.5               | 17.37                | 12.65                                          | 18.54                                          | 1520                              |
| 29                                   | 168.556         | 31769.                                                                                 | 9.959                                                            | -455.8                        | -17.9               | 17.82                | 12.79                                          | 18.82                                          | 1533                              |
| 30                                   | 178.502         | 32188.                                                                                 | 9.961                                                            | -443.0                        | 20.8                | 18.26                | 12.91                                          | 19.08                                          | 1546                              |
| 31                                   | 188.439         | 32553.                                                                                 | 9.959                                                            | -430.0                        | 59.6                | 18.68                | 13.04                                          | 19.33                                          | 1557                              |
| 32                                   | 198.372         | 32951.                                                                                 | 9.954                                                            | -416.9                        | 98.5                | 19.10                | 13.16                                          | 19.57                                          | 1569                              |
| 33                                   | 208.315         | 33377.                                                                                 | 9.947                                                            | -403.7                        | 137.5               | 19.50                | 13.27                                          | 19.79                                          | 1581                              |
| 34                                   | 218.309         | 33789.                                                                                 | 9.936                                                            | -390.4                        | 176.8               | 19.90                | 13.38                                          | 20.00                                          | 1593                              |
| 35                                   | 228.242         | 34210.                                                                                 | 9.923                                                            | -376.9                        | 216.0               | 20.29                | 13.48                                          | 20.19                                          | 1605                              |
| 36                                   | 238.155         | 34610.                                                                                 | 9.908                                                            | -363.4                        | 255.3               | 20.67                | 13.58                                          | 20.38                                          | 1616                              |
| 37                                   | 248.063         | 35023.                                                                                 | 9.891                                                            | -349.8                        | 294.7               | 21.05                | 13.68                                          | 20.56                                          | 1627                              |
| 38                                   | 257.921         | 35436.                                                                                 | 9.871                                                            | -336.1                        | 334.0               | 21.41                | 13.76                                          | 20.72                                          | 1638                              |
| 39                                   | 267.809         | 35857.                                                                                 | 9.850                                                            | -322.3                        | 373.5               | 21.77                | 13.84                                          | 20.87                                          | 1649                              |
| 40                                   | 277.623         | 36284.                                                                                 | 9.828                                                            | -308.4                        | 412.9               | 22.12                | 13.91                                          | 21.00                                          | 1659                              |
| 42                                   | 297.230         | 37117.                                                                                 | 9.778                                                            | -280.4                        | 491.8               | 22.80                | 14.04                                          | 21.25                                          | 1680                              |
| 44                                   | 316.768         | 37946.                                                                                 | 9.724                                                            | -252.2                        | 570.8               | 23.46                | 14.19                                          | 21.49                                          | 1700                              |
| 46                                   | 336.115         | 38641.                                                                                 | 9.665                                                            | -223.6                        | 649.6               | 24.10                | 14.35                                          | 21.76                                          | 1716                              |
| 0.0395 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 15.378                             | 49.224          | 29331.                                                                                 | 9.564                                                            | -617.5                        | -491.2              | 10.23                | 10.00                                          | 13.11                                          | 1391                              |
| 16                                   | 55.227          | 29437.                                                                                 | 9.618                                                            | -611.2                        | -469.5              | 10.63                | 10.18                                          | 13.44                                          | 1398                              |
| 17                                   | 64.891          | 29594.                                                                                 | 9.702                                                            | -600.9                        | -434.4              | 11.26                | 10.47                                          | 13.98                                          | 1409                              |
| 18                                   | 74.555          | 29835.                                                                                 | 9.780                                                            | -590.3                        | -399.0              | 11.86                | 10.74                                          | 14.49                                          | 1422                              |
| 19                                   | 84.403          | 30207.                                                                                 | 9.849                                                            | -579.4                        | -362.9              | 12.45                | 10.99                                          | 14.96                                          | 1437                              |
| 20                                   | 94.294          | 30564.                                                                                 | 9.911                                                            | -568.3                        | -326.4              | 13.02                | 11.23                                          | 15.40                                          | 1452                              |
| 21                                   | 104.214         | 30876.                                                                                 | 9.964                                                            | -556.9                        | -289.6              | 13.58                | 11.45                                          | 15.83                                          | 1465                              |
| 22                                   | 114.223         | 31239.                                                                                 | 10.010                                                           | -545.4                        | -252.4              | 14.11                | 11.65                                          | 16.24                                          | 1479                              |
| 23                                   | 124.230         | 31588.                                                                                 | 10.048                                                           | -533.6                        | -215.0              | 14.64                | 11.84                                          | 16.62                                          | 1493                              |
| 24                                   | 134.305         | 31960.                                                                                 | 10.080                                                           | -521.7                        | -177.2              | 15.14                | 12.02                                          | 16.97                                          | 1506                              |
| 25                                   | 144.399         | 32347.                                                                                 | 10.106                                                           | -509.6                        | -139.2              | 15.64                | 12.18                                          | 17.31                                          | 1520                              |
| 26                                   | 154.527         | 32724.                                                                                 | 10.126                                                           | -497.3                        | -100.9              | 16.12                | 12.34                                          | 17.63                                          | 1533                              |
| 27                                   | 164.678         | 33117.                                                                                 | 10.141                                                           | -484.9                        | -62.5               | 16.59                | 12.50                                          | 17.94                                          | 1546                              |
| 28                                   | 174.815         | 33509.                                                                                 | 10.151                                                           | -472.3                        | -23.9               | 17.04                | 12.65                                          | 18.24                                          | 1558                              |
| 29                                   | 184.970         | 33900.                                                                                 | 10.157                                                           | -459.6                        | 14.8                | 17.49                | 12.79                                          | 18.52                                          | 1571                              |
| 30                                   | 195.124         | 34316.                                                                                 | 10.160                                                           | -446.8                        | 53.7                | 17.93                | 12.91                                          | 18.77                                          | 1583                              |
| 31                                   | 205.244         | 34681.                                                                                 | 10.159                                                           | -433.8                        | 92.7                | 18.35                | 13.04                                          | 19.03                                          | 1595                              |
| 32                                   | 215.376         | 35080.                                                                                 | 10.155                                                           | -420.7                        | 131.8               | 18.77                | 13.17                                          | 19.27                                          | 1607                              |
| 33                                   | 225.531         | 35504.                                                                                 | 10.148                                                           | -407.5                        | 171.1               | 19.17                | 13.28                                          | 19.50                                          | 1619                              |
| 34                                   | 235.727         | 35895.                                                                                 | 10.138                                                           | -394.1                        | 210.5               | 19.57                | 13.39                                          | 19.71                                          | 1630                              |
| 35                                   | 245.870         | 36313.                                                                                 | 10.127                                                           | -380.7                        | 250.0               | 19.96                | 13.50                                          | 19.92                                          | 1641                              |
| 36                                   | 255.982         | 36712.                                                                                 | 10.113                                                           | -367.1                        | 289.5               | 20.34                | 13.60                                          | 20.11                                          | 1652                              |
| 37                                   | 266.095         | 37118.                                                                                 | 10.097                                                           | -353.5                        | 329.1               | 20.72                | 13.70                                          | 20.30                                          | 1663                              |
| 38                                   | 276.161         | 37535.                                                                                 | 10.080                                                           | -339.7                        | 368.7               | 21.08                | 13.79                                          | 20.47                                          | 1673                              |
| 39                                   | 286.256         | 37944.                                                                                 | 10.060                                                           | -325.9                        | 408.4               | 21.44                | 13.86                                          | 20.62                                          | 1684                              |
| 40                                   | 296.295         | 38426.                                                                                 | 10.040                                                           | -312.0                        | 448.0               | 21.80                | 13.94                                          | 20.75                                          | 1696                              |
| 42                                   | 316.316         | 39250.                                                                                 | 9.995                                                            | -284.0                        | 527.4               | 22.48                | 14.08                                          | 21.02                                          | 1716                              |
| 44                                   | 336.255         | 40014.                                                                                 | 9.945                                                            | -255.7                        | 606.9               | 23.14                | 14.23                                          | 21.29                                          | 1735                              |
| 0.0400 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                                |                                                |                                   |
| * 16.013                             | 70.628          | 31515.                                                                                 | 9.667                                                            | -614.0                        | -435.1              | 10.33                | 10.12                                          | 13.13                                          | 1433                              |
| 17                                   | 80.240          | 31809.                                                                                 | 9.801                                                            | -603.9                        | -400.6              | 10.95                | 10.41                                          | 13.66                                          | 1448                              |
| 18                                   | 90.036          | 32107.                                                                                 | 9.912                                                            | -593.3                        | -365.2              | 11.55                | 10.69                                          | 14.18                                          | 1463                              |
| 19                                   | 100.067         | 32463.                                                                                 | 10.004                                                           | -582.5                        | -329.0              | 12.13                | 10.95                                          | 14.66                                          | 1478                              |
| 20                                   | 110.131         | 32794.                                                                                 | 10.081                                                           | -571.4                        | -292.4              | 12.70                | 11.19                                          | 15.11                                          | 1492                              |
| 21                                   | 120.212         | 33130.                                                                                 | 10.143                                                           | -560.1                        | -255.6              | 13.25                | 11.41                                          | 15.54                                          | 1506                              |
| 22                                   | 130.397         | 33471.                                                                                 | 10.195                                                           | -548.6                        | -218.3              | 13.79                | 11.62                                          | 15.95                                          | 1519                              |
| 23                                   | 140.583         | 33841.                                                                                 | 10.237                                                           | -536.9                        | -180.8              | 14.31                | 11.81                                          | 16.33                                          | 1533                              |
| 24                                   | 150.843         | 34204.                                                                                 | 10.271                                                           | -525.0                        | -142.9              | 14.82                | 12.00                                          | 16.68                                          | 1546                              |
| 25                                   | 161.129         | 34585.                                                                                 | 10.297                                                           | -512.9                        | -104.7              | 15.31                | 12.17                                          | 17.02                                          | 1559                              |
| 26                                   | 171.442         | 34950.                                                                                 | 10.318                                                           | -500.6                        | -66.4               | 15.79                | 12.33                                          | 17.34                                          | 1572                              |
| 27                                   | 181.787         | 35333.                                                                                 | 10.333                                                           | -488.2                        | -27.7               | 16.26                | 12.48                                          | 17.65                                          | 1585                              |
| 28                                   | 192.120         | 35726.                                                                                 | 10.344                                                           | -475.7                        | 11.0                | 16.72                | 12.64                                          | 17.95                                          | 1597                              |
| 29                                   | 202.468         | 36100.                                                                                 | 10.351                                                           | -463.0                        | 49.9                | 17.16                | 12.78                                          | 18.23                                          | 1609                              |
| 30                                   | 212.830         | 36510.                                                                                 | 10.354                                                           | -450.1                        | 89.0                | 17.60                | 12.91                                          | 18.49                                          | 1621                              |
| 31                                   | 223.135         | 36896.                                                                                 | 10.354                                                           | -437.1                        | 128.1               | 18.02                | 13.04                                          | 18.75                                          | 1633                              |
| 32                                   | 233.467         | 37300.                                                                                 | 10.352                                                           | -424.0                        | 167.4               | 18.44                | 13.17                                          | 18.99                                          | 1644                              |
| 33                                   | 243.835         | 37727.                                                                                 | 10.347                                                           | -410.8                        | 206.9               | 18.85                | 13.29                                          | 19.22                                          | 1656                              |
| 34                                   | 254.218         | 38083.                                                                                 | 10.339                                                           | -397.4                        | 246.5               | 19.24                | 13.40                                          | 19.45                                          | 1667                              |
| 35                                   | 264.569         | 38496.                                                                                 | 10.330                                                           | -384.0                        | 286.2               | 19.63                | 13.51                                          | 19.66                                          | 1678                              |
| 36                                   | 274.882         | 38907.                                                                                 | 10.319                                                           | -370.4                        | 325.9               | 20.02                | 13.62                                          | 19.86                                          | 1689                              |
| 37                                   | 285.196         | 39300.                                                                                 | 10.307                                                           | -356.8                        | 365.7               | 20.39                | 13.72                                          | 20.05                                          | 1699                              |
| 38                                   | 295.471         | 39721.                                                                                 | 10.293                                                           | -343.0                        | 405.5               | 20.76                | 13.81                                          | 20.23                                          | 1710                              |
| 39                                   | 305.766         | 40112.                                                                                 | 10.278                                                           | -329.1                        | 445.4               | 21.12                | 13.89                                          | 20.39                                          | 1721                              |
| 40                                   | 316.070         | 40695.                                                                                 | 10.262                                                           | -315.2                        | 485.4               | 21.47                | 13.96                                          | 20.51                                          | 1734                              |
| 42                                   | 336.503         | 41521.                                                                                 | 10.226                                                           | -287.2                        | 565.2               | 22.15                | 14.11                                          | 20.81                                          | 1754                              |
| * TWO-PHASE BOUNDARY                 |                 |                                                                                        |                                                                  |                               |                     |                      |                                                |                                                |                                   |

TABLE X1. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial \rho)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /ATM/GMOLE | $(\partial P/\partial T)_\rho$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0405 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 16.664                             | 93.457          | 33912.                                                                                 | 9.835                                                            | -609.8                        | -376.0              | 10.43                | 10.23                                 | 13.17                                 | 1481                              |
| 17                                   | 96.705          | 34057.                                                                                 | 9.894                                                            | -606.3                        | -364.4              | 10.64                | 10.33                                 | 13.35                                 | 1487                              |
| 18                                   | 106.680         | 34491.                                                                                 | 10.044                                                           | -595.8                        | -329.0              | 11.24                | 10.62                                 | 13.88                                 | 1505                              |
| 19                                   | 116.878         | 34793.                                                                                 | 10.161                                                           | -585.1                        | -292.7              | 11.82                | 10.89                                 | 14.38                                 | 1519                              |
| 20                                   | 127.100         | 35098.                                                                                 | 10.252                                                           | -574.1                        | -256.1              | 12.38                | 11.14                                 | 14.84                                 | 1533                              |
| 21                                   | 137.357         | 35463.                                                                                 | 10.323                                                           | -562.8                        | -219.2              | 12.93                | 11.37                                 | 15.27                                 | 1547                              |
| 22                                   | 147.707         | 35782.                                                                                 | 10.379                                                           | -551.3                        | -181.8              | 13.47                | 11.59                                 | 15.68                                 | 1560                              |
| 23                                   | 158.084         | 36176.                                                                                 | 10.423                                                           | -539.6                        | -144.1              | 13.99                | 11.79                                 | 16.05                                 | 1574                              |
| 24                                   | 168.523         | 36532.                                                                                 | 10.458                                                           | -527.8                        | -106.1              | 14.49                | 11.97                                 | 16.41                                 | 1586                              |
| 25                                   | 178.998         | 36904.                                                                                 | 10.485                                                           | -515.7                        | -67.9               | 14.98                | 12.15                                 | 16.75                                 | 1599                              |
| 26                                   | 189.490         | 37255.                                                                                 | 10.505                                                           | -503.5                        | -29.4               | 15.46                | 12.31                                 | 17.07                                 | 1611                              |
| 27                                   | 200.024         | 37628.                                                                                 | 10.521                                                           | -491.1                        | 9.4                 | 15.93                | 12.47                                 | 17.38                                 | 1623                              |
| 28                                   | 210.554         | 38023.                                                                                 | 10.532                                                           | -478.5                        | 48.3                | 16.39                | 12.63                                 | 17.68                                 | 1635                              |
| 29                                   | 221.092         | 38398.                                                                                 | 10.540                                                           | -465.8                        | 87.3                | 16.83                | 12.78                                 | 17.96                                 | 1647                              |
| 30                                   | 231.655         | 38793.                                                                                 | 10.544                                                           | -453.0                        | 126.6               | 17.27                | 12.91                                 | 18.22                                 | 1659                              |
| 31                                   | 242.154         | 39195.                                                                                 | 10.547                                                           | -440.0                        | 165.8               | 17.70                | 13.04                                 | 18.48                                 | 1671                              |
| 32                                   | 252.690         | 39605.                                                                                 | 10.547                                                           | -426.9                        | 205.3               | 18.11                | 13.17                                 | 18.73                                 | 1682                              |
| 33                                   | 263.265         | 40010.                                                                                 | 10.545                                                           | -413.6                        | 245.0               | 18.52                | 13.29                                 | 18.96                                 | 1694                              |
| 34                                   | 273.824         | 40357.                                                                                 | 10.542                                                           | -400.3                        | 284.8               | 18.92                | 13.41                                 | 19.19                                 | 1704                              |
| 35                                   | 284.380         | 40761.                                                                                 | 10.538                                                           | -386.8                        | 324.6               | 19.31                | 13.52                                 | 19.41                                 | 1715                              |
| 36                                   | 294.899         | 41185.                                                                                 | 10.532                                                           | -373.3                        | 364.5               | 19.69                | 13.63                                 | 19.62                                 | 1726                              |
| 37                                   | 305.411         | 41576.                                                                                 | 10.525                                                           | -359.6                        | 404.5               | 20.07                | 13.73                                 | 19.82                                 | 1737                              |
| 38                                   | 315.897         | 42002.                                                                                 | 10.518                                                           | -345.8                        | 444.5               | 20.43                | 13.82                                 | 20.00                                 | 1748                              |
| 39                                   | 326.382         | 42365.                                                                                 | 10.510                                                           | -331.9                        | 484.6               | 20.79                | 13.90                                 | 20.18                                 | 1758                              |
| 40                                   | 337.016         | 43117.                                                                                 | 10.501                                                           | -318.0                        | 525.2               | 21.15                | 13.98                                 | 20.30                                 | 1774                              |
| 0.0410 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 17.333                             | 117.890         | 36883.                                                                                 | 10.066                                                           | -604.8                        | -313.5              | 10.53                | 10.35                                 | 13.22                                 | 1539                              |
| 18                                   | 124.549         | 37009.                                                                                 | 10.171                                                           | -597.9                        | -290.1              | 10.93                | 10.55                                 | 13.58                                 | 1548                              |
| 19                                   | 134.872         | 37197.                                                                                 | 10.299                                                           | -587.2                        | -253.9              | 11.51                | 10.83                                 | 14.10                                 | 1560                              |
| 20                                   | 145.244         | 37494.                                                                                 | 10.402                                                           | -576.2                        | -217.3              | 12.07                | 11.09                                 | 14.57                                 | 1573                              |
| 21                                   | 155.688         | 37874.                                                                                 | 10.483                                                           | -565.0                        | -180.2              | 12.62                | 11.33                                 | 15.00                                 | 1588                              |
| 22                                   | 166.193         | 38176.                                                                                 | 10.548                                                           | -553.6                        | -142.8              | 13.15                | 11.55                                 | 15.42                                 | 1600                              |
| 23                                   | 176.772         | 38590.                                                                                 | 10.599                                                           | -541.9                        | -105.0              | 13.67                | 11.76                                 | 15.79                                 | 1614                              |
| 24                                   | 187.388         | 38941.                                                                                 | 10.640                                                           | -530.1                        | -67.0               | 14.17                | 11.95                                 | 16.16                                 | 1627                              |
| 25                                   | 198.046         | 39307.                                                                                 | 10.672                                                           | -518.0                        | -28.6               | 14.66                | 12.13                                 | 16.49                                 | 1639                              |
| 26                                   | 208.711         | 39647.                                                                                 | 10.696                                                           | -505.8                        | 10.0                | 15.14                | 12.30                                 | 16.82                                 | 1651                              |
| 27                                   | 219.429         | 40007.                                                                                 | 10.715                                                           | -493.4                        | 48.9                | 15.61                | 12.46                                 | 17.13                                 | 1663                              |
| 28                                   | 230.156         | 40398.                                                                                 | 10.728                                                           | -480.9                        | 87.9                | 16.06                | 12.62                                 | 17.43                                 | 1674                              |
| 29                                   | 240.879         | 40765.                                                                                 | 10.737                                                           | -468.2                        | 127.1               | 16.51                | 12.77                                 | 17.71                                 | 1686                              |
| 30                                   | 251.635         | 41140.                                                                                 | 10.742                                                           | -455.3                        | 166.5               | 16.95                | 12.91                                 | 17.98                                 | 1697                              |
| 31                                   | 262.343         | 41570.                                                                                 | 10.745                                                           | -442.4                        | 206.0               | 17.37                | 13.04                                 | 18.23                                 | 1709                              |
| 32                                   | 273.084         | 41981.                                                                                 | 10.744                                                           | -429.3                        | 245.6               | 17.79                | 13.17                                 | 18.48                                 | 1720                              |
| 33                                   | 283.854         | 42354.                                                                                 | 10.742                                                           | -416.0                        | 285.5               | 18.19                | 13.30                                 | 18.72                                 | 1731                              |
| 34                                   | 294.590         | 42721.                                                                                 | 10.737                                                           | -402.7                        | 325.4               | 18.59                | 13.41                                 | 18.94                                 | 1741                              |
| 35                                   | 305.344         | 43110.                                                                                 | 10.730                                                           | -389.2                        | 365.4               | 18.98                | 13.53                                 | 19.16                                 | 1752                              |
| 36                                   | 316.084         | 43571.                                                                                 | 10.722                                                           | -375.6                        | 405.5               | 19.37                | 13.63                                 | 19.36                                 | 1763                              |
| 37                                   | 326.789         | 43956.                                                                                 | 10.713                                                           | -361.9                        | 445.7               | 19.74                | 13.74                                 | 19.56                                 | 1774                              |
| 38                                   | 337.490         | 44387.                                                                                 | 10.703                                                           | -348.1                        | 485.9               | 20.11                | 13.83                                 | 19.74                                 | 1784                              |
| 39                                   | 348.147         | 44710.                                                                                 | 10.691                                                           | -334.3                        | 526.1               | 20.47                | 13.91                                 | 19.92                                 | 1794                              |
| 0.0415 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                        |                                                                  |                               |                     |                      |                                       |                                       |                                   |
| * 18.020                             | 143.963         | 39353.                                                                                 | 10.283                                                           | -599.2                        | -247.7              | 10.64                | 10.47                                 | 13.31                                 | 1586                              |
| 19                                   | 154.088         | 39678.                                                                                 | 10.438                                                           | -588.7                        | -212.5              | 11.20                | 10.76                                 | 13.83                                 | 1601                              |
| 20                                   | 164.614         | 40010.                                                                                 | 10.559                                                           | -577.8                        | -175.9              | 11.76                | 11.03                                 | 14.31                                 | 1615                              |
| 21                                   | 175.246         | 40366.                                                                                 | 10.651                                                           | -566.7                        | -138.8              | 12.30                | 11.28                                 | 14.75                                 | 1629                              |
| 22                                   | 185.898         | 40659.                                                                                 | 10.722                                                           | -555.3                        | -101.4              | 12.83                | 11.51                                 | 15.17                                 | 1641                              |
| 23                                   | 196.686         | 41077.                                                                                 | 10.777                                                           | -543.7                        | -63.4               | 13.35                | 11.73                                 | 15.55                                 | 1655                              |
| 24                                   | 207.477         | 41426.                                                                                 | 10.820                                                           | -531.8                        | -25.3               | 13.85                | 11.92                                 | 15.91                                 | 1667                              |
| 25                                   | 218.312         | 41774.                                                                                 | 10.852                                                           | -519.8                        | 13.2                | 14.34                | 12.11                                 | 16.25                                 | 1679                              |
| 26                                   | 229.146         | 42119.                                                                                 | 10.878                                                           | -507.6                        | 51.8                | 14.82                | 12.28                                 | 16.58                                 | 1690                              |
| 27                                   | 240.041         | 42459.                                                                                 | 10.897                                                           | -495.3                        | 90.8                | 15.29                | 12.45                                 | 16.89                                 | 1702                              |
| 28                                   | 250.965         | 42851.                                                                                 | 10.912                                                           | -482.7                        | 130.0               | 15.74                | 12.61                                 | 17.19                                 | 1713                              |
| 29                                   | 261.870         | 43217.                                                                                 | 10.923                                                           | -470.0                        | 169.3               | 16.19                | 12.76                                 | 17.47                                 | 1724                              |
| 30                                   | 272.806         | 43554.                                                                                 | 10.931                                                           | -457.2                        | 208.9               | 16.62                | 12.90                                 | 17.75                                 | 1735                              |
| 31                                   | 283.734         | 44003.                                                                                 | 10.937                                                           | -444.2                        | 248.5               | 17.05                | 13.04                                 | 18.00                                 | 1747                              |
| 32                                   | 294.678         | 44399.                                                                                 | 10.942                                                           | -431.1                        | 288.3               | 17.46                | 13.17                                 | 18.25                                 | 1758                              |
| 33                                   | 305.626         | 44749.                                                                                 | 10.944                                                           | -417.9                        | 328.3               | 17.87                | 13.30                                 | 18.50                                 | 1768                              |
| 34                                   | 316.560         | 45177.                                                                                 | 10.946                                                           | -404.5                        | 368.4               | 18.27                | 13.42                                 | 18.72                                 | 1780                              |
| 35                                   | 327.505         | 45547.                                                                                 | 10.946                                                           | -391.1                        | 408.6               | 18.66                | 13.53                                 | 18.95                                 | 1790                              |
| 36                                   | 338.489         | 46071.                                                                                 | 10.946                                                           | -377.5                        | 449.0               | 19.04                | 13.64                                 | 19.15                                 | 1803                              |
| 37                                   | 349.386         | 46453.                                                                                 | 10.946                                                           | -363.8                        | 489.3               | 19.42                | 13.74                                 | 19.36                                 | 1813                              |

\* TWO-PHASE BOUNDARY

TABLE XI. THERMODYNAMIC PROPERTIES OF PARAHYDROGEN, ISOCHORES-CONTINUED

| TEMPERATURE<br>DEG. KELVIN           | PRESSURE<br>ATM | $(\partial P/\partial p)_T$<br>ISOTHERM<br>DERIVATIVE<br>CM <sup>3</sup> /GMOLE | $(\partial P/\partial T)_p$<br>ISOCORE<br>DERIVATIVE<br>ATM/K | INTERNAL<br>ENERGY<br>J/GMOLE | ENTHALPY<br>J/GMOLE | ENTROPY<br>J/GMOLE-K | $C_v$ , HEAT<br>CAPACITY<br>J/GMOLE-K | $C_p$ , HEAT<br>CAPACITY<br>J/GMOLE-K | VELOCITY<br>OF SOUND<br>METER/SEC |
|--------------------------------------|-----------------|---------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------|---------------------|----------------------|---------------------------------------|---------------------------------------|-----------------------------------|
| 0.0420 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                 |                                                               |                               |                     |                      |                                       |                                       |                                   |
| * 18.726                             | 171.685         | 42117.                                                                          | 10.580                                                        | -592.7                        | -178.5              | 10.74                | 10.60                                 | 13.46                                 | 1639                              |
| 19                                   | 174.564         | 42239.                                                                          | 10.618                                                        | -589.8                        | -168.7              | 10.89                | 10.68                                 | 13.60                                 | 1644                              |
| 20                                   | 185.280         | 42685.                                                                          | 10.737                                                        | -579.0                        | -132.0              | 11.45                | 10.97                                 | 14.07                                 | 1659                              |
| 21                                   | 196.067         | 42931.                                                                          | 10.827                                                        | -567.9                        | -94.8               | 11.99                | 11.23                                 | 14.53                                 | 1670                              |
| 22                                   | 206.869         | 43240.                                                                          | 10.896                                                        | -556.5                        | -57.4               | 12.52                | 11.47                                 | 14.94                                 | 1682                              |
| 23                                   | 217.860         | 43631.                                                                          | 10.949                                                        | -544.9                        | -19.3               | 13.03                | 11.69                                 | 15.32                                 | 1695                              |
| 24                                   | 228.826         | 43970.                                                                          | 10.991                                                        | -533.1                        | 18.9                | 13.53                | 11.90                                 | 15.68                                 | 1707                              |
| 25                                   | 239.831         | 44314.                                                                          | 11.024                                                        | -521.1                        | 57.5                | 14.02                | 12.09                                 | 16.02                                 | 1718                              |
| 26                                   | 250.835         | 44650.                                                                          | 11.051                                                        | -508.9                        | 96.2                | 14.50                | 12.26                                 | 16.35                                 | 1730                              |
| 27                                   | 261.901         | 44990.                                                                          | 11.073                                                        | -496.6                        | 135.2               | 14.97                | 12.43                                 | 16.66                                 | 1741                              |
| 28                                   | 273.019         | 45370.                                                                          | 11.092                                                        | -484.1                        | 174.6               | 15.42                | 12.60                                 | 16.96                                 | 1752                              |
| 29                                   | 284.103         | 45733.                                                                          | 11.107                                                        | -471.4                        | 214.0               | 15.87                | 12.75                                 | 17.25                                 | 1763                              |
| 30                                   | 295.203         | 46041.                                                                          | 11.121                                                        | -458.6                        | 253.6               | 16.30                | 12.89                                 | 17.52                                 | 1773                              |
| 31                                   | 306.349         | 46458.                                                                          | 11.133                                                        | -445.6                        | 293.5               | 16.73                | 13.03                                 | 17.78                                 | 1785                              |
| 32                                   | 317.481         | 46804.                                                                          | 11.144                                                        | -432.5                        | 333.4               | 17.14                | 13.17                                 | 18.04                                 | 1795                              |
| 33                                   | 328.599         | 47156.                                                                          | 11.154                                                        | -419.3                        | 373.5               | 17.55                | 13.29                                 | 18.29                                 | 1806                              |
| 34                                   | 339.783         | 47727.                                                                          | 11.164                                                        | -405.9                        | 413.8               | 17.95                | 13.41                                 | 18.51                                 | 1820                              |
| 0.0425 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                 |                                                               |                               |                     |                      |                                       |                                       |                                   |
| * 19.453                             | 201.273         | 45562.                                                                          | 10.889                                                        | -585.5                        | -105.6              | 10.84                | 10.77                                 | 13.61                                 | 1701                              |
| 20                                   | 207.333         | 45565.                                                                          | 10.928                                                        | -579.5                        | -85.2               | 11.14                | 10.92                                 | 13.86                                 | 1705                              |
| 21                                   | 218.189         | 45570.                                                                          | 10.995                                                        | -568.5                        | -48.3               | 11.68                | 11.19                                 | 14.32                                 | 1712                              |
| 22                                   | 229.157         | 45930.                                                                          | 11.056                                                        | -557.2                        | -10.8               | 12.21                | 11.44                                 | 14.72                                 | 1724                              |
| 23                                   | 240.327         | 46243.                                                                          | 11.110                                                        | -545.6                        | 27.4                | 12.72                | 11.66                                 | 15.11                                 | 1735                              |
| 24                                   | 251.465         | 46586.                                                                          | 11.156                                                        | -533.8                        | 65.7                | 13.22                | 11.87                                 | 15.47                                 | 1747                              |
| 25                                   | 262.636         | 46914.                                                                          | 11.195                                                        | -521.9                        | 104.3               | 13.71                | 12.06                                 | 15.81                                 | 1758                              |
| 26                                   | 273.817         | 47285.                                                                          | 11.227                                                        | -509.7                        | 143.1               | 14.19                | 12.24                                 | 16.13                                 | 1769                              |
| 27                                   | 285.050         | 47613.                                                                          | 11.251                                                        | -497.4                        | 182.2               | 14.65                | 12.42                                 | 16.45                                 | 1780                              |
| 28                                   | 296.354         | 47974.                                                                          | 11.269                                                        | -484.9                        | 221.7               | 15.11                | 12.59                                 | 16.74                                 | 1791                              |
| 29                                   | 307.616         | 48328.                                                                          | 11.281                                                        | -472.2                        | 261.2               | 15.55                | 12.74                                 | 17.03                                 | 1802                              |
| 30                                   | 318.859         | 48596.                                                                          | 11.287                                                        | -459.4                        | 300.8               | 15.98                | 12.89                                 | 17.30                                 | 1811                              |
| 31                                   | 330.186         | 48877.                                                                          | 11.287                                                        | -446.4                        | 340.8               | 16.41                | 13.03                                 | 17.56                                 | 1820                              |
| 32                                   | 341.465         | 49104.                                                                          | 11.283                                                        | -433.4                        | 380.7               | 16.82                | 13.17                                 | 17.82                                 | 1828                              |
| 0.0430 GMOLE/CM <sup>3</sup> ISOCORE |                 |                                                                                 |                                                               |                               |                     |                      |                                       |                                       |                                   |
| * 20.201                             | 232.634         | 47909.                                                                          | 11.281                                                        | -577.4                        | -29.3               | 10.94                | 10.99                                 | 13.93                                 | 1747                              |
| 21                                   | 241.648         | 48279.                                                                          | 11.234                                                        | -568.6                        | 0.8                 | 11.37                | 11.18                                 | 14.19                                 | 1755                              |
| 22                                   | 252.819         | 48740.                                                                          | 11.234                                                        | -557.3                        | 38.5                | 11.90                | 11.41                                 | 14.53                                 | 1766                              |
| 23                                   | 264.111         | 48903.                                                                          | 11.270                                                        | -545.8                        | 76.6                | 12.41                | 11.63                                 | 14.90                                 | 1775                              |
| 24                                   | 275.418         | 49237.                                                                          | 11.320                                                        | -534.0                        | 115.0               | 12.91                | 11.84                                 | 15.26                                 | 1786                              |
| 25                                   | 286.753         | 49561.                                                                          | 11.370                                                        | -522.1                        | 153.6               | 13.40                | 12.03                                 | 15.61                                 | 1797                              |
| 26                                   | 298.132         | 49987.                                                                          | 11.409                                                        | -510.0                        | 192.6               | 13.87                | 12.22                                 | 15.93                                 | 1810                              |
| 27                                   | 309.527         | 50311.                                                                          | 11.433                                                        | -497.6                        | 231.7               | 14.34                | 12.41                                 | 16.25                                 | 1820                              |
| 28                                   | 321.004         | 50637.                                                                          | 11.436                                                        | -485.1                        | 271.3               | 14.79                | 12.58                                 | 16.55                                 | 1829                              |
| 29                                   | 332.443         | 50997.                                                                          | 11.417                                                        | -472.5                        | 310.9               | 15.24                | 12.75                                 | 16.81                                 | 1838                              |
| 30                                   | 343.810         | 51221.                                                                          | 11.375                                                        | -459.6                        | 350.5               | 15.67                | 12.91                                 | 17.06                                 | 1845                              |
| * TWO-PHASE BOUNDARY                 |                 |                                                                                 |                                                               |                               |                     |                      |                                       |                                       |                                   |

TABLE XII. EXPERIMENTAL VS. CALCULATED  $C_V$ 

| EXPERIMENTAL VALUES, FROM REFERENCE 7 |                       |                                 |                    | CALCULATED VALUES, THIS PAPER |                         |                      |
|---------------------------------------|-----------------------|---------------------------------|--------------------|-------------------------------|-------------------------|----------------------|
| PRESSURE<br>ATM                       | TEMPERATURE<br>DEG. K | DENSITY<br>GMOL/CM <sup>3</sup> | $C_V$<br>J/GMOLE-K | $C_V$<br>J/GMOLE-K            | DIFFERENCE<br>J/GMOLE-K | PERCENT<br>DEVIATION |
| 13.25                                 | 33.497                | 0.01095                         | 17.56              | 17.37                         | 0.19                    | 1.07                 |
| 14.77                                 | 34.695                | 0.01095                         | 16.07              | 16.09                         | -0.02                   | -0.13                |
| 16.87                                 | 36.367                | 0.01095                         | 15.09              | 15.07                         | 0.03                    | 0.17                 |
| 19.10                                 | 38.150                | 0.01095                         | 14.52              | 14.48                         | 0.05                    | 0.32                 |
| 21.52                                 | 40.105                | 0.01095                         | 14.14              | 14.09                         | 0.05                    | 0.36                 |
| 24.26                                 | 42.325                | 0.01095                         | 13.88              | 13.81                         | 0.08                    | 0.54                 |
| 26.98                                 | 44.538                | 0.01095                         | 13.69              | 13.65                         | 0.05                    | 0.34                 |
| 29.54                                 | 46.624                | 0.01095                         | 13.61              | 13.57                         | 0.04                    | 0.28                 |
| 31.98                                 | 48.607                | 0.01095                         | 13.56              | 13.54                         | 0.02                    | 0.15                 |
| 34.36                                 | 50.555                | 0.01095                         | 13.57              | 13.54                         | 0.03                    | 0.22                 |
| 45.59                                 | 59.757                | 0.01094                         | 13.74              | 13.80                         | -0.06                   | -0.43                |
| 58.31                                 | 70.241                | 0.01094                         | 14.68              | 14.62                         | 0.06                    | 0.40                 |
| 14.72                                 | 34.216                | 0.01330                         | 17.67              | 17.52                         | 0.15                    | 0.88                 |
| 18.19                                 | 36.402                | 0.01330                         | 15.27              | 15.22                         | 0.05                    | 0.30                 |
| 21.33                                 | 38.384                | 0.01329                         | 14.56              | 14.56                         | -0.01                   | -0.06                |
| 24.22                                 | 40.214                | 0.01329                         | 14.15              | 14.18                         | -0.03                   | -0.18                |
| 27.22                                 | 42.107                | 0.01329                         | 13.92              | 13.92                         | 0.00                    | 0.03                 |
| 30.19                                 | 43.985                | 0.01329                         | 13.77              | 13.75                         | 0.02                    | 0.12                 |
| 33.28                                 | 45.940                | 0.01329                         | 13.68              | 13.65                         | 0.03                    | 0.18                 |
| 36.53                                 | 47.994                | 0.01329                         | 13.61              | 13.60                         | 0.01                    | 0.09                 |
| 39.79                                 | 50.057                | 0.01329                         | 13.60              | 13.59                         | 0.01                    | 0.09                 |
| 55.25                                 | 59.868                | 0.01328                         | 13.88              | 13.87                         | 0.02                    | 0.12                 |
| 71.10                                 | 69.974                | 0.01328                         | 14.68              | 14.67                         | 0.01                    | 0.06                 |
| 87.02                                 | 80.206                | 0.01327                         | 16.03              | 16.01                         | 0.02                    | 0.10                 |
| 102.25                                | 90.055                | 0.01327                         | 17.57              | 17.64                         | -0.07                   | -0.38                |
| 14.56                                 | 33.889                | 0.01619                         | 18.64              | 17.87                         | 0.77                    | 4.15                 |
| 18.88                                 | 36.035                | 0.01619                         | 15.20              | 15.05                         | 0.16                    | 1.05                 |
| 23.29                                 | 38.194                | 0.01619                         | 14.38              | 14.38                         | 0.                      | 0.                   |
| 31.65                                 | 42.244                | 0.01619                         | 13.81              | 13.83                         | -0.03                   | -0.18                |
| 35.80                                 | 44.245                | 0.01619                         | 13.69              | 13.69                         | 0.                      | 0.                   |
| 39.79                                 | 46.166                | 0.01618                         | 13.63              | 13.61                         | 0.02                    | 0.15                 |
| 47.73                                 | 49.986                | 0.01618                         | 13.61              | 13.59                         | 0.01                    | 0.09                 |
| 68.32                                 | 59.894                | 0.01617                         | 13.92              | 13.93                         | -0.01                   | -0.09                |
| 89.06                                 | 69.931                | 0.01616                         | 14.83              | 14.77                         | 0.07                    | 0.45                 |
| 109.81                                | 80.052                | 0.01616                         | 16.10              | 16.11                         | -0.01                   | -0.08                |
| 129.91                                | 89.943                | 0.01615                         | 17.70              | 17.75                         | -0.05                   | -0.28                |
| 13.61                                 | 33.316                | 0.01869                         | 17.36              | 16.51                         | 0.84                    | 4.85                 |
| 16.29                                 | 34.425                | 0.01869                         | 15.47              | 15.38                         | 0.09                    | 0.59                 |
| 20.72                                 | 36.217                | 0.01869                         | 14.46              | 14.39                         | 0.07                    | 0.49                 |
| 25.61                                 | 38.159                | 0.01869                         | 14.01              | 14.01                         | -0.00                   | -0.03                |
| 30.39                                 | 40.040                | 0.01869                         | 13.78              | 13.81                         | -0.03                   | -0.21                |
| 35.33                                 | 41.969                | 0.01869                         | 13.66              | 13.66                         | 0.00                    | 0.03                 |
| 40.60                                 | 44.018                | 0.01868                         | 13.56              | 13.56                         | 0.00                    | 0.03                 |
| 46.06                                 | 46.142                | 0.01868                         | 13.55              | 13.53                         | 0.02                    | 0.15                 |
| 51.47                                 | 48.238                | 0.01868                         | 13.54              | 13.54                         | 0.                      | 0.                   |
| 56.67                                 | 50.249                | 0.01868                         | 13.56              | 13.58                         | -0.02                   | -0.12                |
| 82.68                                 | 60.335                | 0.01867                         | 14.01              | 14.03                         | -0.02                   | -0.12                |
| 105.93                                | 69.404                | 0.01866                         | 14.81              | 14.81                         | 0.00                    | 0.03                 |
| 132.61                                | 79.924                | 0.01865                         | 16.18              | 16.20                         | -0.02                   | -0.13                |
| 156.25                                | 89.331                | 0.01864                         | 17.59              | 17.76                         | -0.17                   | -0.95                |
| 16.97                                 | 33.696                | 0.02292                         | 13.81              | 13.61                         | 0.20                    | 1.45                 |
| 24.85                                 | 35.943                | 0.02292                         | 13.51              | 13.49                         | 0.02                    | 0.15                 |
| 39.40                                 | 40.010                | 0.02291                         | 13.38              | 13.38                         | 0.00                    | 0.03                 |
| 46.37                                 | 41.943                | 0.02291                         | 13.38              | 13.36                         | 0.03                    | 0.19                 |
| 53.43                                 | 43.900                | 0.02291                         | 13.39              | 13.36                         | 0.03                    | 0.19                 |
| 60.94                                 | 45.976                | 0.02290                         | 13.45              | 13.39                         | 0.06                    | 0.44                 |
| 68.42                                 | 48.043                | 0.02290                         | 13.49              | 13.49                         | 0.                      | 0.                   |
| 75.80                                 | 50.086                | 0.02290                         | 13.59              | 13.59                         | 0.00                    | 0.03                 |
| 111.49                                | 60.017                | 0.02288                         | 14.15              | 14.16                         | -0.01                   | -0.09                |
| 146.34                                | 69.823                | 0.02287                         | 15.10              | 15.07                         | 0.04                    | 0.25                 |
| 181.52                                | 79.870                | 0.02285                         | 16.55              | 16.43                         | 0.13                    | 0.76                 |
| 217.64                                | 90.319                | 0.02284                         | 18.25              | 18.18                         | 0.08                    | 0.41                 |
| 19.05                                 | 33.107                | 0.02546                         | 13.19              | 13.22                         | -0.03                   | -0.22                |
| 23.97                                 | 34.245                | 0.02546                         | 13.18              | 13.21                         | -0.03                   | -0.22                |
| 25.62                                 | 34.622                | 0.02546                         | 13.20              | 13.21                         | -0.02                   | -0.13                |
| 29.13                                 | 35.434                | 0.02545                         | 13.19              | 13.22                         | -0.03                   | -0.19                |
| 35.65                                 | 36.926                | 0.02545                         | 13.21              | 13.24                         | -0.03                   | -0.19                |
| 37.52                                 | 37.354                | 0.02545                         | 13.23              | 13.24                         | -0.02                   | -0.13                |
| 46.04                                 | 39.301                | 0.02545                         | 13.28              | 13.26                         | 0.03                    | 0.19                 |
| 53.96                                 | 41.109                | 0.02545                         | 13.33              | 13.28                         | 0.05                    | 0.35                 |
| 74.75                                 | 45.860                | 0.02544                         | 13.45              | 13.41                         | 0.04                    | 0.31                 |
| 83.87                                 | 47.949                | 0.02543                         | 13.55              | 13.53                         | 0.03                    | 0.19                 |
| 93.05                                 | 50.060                | 0.02543                         | 13.63              | 13.65                         | -0.02                   | -0.12                |
| 135.28                                | 59.845                | 0.02541                         | 14.25              | 14.28                         | -0.03                   | -0.23                |
| 179.76                                | 70.316                | 0.02539                         | 15.34              | 15.28                         | 0.05                    | 0.35                 |
| 217.94                                | 79.472                | 0.02538                         | 16.65              | 16.54                         | 0.11                    | 0.65                 |
| 259.84                                | 89.674                | 0.02536                         | 18.30              | 18.25                         | 0.05                    | 0.30                 |

TABLE XII. EXPERIMENTAL VS. CALCULATED  $C_v$  - CONTINUED

| EXPERIMENTAL VALUES, FROM REFERENCE 7 |                       |                           |                              | CALCULATED VALUES, THIS PAPER |                                   |                      |
|---------------------------------------|-----------------------|---------------------------|------------------------------|-------------------------------|-----------------------------------|----------------------|
| PRESSURE<br>ATM                       | TEMPERATURE<br>DEG. K | DENSITY<br>G/MOLE- $CM^3$ | $C_v$<br>J/GMOL- $^{\circ}K$ | $C_v$<br>J/GMOL- $^{\circ}K$  | DIFFERENCE<br>J/GMOL- $^{\circ}K$ | PERCENT<br>DEVIATION |
| 11.03                                 | 27.532                | 0.03073                   | 12.55                        | 12.62                         | -0.07                             | -0.53                |
| 24.44                                 | 29.628                | 0.03072                   | 12.70                        | 12.77                         | -0.06                             | -0.49                |
| 40.98                                 | 32.215                | 0.03071                   | 12.95                        | 12.95                         | 0.                                | 0.                   |
| 54.04                                 | 34.262                | 0.03071                   | 13.12                        | 13.08                         | 0.03                              | 0.26                 |
| 67.30                                 | 36.344                | 0.03070                   | 13.25                        | 13.21                         | 0.04                              | 0.32                 |
| 80.58                                 | 38.439                | 0.03070                   | 13.37                        | 13.32                         | 0.05                              | 0.34                 |
| 93.61                                 | 40.505                | 0.03069                   | 13.47                        | 13.41                         | 0.07                              | 0.50                 |
| 106.09                                | 42.494                | 0.03069                   | 13.54                        | 13.49                         | 0.04                              | 0.31                 |
| 114.76                                | 43.881                | 0.03068                   | 13.64                        | 13.56                         | 0.08                              | 0.58                 |
| 127.31                                | 45.898                | 0.03068                   | 13.74                        | 13.66                         | 0.09                              | 0.64                 |
| 139.58                                | 47.880                | 0.03067                   | 13.86                        | 13.80                         | 0.05                              | 0.39                 |
| 151.89                                | 49.879                | 0.03067                   | 13.97                        | 13.94                         | 0.03                              | 0.21                 |
| 213.72                                | 60.070                | 0.03064                   | 14.69                        | 14.67                         | 0.02                              | 0.11                 |
| 268.77                                | 69.365                | 0.03061                   | 15.63                        | 15.59                         | 0.04                              | 0.27                 |
| 327.68                                | 79.554                | 0.03059                   | 17.04                        | 17.00                         | 0.03                              | 0.20                 |
| 27.62                                 | 20.140                | 0.03677                   | 11.34                        | 11.41                         | -0.08                             | -0.66                |
| 45.92                                 | 22.205                | 0.03676                   | 11.80                        | 11.82                         | -0.02                             | -0.18                |
| 62.16                                 | 24.028                | 0.03675                   | 12.11                        | 12.12                         | -0.01                             | -0.07                |
| 63.54                                 | 24.182                | 0.03675                   | 12.13                        | 12.14                         | -0.01                             | -0.10                |
| 80.54                                 | 26.087                | 0.03674                   | 12.41                        | 12.41                         | -0.00                             | -0.03                |
| 98.79                                 | 28.132                | 0.03673                   | 12.67                        | 12.69                         | -0.02                             | -0.13                |
| 116.75                                | 30.145                | 0.03672                   | 12.90                        | 12.92                         | -0.02                             | -0.13                |
| 134.52                                | 32.142                | 0.03671                   | 13.11                        | 13.13                         | -0.02                             | -0.16                |
| 152.14                                | 34.124                | 0.03671                   | 13.30                        | 13.32                         | -0.03                             | -0.19                |
| 169.18                                | 36.050                | 0.03670                   | 13.48                        | 13.49                         | -0.01                             | -0.06                |
| 186.11                                | 37.971                | 0.03669                   | 13.63                        | 13.64                         | -0.01                             | -0.09                |
| 203.41                                | 39.944                | 0.03668                   | 13.76                        | 13.76                         | 0.                                | 0.                   |
| 220.59                                | 41.916                | 0.03667                   | 13.87                        | 13.87                         | -0.00                             | -0.03                |
| 237.85                                | 43.909                | 0.03667                   | 14.00                        | 13.99                         | 0.00                              | 0.03                 |
| 255.18                                | 45.923                | 0.03666                   | 14.12                        | 14.12                         | 0.00                              | 0.03                 |
| 272.74                                | 47.978                | 0.03665                   | 14.26                        | 14.29                         | -0.03                             | -0.21                |
| 290.16                                | 50.029                | 0.03664                   | 14.39                        | 14.46                         | -0.07                             | -0.47                |
| 306.98                                | 52.051                | 0.03662                   | 14.52                        | 14.62                         | -0.10                             | -0.69                |
| 324.34                                | 54.085                | 0.03662                   | 14.67                        | 14.79                         | -0.13                             | -0.86                |
| 49.77                                 | 19.916                | 0.03789                   | 11.31                        | 11.31                         | 0.                                | 0.                   |
| 67.82                                 | 21.863                | 0.03788                   | 11.71                        | 11.71                         | 0.                                | 0.                   |
| 72.61                                 | 22.377                | 0.03787                   | 11.80                        | 11.81                         | -0.01                             | -0.07                |
| 87.03                                 | 23.924                | 0.03787                   | 12.06                        | 12.07                         | -0.01                             | -0.07                |
| 105.78                                | 25.930                | 0.03786                   | 12.39                        | 12.37                         | 0.02                              | 0.14                 |
| 125.49                                | 28.037                | 0.03785                   | 12.67                        | 12.67                         | 0.00                              | 0.03                 |
| 144.41                                | 30.060                | 0.03784                   | 12.92                        | 12.92                         | -0.00                             | -0.03                |
| 163.30                                | 32.082                | 0.03783                   | 13.15                        | 13.15                         | -0.00                             | -0.03                |
| 181.71                                | 34.056                | 0.03782                   | 13.35                        | 13.35                         | 0.                                | 0.                   |
| 197.41                                | 35.742                | 0.03781                   | 13.51                        | 13.51                         | 0.00                              | 0.03                 |
| 214.03                                | 37.538                | 0.03780                   | 13.65                        | 13.66                         | -0.02                             | -0.12                |
| 272.42                                | 43.923                | 0.03777                   | 14.08                        | 14.08                         | 0.                                | 0.                   |
| 15.16                                 | 16.139                | 0.03791                   | 10.32                        | 10.28                         | 0.04                              | 0.36                 |
| 36.04                                 | 18.404                | 0.03790                   | 10.92                        | 10.94                         | -0.02                             | -0.19                |
| 55.16                                 | 20.481                | 0.03789                   | 11.46                        | 11.43                         | 0.03                              | 0.26                 |
| 69.63                                 | 22.038                | 0.03788                   | 11.74                        | 11.74                         | -0.00                             | -0.04                |
| 88.75                                 | 24.088                | 0.03787                   | 12.09                        | 12.10                         | -0.00                             | -0.03                |
| 107.91                                | 26.136                | 0.03786                   | 12.41                        | 12.40                         | 0.01                              | 0.10                 |
| 126.85                                | 28.160                | 0.03785                   | 12.68                        | 12.69                         | -0.00                             | -0.03                |
| 145.89                                | 30.196                | 0.03785                   | 12.92                        | 12.94                         | -0.01                             | -0.10                |
| 164.98                                | 32.239                | 0.03784                   | 13.16                        | 13.17                         | -0.01                             | -0.06                |
| 183.80                                | 34.255                | 0.03783                   | 13.37                        | 13.37                         | 0.                                | 0.                   |
| 199.86                                | 35.982                | 0.03782                   | 13.52                        | 13.54                         | -0.01                             | -0.09                |
| 218.09                                | 37.951                | 0.03781                   | 13.69                        | 13.70                         | -0.01                             | -0.09                |
| 236.44                                | 39.930                | 0.03780                   | 13.82                        | 13.83                         | -0.00                             | -0.03                |
| 254.58                                | 41.911                | 0.03780                   | 13.95                        | 13.95                         | 0.00                              | 0.03                 |
| 272.70                                | 43.900                | 0.03779                   | 14.08                        | 14.08                         | -0.00                             | -0.03                |
| 290.82                                | 45.902                | 0.03778                   | 14.22                        | 14.21                         | 0.00                              | 0.03                 |
| 309.13                                | 47.938                | 0.03777                   | 14.35                        | 14.40                         | -0.05                             | -0.32                |
| 327.43                                | 49.992                | 0.03776                   | 14.49                        | 14.57                         | -0.08                             | -0.55                |
| 70.88                                 | 18.021                | 0.03937                   | 10.73                        | 10.76                         | -0.03                             | -0.27                |
| 90.42                                 | 20.048                | 0.03936                   | 11.23                        | 11.25                         | -0.02                             | -0.15                |
| 109.45                                | 21.999                | 0.03935                   | 11.66                        | 11.66                         | -0.00                             | -0.04                |
| 129.00                                | 23.985                | 0.03934                   | 12.02                        | 12.02                         | -0.01                             | -0.07                |
| 148.56                                | 25.963                | 0.03933                   | 12.36                        | 12.34                         | 0.02                              | 0.14                 |
| 168.06                                | 27.931                | 0.03932                   | 12.64                        | 12.64                         | 0.00                              | 0.03                 |
| 187.65                                | 29.909                | 0.03931                   | 12.90                        | 12.90                         | 0.                                | 0.                   |
| 207.43                                | 31.907                | 0.03930                   | 13.14                        | 13.15                         | -0.02                             | -0.13                |
| 227.23                                | 33.907                | 0.03929                   | 13.36                        | 13.38                         | -0.01                             | -0.09                |
| 246.87                                | 35.894                | 0.03928                   | 13.56                        | 13.58                         | -0.02                             | -0.12                |
| 267.29                                | 37.971                | 0.03927                   | 13.74                        | 13.77                         | -0.03                             | -0.24                |
| 286.47                                | 39.935                | 0.03926                   | 13.88                        | 13.92                         | -0.03                             | -0.24                |
| 305.57                                | 41.897                | 0.03925                   | 14.02                        | 14.05                         | -0.04                             | -0.27                |
| 324.96                                | 43.899                | 0.03924                   | 14.16                        | 14.20                         | -0.04                             | -0.27                |
| 344.49                                | 45.915                | 0.03923                   | 14.31                        | 14.35                         | -0.05                             | -0.32                |
| 198.83                                | 21.991                | 0.04181                   | 11.52                        | 11.49                         | 0.03                              | 0.29                 |
| 219.32                                | 23.917                | 0.04180                   | 11.91                        | 11.89                         | 0.02                              | 0.18                 |
| 241.50                                | 25.987                | 0.04179                   | 12.29                        | 12.27                         | 0.02                              | 0.17                 |
| 263.74                                | 28.055                | 0.04178                   | 12.62                        | 12.61                         | 0.01                              | 0.07                 |
| 285.31                                | 30.055                | 0.04177                   | 12.91                        | 12.91                         | 0.                                | 0.                   |
| 306.78                                | 32.046                | 0.04176                   | 13.18                        | 13.18                         | 0.                                | 0.                   |
| 327.75                                | 33.990                | 0.04175                   | 13.41                        | 13.41                         | -0.01                             | -0.06                |









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