Electrical Resistivity of Alkali Elements

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This paper presents and discusses the available data and information on the electrical resistivity of alkali elements (lithium, sodium, potassium, rubidium, cesium, and francium) and contains recommended reference values (or provisional or typical values). The compiled data include all the experimental data available from the literature and cover the temperature dependence, pressure dependence, and magnetic flux density dependence. The temperature range covered by the compiled data is from cryogenic temperatures to above the critical temperature of the elements. The recommended values are generated from critical evaluation, analysis, and synthesis of the available data and information and are given for both the total electrical resistivity and the intrinsic electrical resistivity. For most of the elements, the recommended values cover the temperature range from 1 K to 2000 K.

Key words: Alkali elements: cesium; electrical resistivity; francium; lithium; magnetic flux density dependence; potassium; pressure dependence; rubidium; sodium; temperature dependence.

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List of Symbols

a	Constant
A	Code for dc potentiometer method
b	Constant
B	Magnetic flux density; code for dc bridge method
c	Constant
C	Code for ac potentiometer method
d	Constant
D	Code for ac bridge method
E	Code for eddy current method
G	Code for galvanometer amplifier method
I	Code for Induction method
L_F	Latent heat
M	Atomic weight
P	Pressure
Q	Code for Q-meter method
R	Resistance
T	Temperature
T_k	Knot temperature
T_m	Melting point
T_c	Critical temperature
T'	Reduced temperature
ρ	Electrical resistivity
ρ_0	Residual electrical resistivity
ρ_i	Intrinsic electrical resistivity
σ	Electrical conductivity
σ'	Reduced electrical conductivity
θ_D	Debye temperature
θ_R	Empirical temperature
$\rightarrow$	Code for miscellaneous methods

1. Introduction

The purpose of this work is to present and discuss the available data and information on the electrical resistivity of alkali elements, to critically evaluate, analyze, and synthesize the data, and to make recommendations for the best values for using of the electrical resistivity over a wide temperature range. Experimental electrical resistivity data are available in the world literature for elements Li, Na, K, Rb, and Cs, and there exist estimated values for Fr. These elements are of much interest to both engineers and scientists since liquid alkali metals have excellent heat transfer characteristics. For instance, sodium has been used as a coolant for nuclear reactors and nuclear powered submarines.

Table 1 contains information on the crystal structures, transition temperatures, and certain other pertinent physical constants of the alkali elements. This information is very useful in data analysis and synthesis. For example the electrical resistivity of a material changes abruptly when the material undergoes any transformation. One must, therefore, be extremely cautious in attempting to extrapolate the electrical resistivity value across any transition temperature. No attempt has been made to critically evaluate the temperatures and constants given in table 1, and they should not be considered as recommended values.

This work is organized in six sections. In the theoretical background section, the elementary theory of electrical resistivity is discussed. In the section on data evaluation and generation of recommended values, the general procedures and methods for data evaluation and for the generation of recommended values are outlined.

In the data presentation section, the electrical resistivity of each of the alkali elements is presented separately in the order of increasing atomic number. Values of electrical resistivities are given for both the solid and liquid states. For an element at moderate and high temperatures the true electrical resistivity values for different high-purity (99.9$^+$) samples at each temperature should be but little different; therefore, a set of recommended electrical resistivity values can be given for a high-purity element. At low temperatures, however, the electrical resistivity for different samples with small differences in impurity and/or imperfection differ greatly, and a set of recommended or provisional values applies only to a sample with that particular amount of impurity

TABLE 1. PHYSICAL CONSTANTS OF ALKALI ELEMENTS[a]

Name	Atomic No.	Atomic[b] Weight	Density[c] Kg m^{-3} x 10^{-3}	Crystal[d] Structure	Phase Transition	Debye[e] Temperature at 0 K	Debye[e] Temperature 298 K	Melting Point, K	Normal Boiling Point, K	Critical Temp., K
Lithium (Li)	3	6.941	0.534	b.c.c.	Martensitic transformation at low temp.	352 ± 1.7	448	453.7	1617	3720
Sodium (Na)	11	22.989	0.9712	b.c.c.	Martensitic transformation at low temp.	157 ± 1	155 ± 5	371.0	1157	2733
Potassium (K)	19	39.098	0.871	b.c.c.		89.4 ± 0.5	100	336.35	1032	2280.8 ± 3
Rubidium (Rb)	37	85.4678	1.53	b.c.c.		54 ± 4	59	312.64	961	2106 ± 5
Cesium (Cs)	55	132.9054	1.873	b.c.c.		40 ± 5	43	301.55	944	2051.1 ± 4.4
Francium (Fr)	87	(223)	2.14			39		300.2	950	

[a] Information taken from Ref. [1].

[b] Atomic weights based on $^{12}C = 12$ as adopted by the International Union of Pure and Applied Chemistry in 1971. The number in parentheses is the mass number of the isotope of longest known half life.

[c] Density values given for 293 K.

[d] Structure at room temperature.

[e] Deduced from specific heat measurements.

and imperfection. Thus, the low-temperature electrical resistivity of an element may be presented as a family of curves, each of which is recommended for a sample with a particular amount of impurity and degree of imperfection, and hence a particular residual resistivity, ρ_0. In this work, to well-defined curves are recommended for the full temperature range: one representing the intrinsic electrical resistivity, ρ_i, which is a unique function of temperature and is zero at absolute zero, and the other representing the total resistivity, ρ, for the purest form of each element on which measurements have been made. The latter curve at low temperatures is only applicable to the particularly characterized specimen with residual electrical resistivity clearly specified in the Remarks. These two curves come together at temperatures above about 100 K. Figure 1 shows the relationship beteen ρ_i, ρ_0, and ρ.

The recommended or provisional electrical resistivities are tabulated with uniform but step-wise increasing increments in temperature as the temperature increases. The estimated accuracy of the recommended or provisional values for each element in each different temperature range is given in the discussion. The asterisked values in the tables are interpolated, extrapolated, or estimated in the temperature ranges where no experimental data are available.

From the recommended values of ρ and ρ_i which are tabulated in this report, the electrical resistivity of a particular sample at low temperatures can be predicted by either of the following to ways. One way is to find the difference between the measured resistivity value and the recommended ρ value at the same low temperature, then add this difference to the recommended ρ values at other temperatures. The second way is to compare the measured low temperature (i.e. below 100 K) value with ρ_i and get the difference which is the residual resistivity of this particular sample, then add this ρ_0 to the recommended ρ_i at the other temperatures.

In the figure showing experimental data, a data set that consists of a single point is denoted by a number enclosed by a square, and a curve that connects a set of data points is denoted by a ringed number. These numbers correspond to those in the accompanying table on specimen characterization and measurement information and in the data table. When several sets of data are too close together to be distinguishable, some of the data sets or data points, those listed in the table, are omitted from the figure for the sake of clarity. For all elements except francium, both logarithmic plotting and linear plotting of electrical resistivity are used in order that details may be clearly shown for both the low and high temperature regions. The recommended values are presented in the same figure. The heavy solid curves represent recommended values, and the dashed curves give provisional values in the temperature ranges where few experimental data or none are available. In the figure, the melting point (M.P.), normal boiling point (N.B.P.), and critical temperature (C.T.) of the elements are indicated. Some of these transition points are also mentioned in the text. At the melting point the resistivity exhibits sharp discontinuity.

The tables on specimen characterization and measurement information give for each set of data the folloing information: the publication reference number, author's name, year of publication, experimental method used for the measurement, temperature range covered by the data, substance name and specimen designation, as well as the detailed description and characterization of the specimen and information on measurement conditions that are reported in the original paper. In these tables the code designations used for the experimental methods for electrical resistivity determination are as follows:

A DC Potentiometer Method
B DC Bridge Method
C AC Potentiometer Method

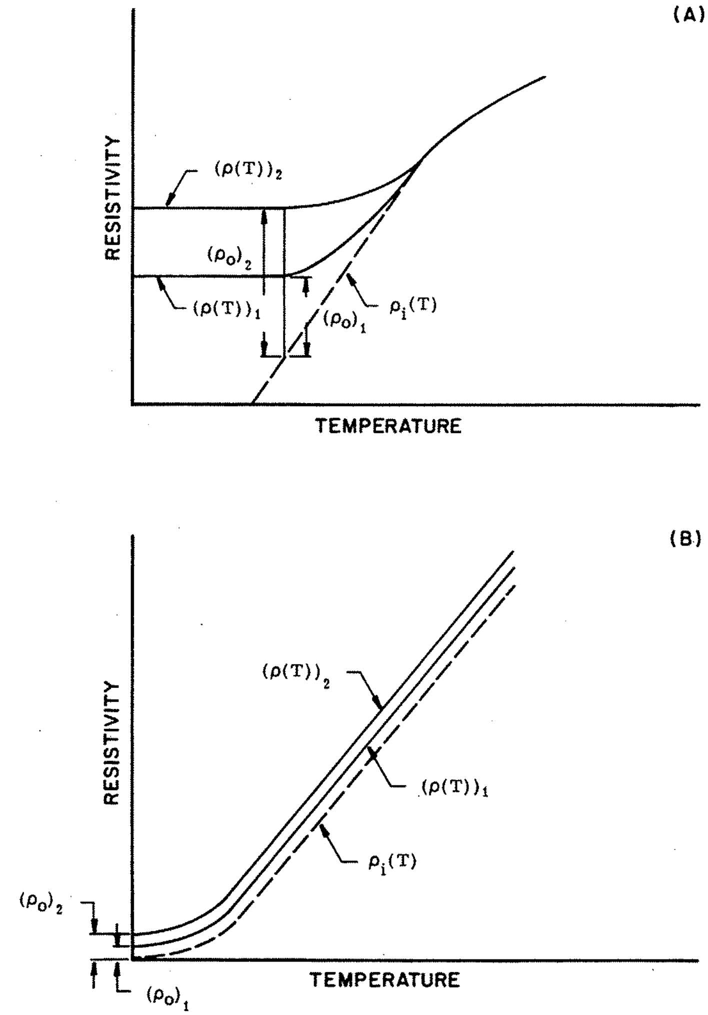


Figure 1. Relationship between intrinsic resistivity $\rho_i(T)$, residual resistivity, ρ_o, and total resistivity, $\rho(T)$. (A) logarithm scale, (B) linear scale.

D AC Bridge Method
E Eddy Current Method
G Galvonometer Amplifier Method
I Induction Method
Q Q-Meter Method
V Voltmeter and Ameter Direct Reading
→ Other than above and described in the remarks

For a comprehensive yet concise review of all these methods, the reader is referred to the references of Appendix 8.1.

The available data and information for the pressure dependence and magnetic flux density dependence of the electrical resistivity are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented in this report.

In the Thirteenth General Conference on Weights and Measures held in October 1967 in Paris, the unit "ohm-meter" (symbol: Ω m) as adopted as the SI unit for electrical resistivity. In this work, the SI units are used. Table 2 gives conversion factors which may be used to convert the electrical resistivity values in Ω m presented in this work to values in any of the several other units listed. Conversion tables for units of temperature, pressure, and magnetic flux density are listed in Appendix 8.2. It should be noted that certain of these conversion factors are not exact relationship.

In the summary and conclusions section, figures are presented in which all the recommended curves on the intrinsic electrical resistivity are grouped together in order to facilitate a visual comparison.

The complete bibliographic citation for the 129 references are given in the references section. Most of the references are available at CINDAS which are listed at the end of reference citations with numbers prefixed with the letter E or T.

2. Theoretical Background

The electrical resistivity, $\rho(T)$, of a metal is often described approximately by the Matthiessen rule [2][1]

$$\rho(T) = \rho_o + \rho_i(T), \qquad (1)$$

[1] Figures in brackets indicate literature references in section 7.

TABLE 2. CONVERSION FACTORS FOR UNITS OF ELECTRICAL RESISTIVITY*

MULTIPLY ↓ by appropriate factor to OBTAIN →	abΩ cm	μΩ cm	Ω cm	statΩ cm	Ω m	Ω cir. mil ft^{-1}	Ω in.	Ω ft.
abohm-centimeter (emu)	1	0.001	10^{-9}	1.113×10^{-21}	10^{-11}	6.015×10^{-3}	3.937×10^{-10}	3.281×10^{-11}
microohm-centimeter	1000	1	10^{-6}	1.113×10^{-18}	10^{-8}	6.015	3.937×10^{-7}	3.281×10^{-8}
ohm-centimeter	10^{9}	10^{6}	1	1.113×10^{-12}	0.01	6.015×10^{6}	0.3937	0.0328
statohm-centimeter (esu)	8.987×10^{20}	8.987×10^{17}	8.987×10^{11}	1	8.987×10^{9}	5.406×10^{18}	3.538×10^{11}	2.949×10^{10}
ohm-meter	10^{11}	10^{8}	100	1.113×10^{-10}	1	6.015×10^{8}	39.37	3.281
ohm-circular mil per foot	166.2	0.1662	1.662×10^{-7}	1.850×10^{-19}	1.662×10^{-9}	1	6.54×10^{-8}	5.45×10^{-9}
ohm-inch	2.54×10^{9}	2.54×10^{6}	2.54	2.827×10^{-12}	0.0254	1.528×10^{7}	1	0.083
ohm-foot	3.048×10^{10}	3.048×10^{7}	30.48	3.3924×10^{-11}	0.3048	1.833×10^{8}	12	1

*This table is based on the universal constants from "The International System of Units (SI)," National Bureau of Standards, NBS Special Publication 330, 43 pp, 1974.

where ρ_0 is the residual resistivity at absolute zero and $\rho_i(T)$, the intrinsic resistivity, is the temperature-dependent resistivity of an ideally pure sample of the metal. The quantity ρ_0 arises from the presence of impurities, defects, and strains in the metal lattice, while $\rho_i(T)$ is caused by the interaction of the conduction electrons with the thermally induced vibrations of the lattice ions; that is, the phonons in the crystal. For a pure annealed sample at room temperature, ρ_0 is only a small fraction of the total resistivity. There are a number of mechanisms that could produce deviation from the Matthiessen rule, i.e., a term $\Delta\rho$ which could appear on the right-hand side of equation (1). The first comprehensive survey of such deviation as made by J. Bass [128]. A more recent study by Cimberle, et al. [129] brings references up to date.

The intrinsic resistivity due to electron-phonon interactions may be approximated by the Grüneisen-Bloch relation [3]

$$\rho_i(T) = \frac{C}{M\,\theta_R}\left(\frac{T}{\theta_R}\right)^5 \int_0^{\theta_R/T} \frac{z^5\,dz}{(e^z-1)(1-e^{-z})}, \qquad (2)$$

where C is a constant, M is the atomic eight, T is the absolute temperature, and θ_R is an empirical temperature characterizing the metal's ideal electrical resistivity in the same way that the Debye temperature, θ_D, characterizes a solid's lattice specific heat. It is often true that $\theta_R \approx \theta_D$. Below about 0.1 θ_R this relation reduces to

$$\rho_i(T) \approx 124.4\,\frac{C}{M}\,\frac{T^5}{\theta_R^{\,6}} \qquad (3)$$

At high temperatures, as $T \geq \theta_R$,

$$\rho_i(T) \approx \frac{C}{4M}\,\frac{T}{\theta_R^{\,2}}. \qquad (4)$$

The Grüneisen-Bloch equation is derivable for idealized monovalent metals with Debye phonon spectra and spherical Fermi surfaces totally neglecting the effect of Umklapp processes. However, because of its comparative simplicity, the Grüneisen-Bloch equation provides a most valuable tool for analyzing and discussing experimental data.

The Grüneisen-Bloch equation never holds over the entire temperature range for the alkali metals. It is approximately valid only at low and high temperatures. By inverting the computation, one may intercompare the behavior of different metals by treating the experimental results as deviations from the Grüneisen-Bloch equation which is done by employing θ_R as a variable parameter and computing the value that it must possess at any temperature in order for the Grüneisen-Bloch equation to agree with the experiment.

In all alkali metals the electrical resistivity increases abruptly on passing through the melting point and continues to rise in the liquid phase. The sudden change is due to the greater disorder of the liquid state and the disappearance of any definite crystal structure.

Mott [4] has presented a simple and fairly successful theory of molten metals. He ignored the disordered positions and diffusive movements of the vibrating ions and assumed that near the melting point the ions of the liquid metal still maintain a more or less regular pattern. Using an Einstein model, he obtained

$$\left(\frac{\rho_L}{\rho_S}\right)_{T_m} = \exp\left(\frac{80L_F}{T_m}\right), \qquad (5)$$

where ρ_L and ρ_S are the electrical resistivities of the liquid and solid phases, T_m is the melting point, and L_F is the latent heat of fusion in kilojoules per mole. The calculated values of $(\rho_L/\rho_S)_{T_m}$ according to this formula compare moderately well with experimental data for alkali metals.

To estimate the electrical conductivity of molten alkali metals from the melting point to the critical point, Grosse [5] has proposed an empirical equation of the form of a simple equilateral hyperbola:

$$(\sigma' + b)(T' + b) = a \qquad (6)$$

where $\sigma' = \sigma/\sigma_m$ is the reduced electrical conductivity and $T' = (T - T_m)/(T_c - T_m)$ is the reduced temperature, σ_m being the electrical conductivity of the liquid at the melting point and T_c the critical temperature; the quantities a and b are constants determined by the distances of the vertex of the hyperbola from the axes. The estimated values by Grosse's equation are valid for sodium, potassium, rubidium, and cesium, but not valid for lithium.

3. Data Evaluation and Generation of Recommended Values

Data analysis and synthesis were performed in this work whenever possible. This included critical evaluation of available data and related information, reconciliation of disagreements in conflicting data, correlation of data in terms of various parameters, and curve fitting with theoretical or empirical equations. Besides critical evaluation and analysis of the existing data, semiempirical techniques have been employed to fill gaps and to extrapolate existing data so that the resulting recommended values are internally consistent and cover as wide a range of temperature as possible.

In the critical evaluation of the validity of electrical resistivity data, any unusual dependence or anomaly was carefully investigated, the experimental techniques were reviewed to see whether the actual boundary conditions in the experiment agreed with those assumed in the theory, and the author's estimations of uncertainty were checked to ensure that all the possible sources of errors were considered. The sources of errors may have included uncertainty in the measurement of specimen dimensions and of the distance between the potential probes, uncertainty due to the effects of thermal expansion, uncertainty in temperature measurements, uncertainty in the sensitivity of measuring circuits, and so on.

Many authors have included detailed error estimates in their published papers, and from these it is possible to evaluate the uncertainty for a particular method. However, experience has shown that the uncertainty estimates of most authors are unreliable. In many cases the difference between the results of two sets of data is much larger than the sum of their stated uncertainties.

Besides evaluating and analyzing individual data sets, correlating data in terms of various relevant parameters is a valuable technique and has frequently been used in data analysis. These parameters may include purity, density, residual electrical resistivity, and so on.

For meaningful data correlation, information on specimen characterization is very important. A full description of the specimen should include, wherever applicable, the following: purity or chemical composition, type of crystal, crystal axis orientation for a single crystal, microstructure, grain size, preferred grain orientation, inhomogeneity or additional phases for a polycrystalline specimen, specimen shape and dimensions, method and procedure of fabrication, sample history or treatment, test environment, and pertinent physical properties such as density, hardness, and transition temperature. Data on poorly characterized materials can hardly be analyzed or used for data correlation.

Besides specimen characterization, a full description of experimental details should be given by the author in order that his data can be meaningfully evaluated and fully utilized. Sometimes, as an initial method of evaluating the quality of a paper, consideration might be given to the amount of experimental detail reported in the paper; lack of experimental detail might lead to the results being given less weight.

Our preliminary recommended values for the electrical resistivity of the alkali elements were derived from experimental data that were considered reliable, using computer least square fits and graphing aid. These values are then corrected for thermal linear expansion and smoothing with a cubic spline function of variable knots in the form of equation (7) and the final recommended values are obtained.

$$\log\rho_i = a + b(\log T - \log T_k) + c(\log T - \log T_k)^2 + d(\log T - \log T_k)^3 \qquad (7)$$

where T = variable temperature in a given interval and T_k = minimum temperature in the interval.

Thermal linear expansion correction is necessary since the electrical resistivity measurements are ordinarily made at constant pressure on a sample with dimensions that change with temperature. In deriving the resistivity ρ from a measured resistance R using an equation such as

$$\rho = RA/\ell \qquad (8)$$

where ℓ is length of the specimen and A its cross-section. It is common to use for A and ℓ the values measured at room temperature. This will not cause serious error in the results of measurements over not-too-large a temperature range, but the difference between

$$\rho_{uncorrected}(T) = R(T)A(293\ K)/\ell(293\ K) \quad (9)$$

and

$$\rho_{corrected}(T) = R(T)A(T)/\ell(T) \quad (10)$$

should not be ignored. In the present work it has been important to determine which quantity is being reported in the research paper and to bring the results to a common basis by using a relation such as

$$\rho_{uncorrected}(T) = \rho_{corrected}(T) \cdot \left(\frac{A(T)}{A(293\ K)} \cdot \frac{\ell\ (293\ k)}{\ell\ (T)}\right)^{-1}$$

$$\cong \rho_{corrected}(T)\left[1 + \frac{\ell\ (T) - \ell\ (93K)}{\ell(293\ k)}\right]^{-1} \quad (11)$$

before making comparisons. It should be noted that not all the methods of measuring ρ are equivalent to measuring R, A, and ℓ, and that the correction for dimensional changes with temperature may differ with different experimental set up. It has been most convenient to convert the data reported as $\rho_{corrected}(T)$ to that of $\rho_{uncorrected}(T)$ and to carry out the synthesis of all data as $\rho_{uncorrected}(T)$. The final results have, however, been corrected to and reported as $\rho_{corrected}(T)$.

In estimating the uncertainty of our recommended values, the accuracy that can be achieved by the various experimental technique, the scatter of data, and the purity of the materials, among other factors, were taken into consideration. The uncertainty of a value is the maximum percentage deviation of the value from its true value. The ranges of uncertainties of recommended and provisional values are less than or equal to ±5% and greater than ±5%, respectively.

4. Electrical Resistivity of Alkali Elements

4.1. Lithium

Lithium, with atomic number 3, is a silvery white, soft alkali metal. It is the lightest of all metals with a density of 0.534 g cm^{-3} at 293 K. Except at low temperature, it has a body-centered cubic crystalline structure. It melts at 453.7 K and boils at about 1620 K. Its critical temperature has been estimated to be about 3720 K. Upon cooling through 75 K, body-centered cubic crystalline lithium undergoes a spontaneous martensitic transformation to a close-packed hexagonal structure. The transformation does not take place completely and staking faults are usually present. At 4 K possibly as much as 90% has transformed to this second phase. On reheating, reversion to the body-centered crystalline structure does not begin until 90 K and will not be complete until 160 K. Naturally occurring lithium is composed of two stable isotopes: ^{7}Li (92.58%) and ^{6}Li (7.42%). Three other radioactive isotopes are known to exist. Lithium ranks 33rd in the order of abundance of elements in the continental crust of the earth (0.002% by weight).

a. Temperature Dependence

There are 44 sets of experimental data available for the electrical resistivity of lithium. The information on specimen characterization and measurement conditions for each of the data sets is given in table 4. The data are tabulated in table 5 and shown in figures 2 and 3. Determinations of the electrical resistivity of lithium for the solid and liquid phases cover continuously the temperature range from 1.2 to 1700 K.

There are 22 data sets obtained below 90 K. Among these, eight sets are single data points at liquid helium temperature. Dugdale, Gugan, and Okumura [6] reported the data for Li consisting of over 99% ^{6}Li (curve 34). Krill [7] (curve 29) had the purest material (99.98% pure). There are seven sets of intrinsic resistivity values belo 80 K, but these disagree by as much as a factor of 9. It is evident that these are large deviations from Matthiessen's Rule. The data of Krill and Lapierre [127] on dilute solutions of Ag in Li indicates that $\rho-\rho_o$ may exceed ρ_i by a factor of 3 or more below 30 K, and that $\rho-\rho_i$ may exceed ρ_o by a factor of 2 or more above 80 K: at intermediate T deviations from Matthiessen's Rule are of the order of 20% of the total resistivity. In addition, Li undergoes a martensitic transition (b.c.c.-h.c.p.) at low T, as a result of which electrical resistivity values depend somewhat on the thermal history of the samples; see Dugdale and Gugan [21]. Because of these difficulties, Krill's data for ρ have been relied on at the lowest temperatures, since his material had the lowest ρ_o. In view of Krill's lack of attention to the martensitic transition, his values for ρ must be considered as provisional. In view of the deviations from Matthiessen's Rule, useful values of ρ_i at the lowest temperatures can be derived only by a more elaborate analysis, and are omitted here.

There are 21 data sets from 80 to 453.7 K. They agree with one another within 5%. Dugdale and Gugan [8] reported electrical resistivities at constant volume (curve 7), which are very close to those at zero pressure (curve 6). A least-mean-square error fit to the selected experimental data in this range was made with a Bloch-Grüneisen equation. The resulting values were corrected for thermal linear expansion, and then fitted with the cubic spline function equation (7) to obtain the final recommended values in this temperature range. The coefficients of equation (7) obtained in this manner are as follows:

Temperature range, K	a	b	c	d
40 – 81.06	−1.173	3.193	7.549	−17.43
81.06 – 92.295	0.0139	2.904	−8.494	38.64
92.295 – 453.6	0.1575	2.314	−1.962	1.127

There are 17 data sets available for the liquid state. They agree with one another within about 10%. Freedman and Robertson [9] (curve 5) give the lowest values while Rigney et al. [10] (curve 11) give the highest values. Grosse [5] derived electrical resistivity values (curve 45) in the range from the melting point to his estimated critical temperature, 4150 K, by fitting the experimental data of Freedman and Robertson [9] (curve 5) and Kapelner et al. [11] (curve 38) to a hyperbola equation. All the experimental data except Rigney's data ere used here for fitting the cubic spline function equation (7) to obtain the final recommended values. The coefficients of equation (7) are the following:

Temperature range, K	a	b	c	d
453.7 – 1080.5	1.395	0.622	−0.228	0.430
1080.5 – 2200	1.620	0.634	0.258	0.314

The resistivity values represented by these equations are not corrected for thermal linear expansion of the container, which in most cases is not specified.

At the melting point (463.7 K), the electrical resistivity of Li in the liquid state is about 60% higher than that of the solid state.

The recommended values for the total and intrinsic electrical resistivities of lithium are listed in table 3, and those for the total electrical resistivity are also shown in figures 2 and 3. The recommended values for the total resistivity are for 99.98⁺% pure lithium and those at temperatures below 50 K are applicable only to a specimen with residual resistivity of 0.00724×10^{-8} Ωm. The recommended values for the liquid state are for the saturated liquid. The recommended values from 1 to 453.7 K are corrected for thermal linear expansion. The correction amounts to −0.79% at 1 K, −0.72% at 80 K, and 0.85% at 453.7 K. The uncertainty of the recommended values for the total electrical resistivity is believed to be within ±20% from 1 K to 60 K, within ±5% from 60 K to 1500 K and within ±10% from 1500 K to 2000 K. Above 40 K the uncertainty of the recommended values for the intrinsic resistivity is a little higher than that of the total electrical resistivity; below 40 K, because of the deviations from Matthiessen's Rule, the uncertainty of ρ_i is too large and values are not listed in the table.

b. Pressure Dependence

There are 10 sets of experimental data available for the electrical resistivity of lithium as a function of pressure. The information on specimen characterization and measurement condition for each of the data sets is given in table 6. The data are tabulated in table 7 and shown in figure 4.

The available data and information for the pressure dependence of electrical resistivity of lithium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only the available experimental data are presented here.

c. Magnetic Flux Density Dependence

There are 9 sets of experimental data available for the electrical resistivity of lithium under the influence of magnetic field. The information on specimen characterization and measurement information for each of the data sets is given in table 8. The data are tabulated in table 9 and shown in figure 5.

The available data and information for the magnetic flux density dependence of electrical resistivity of lithium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

TABLE 3. RECOMMENDED ELECTRICAL RESISTIVITY OF LITHIUM
(Temperature Dependence)

[Temperature, T, K; Total Resistivity, ρ, 10^{-8} Ωm; Intrinsic Resistivity, ρ_i, 10^{-8} Ωm]

Solid					Liquid	
T	ρ	T	ρ	ρ_i†	T	ρ
1	0.00724*	35	0.047*		453.7	24.80
2	0.00724*	40	0.074*	0.067*	500	26.33
3	0.00725*	45	0.109*	0.102*	600	29.34
4	0.00727*	50	0.162*	0.155*	700	32.10
5	0.00730*	60	0.345*	0.338*	800	34.71
6	0.00735*	70	0.636	0.629	900	37.22
7	0.00740*	80	1.000	0.993	1000	39.69
8	0.00745*	90	1.36	1.35	1100	42.13
9	0.00751*	100	1.73	1.72	1200	44.61
10	0.00760*	150	3.72	3.71	1300	47.41
11	0.00773*	200	5.71	5.70	1400	49.97
12	0.00792*	250	7.65	7.64	1500	53.00
13	0.00817*	273.15	8.53	8.52	1600	56.34*
14	0.00849*	293	9.28	9.27	1700	60.03*
15	0.00889*	300	9.55	9.54	1800	64.12*
16	0.00936*	350	11.45	11.44	1900	68.67*
18	0.0106*	400	13.40	13.39	2000	73.73*
20	0.0122*	450	15.44	15.43	2100	79.44*
25	0.0185*	453.7	15.59	15.58	2200	85.59*
30	0.0300*					

† At temperatures below 40 K, the uncertainty of ρ_i is so large that values are not listed.

* Provisional values.

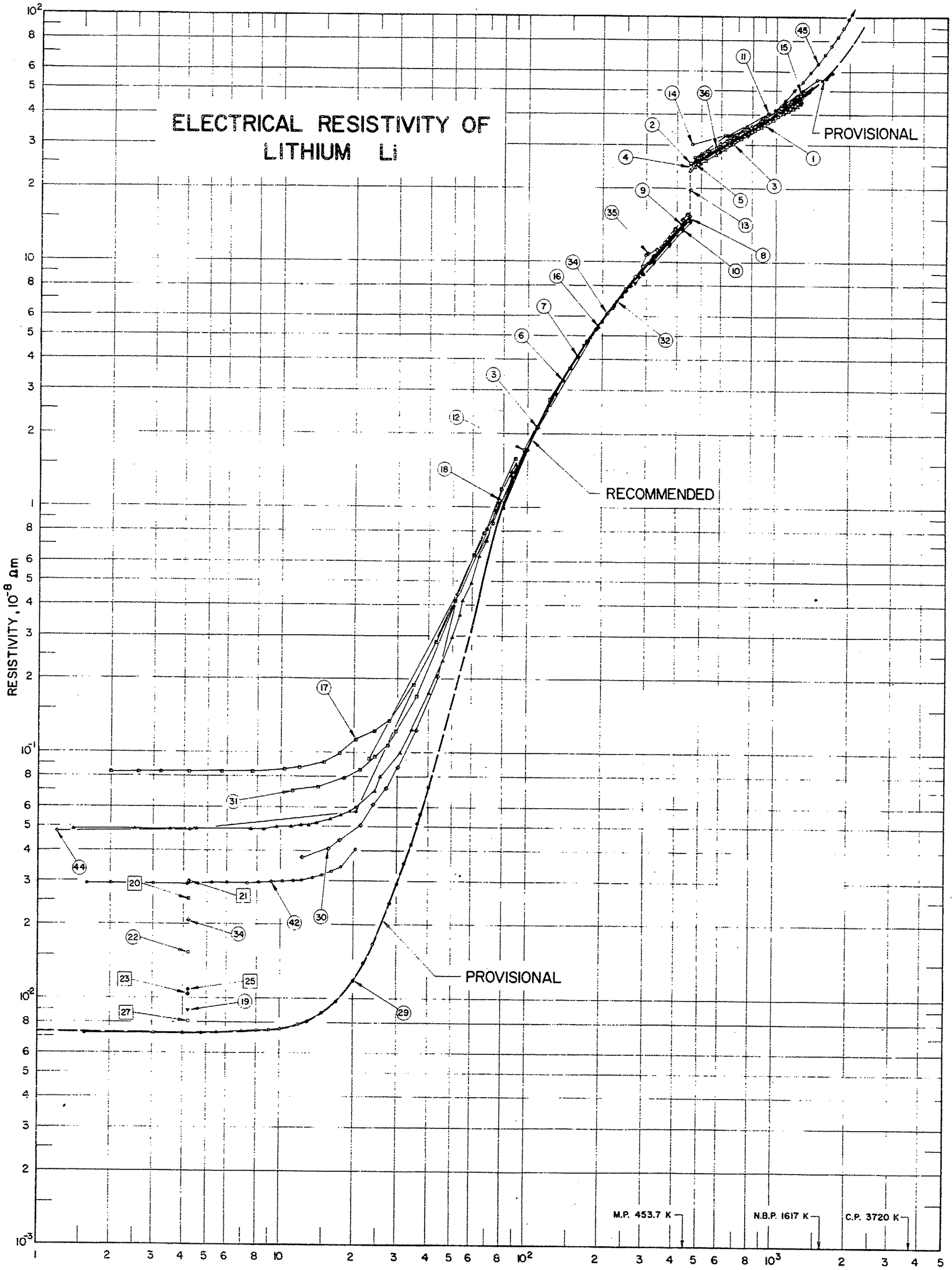

ELECTRICAL RESISTIVITY OF
LITHIUM Li
PROVISIONAL
RECOMMENDED
PROVISIONAL
M.P. 453.7 K
N.B.P. 1617 K
C.P. 3720 K
RESISTIVITY, 10^{-8} Ωm
TEMPERATURE, K
CINDAS

FIGURE 2

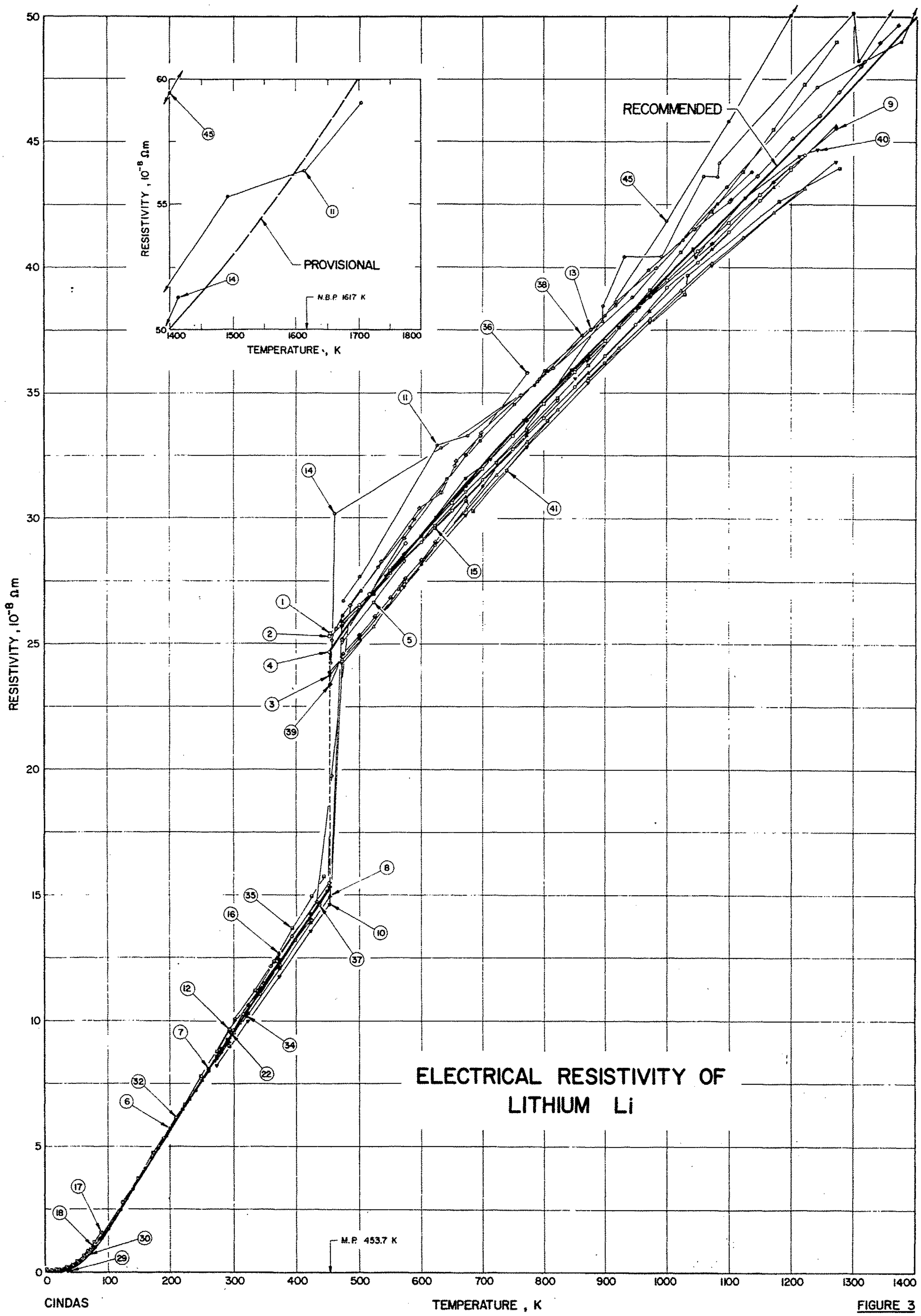

RESISTIVITY , 10⁻⁸ Ωm
TEMPERATURE , K
RECOMMENDED
PROVISIONAL
N.B.P. 1617 K
M.P. 453.7 K
ELECTRICAL RESISTIVITY OF
LITHIUM Li
CINDAS

FIGURE 3

TABLE 4. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Temperature Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	12	Shpil'rain, E'.E'., Soldatenko, Yu.A., Yakimovich, K.A., Fomin, V.A., Savchenko, V.A., Belova, A.M., Kagan, D.N. and Krainova, I. F.	1965	A	454-1223	Li(I)	99.6^+ Li, 0.26 Na, 0.0011 K, 0.0013 Ca and <0.015 other impurities; specimen was in liquid state which was enclosed in a stainless steel tube; specimen density = [0.5368 -1.0208 $\times 10^{-4}$ (T-273.15)] g/cm^3; melting point = 453.65 K, boiling point = 1603 K; resistivity was measured in the insert atmosphere and the experiment results was presented as the following equation. $\rho = 20.96 + 2.4705 \times 10^{-2}$ (T-273.15) ρ in units of 10^{-8} Ωm, T in K.
2	12	Shpil'rain, E'.E'., et al.	1965	A	454-1223	Li(II)	99.8^+ Li, 0.13 Na, 0.01 Ca, 0.001 K and <0.015 other impurities; specimen was in liquid state which was enclosed in a stainless steel tube; other specifications similarly as above specimen; $\rho = 19.82 + 3.053 \times 10^{-2}$ (T-273.15) -4.81×10^{-6} $(T-273.15)^2$
3	12	Shpil'rain, E'.E'., et al.	1965	A	454-1223	Li(III)	Similar to the above specimen; $\rho = 17.80 + 3.47 \times 10^{-2}$ (T-273.15) -8.447×10^{-6} $(T-273.15)^2$
4	13	Faber, T.E.	1966	A	273-573		Nominally pure Li was supplied by A.D. Mackay Inc.; specimen was forced by dry helium gas into a clean stainless steel tube 2.5 mm inner diameter and 11.5 cm in length; for measurements at elevated temperature, the tube was enclosed in a furnace filled with helium.
5	9	Freedman, J.F. and Robertson, W.D.	1961	B	473-923		$99.^+$ Li, major impurity Na; vacuum distilled specimen was supplied by Nuclear Development Corp.; specimen was in liquid state and was enclosed in 304 stainless steel tube with 0.349" in diameter and 20" in length.
6	8	Dugdale, J.S. and Gugan, D.	1962	A	80-290		Pure Li specimen was obtained from the Lithium Corporation of America; 0.05 cm in diameter and 10 cm in length; resistivity was measured at zero pressure condition.
7	8	Dugdale, J.S. and Gugan, D.	1962	A	80-290		Similar to the above specimen; resistivity was calculated at constant density.
8	14	Shpil'rain, E'.E'. and Savchenko, V.A.	1968	A	273-1273	Li 1	0.8 Na, 0.0054 K, 0.003 Ca, <0.003 Al, 0.0018 Mg, 0.001 Si, <0.0003 Mn, 0.003 Fe, 0.0036 Ni, 0.0069 Cr, 0.03 Zr and 0.0005 C; specimen was filled in a 1Kh18N9T stainless steel test tube, 15 mm in diameter and 500 mm long with a wall thickness of 0.75 mm; data presented as smooth value by least squares method.
9	14	Shpil'rain, E'.E'. and Savchenko, V.A.	1968	A	273-1273	Li 2	0.1 Na, 0.0015 K, <0.002 Ca, <0.005 Al, 0.0012 Mg, <0.003 Si, 0.002 Mn, <0.13 Fe, 0.016 Ni, 0.024 Cr, <0.00025 Zr, 0.0012 N_2 and 0.096 O_2; other specifications similar to the above specimen.
10	14	Shpil'rain, E'.E'. and Savchenko, V.A.	1968	A	273-1273	Li 3	0.1 Na, 0.0015 K, <0.003 Ca, <0.005 Al, 0.006 Mg, 0.025 Si, 0.00082 Mn, <0.01 Fe, <0.01 Nb, <0.01 Cr, <0.01 Zr, 0.0012 N_2 and 0.045 O_2; other specifications similar to the above specimen.
11	10	Rigney, D.V., Kapelner, S.M., and Cleany, R.E.	1965	A	479-1703		0.24 O_2, <0.003 N_2, <0.0002 C, <0.001 Zr, <0.01 Nb, 0.013 Na, <0.01 Fe and <0.001 Ni; specimen was in liquid state and was filled in Nb-1 Zr capsule.
12	15	Bidwell, C.C.	1926		73-423		Specimen 1.10 cm in diameter and 25 cm in length was produced by extrusion through a die.
13	16	Tepper, F., Felenak, J., Roehlieh, F. and May, V.	1965	A	308-1360		Li specimen was filled in a Hyanes-25 Alloy cylindrical cell; density (g/cm^3) = 0.5345 - 0.30884 $\times 10^{-4}$ (T-305.15); T in K.
14	17	Roehlieh, F. and Tepper, F.	1965	A	463-1366		Liquid Li specimen placed in a Hyanes-25 Alloy cylindrical cell 0.5" outside diameter 0.063" in wall and 26" in length; data were extracted from the smooth curve.

TABLE 4. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
15	18	Semyachkin, B. E. and Solov'ev, A.N.	1964	A	453-1273		Li specimen TV8774-58 was placed in 1 kh 18N9T 0.8/0.5 mm capillary with 600 mm in length.
16	19	Guntz, A. and Broniewski, W.	1909		86-372		Pure
17	20	Rosenberg, H.M.	1956		2-293	Li 1	Pure Li was distilled into a stainless steel capillary 0.83 mm inside diameter, copper leads were in direct contact with the specimen.
18	20	Rosenberg, H.M.	1956		2-293	Li 2	Similar to the above specimen; except the copper contacts was soldered outside the capillary.
19	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2, 80	Li 18C	Pure Li wire specimen 3 mm in diameter and 10 cm in length; specimen was obtained from the Lithium Corporation of America; it was heated at 423 K for 20 hrs.
20	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2	Li 7A	Similar to the above specimen; except the diameter is 0.5 mm and no heat treatment.
21	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2	Li 16A	Similar to the above specimen.
22	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2	Li 8B	Similar to the above specimen.
23	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2	Li 12C	Similar to the above specimen.
24*	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2	Li 13C	Similar to the above specimen.
25	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2	Li 15C	Similar to the above specimen.
26	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2	Li 19C	Similar to the above specimen.
27	21	Dugdale, J.S. and Gugan, D.	1961	A	4.2	Li 17C	Similar to the above specimen; except the diameter is 5 mm and specimen was heat treated for 24 hrs at 423 K.
28	22	Krautz, E.	1950	A	273		Pure.
29	7	Krill, G.	1971	A	1.3-40		99.98 pure; <0.0045 K, <0.004 Cl, <0.003 Na, <0.003 N_2, <0.001 Ca and <0.0003 Fe; specimen was 0.5 mm in diameter and 50 cm in length; $\rho_0/\rho_{300} = 7 \times 10^{-4}$.
30	23	MacDonald, D.K.C., White, G.K., and Woods, S.B.	1955	A	12-295	Li 2	Pure Li specimen was obtained from Messers, A.D. Mackay, Inc.; specimen was extruded with a hydraulic press into a stainless steel tube with a film of Vaseline lubricating the inside wall of the tube; specimen diameter 1.4 mm.
31	23	MacDonald, D.K.C., et al.	1955	A	12-295	Li 3	Pure Li specimen was supplied by New Metals an Chemicals Ltd. (London); other specifications were similar to the above specimen.
32	6	Dugdale, J.S., Gugan, D., and Okumura, K.	1961	A	4.2-320	Li 1	92.7† ^{7}Li; 7.3 ^{6}Li; 0.012 Al; 0.058 Ca; 0.017 Na; 0.011 K; 0.008 Fe, 0.004 Cu, 0.14 Mg and 0.04 N; the specimen was extruded into the form of wire about 0.5 mm in diameter and 100 cm in length; the results of electrical resistivity was taken from the ideal resistivity plus the residual resistivity .
33	6	Dugdale, J.S., et al.	1961	A	4.2-320	Li 2	0.043 Na, 0.011 K, 0.006 Cu and 0.0614 Mg; other specifications similar to the above specimen.
34	6	Dugdale, J.S., et al.	1961	A	4.2-320	^{6}Li	99.3 ^{6}Li, 0.7 ^{7}Li, 1.46 Ca, 0.066 Na, 0.4 Fe, 0.2 Cu, 0.035 Mg, 0.13 Sr, 0.2 Ba and trace Al, Cr and F; specimen was obtained from Oak Ridge National Lab.; specimen was extruded in the form of wire about 0.5 mm in diameter and 100 cm in length; electrical resistivity was taken from the ideal resistivity plus the residual resistivity.

* Not shown in figure.

TABLE 4. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
35	24	Grube, G., Vosskühler, H., and	1932		273-443		99.0 pure, 0.62 K, 0.14 Na, 0.02 Fe_2O_3, 0.05 SiO_2, 0.32 Li_3N, and trace of Al_2O_3; density 0.534 g cm^{-3}.
36	25	Ioannides, P., Nanyen, V.T., and Enderby, J.E.	1973		473-773		Pure; liquid state.
37	11	Kapelner, S. and Bratton, W.	1961	A	299.9-452.6		99.9^+ Li, 0.03 Na, 0.01 each K, Ca, N, Ni, 0.002 each Cl, Cr, 0.005 Fe; the specimen was purchased from Lithium Corp. of America; the specimen was purified by heating to 870°C for 2 hr over titanium sponge and was then maintained slightly above its melting point in intimate contact with the sponge prior to transfer to the dry box; the specimen container was type 347 stainless steel (0.75 in. O.D., 16 in. long), 0.095 in. wall thickness.
38	11	Kapelner, S. and Bratton, W.	1961	A	454.6-1137.6		Same as above specimen; in liquid state.
39	26	Arnol'dov, M.N., Ivanovskii, M.N., Pleshivtsev, A.D., Subbotin, V.I., and Shmatko, B.A.	1970		454-623		0.5 Na, 0.01 each O_2, N_2, Ba, 0.003 H_2, 0.0001 C_2, 0.006 Ca, 0.03 Cr, 0.04 Si, and < 0.003 other; liquid state specimen; electrical resistivity data were reported as the equation $\rho = 1.86 \times 10^{-5} + 2.98 \times 10^{-8}$ (T-273 K) ρ in units of 10^{-2} Ωm and T in K.
40	27	Savchenko, V.A. and Shpil'rain, E'.E'.	1970		543.5-1243.9		0.1 Na, 0.05 Al, 0.0021 Ca, 0.001 C, 0.0001 Cr, 0.003 Fe, 0.0013 K, 0.0027 Mg, 0.0008 Mn, 0.0012 N_2, 0.0001 Ni, 0.03 Si, 0.1 O_2, and 0.0001 Zr; liquid state specimen.
41	27	Savchenko, V.A. and Shpil'rain, E'.E'.	1970		543.5-1243.9	Li + 0.1 Na	0.1 Na, 0.055 Al, 0.0015 each Ca, K, 0.024 Cr, 0.13 Fe, 0.001 Mg, 0.002 Mn, 0.0012 N_2, 0.016 Ni, 0.045 O_2, 0.003 Si, and 0.00025 Zr; liquid state specimen.
42	28	MacDonald, D.K.C. and Mendelsohn, K.	1950	G	1.6-20	Li 1	Pure; $R_0/R_{290} \sim 3.3 \times 10^{-3}$; specimen was obtained from Dr. R. A. Hull; relative electrical resistance data were reported; electrical resistivity were calculated by using the electrical resistivity at 290 K and the thermal expansion correction at the measuring temperature.
43*	29	Meissner, W. and Voigt, B.	1930		20.4-273.16	Li 1	Pure; specimen was obtained from Kahlb.; sample dimension 0.5 mm in diameter and 50 mm in length; relative resistance data were reported; electrical resistivity were calculated by using the electrical resistivity at 273.16 K and the thermal expansion correction at the measuring temperature.
44	29	Meissner, W. and Voigt, G.	1930		1.19-273.16	Li 2	Pure; sample dimension 1 x 3 x 28 mm; relative resistance were reported; electrical resistivity data were calculated by using the electrical resistivity at 273.16 K and the thermal expansion correction at the measuring temperature.
45	5	Grosse, A.V.	1966		454-4150		Electrical resistivity data were calculated from the semiempirically equation $(\sigma' + 0.302)(T' + 0.302) = 0.392$ where $\sigma' = \sigma/\sigma_m$ and $T' = T - T_m/(T_{c.t.} - T_{m.p.})$.

* Not shown in figure.

TABLE 5. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Temperature Dependence)

[Temperature, T, K; Resistivity, ρ, 10^{-8} Ωm]

T	ρ
CURVE 1	
454	25.43
500	26.57
550	27.81
600	29.05
650	30.29
700	31.52
750	32.76
800	34.00
850	35.24
900	36.47
950	37.71
1000	38.95
1050	40.19
1100	41.42
1150	42.66
1200	43.90
1223	44.47
CURVE 2	
453.65	25.33
500	26.50
550	27.90
600	29.29
650	30.61
700	31.97
750	33.29
800	34.56
850	35.83
900	37.07
950	38.28
1000	39.47
1050	40.64
1100	41.77
1150	42.89
1200	43.98
1223	44.48*
CURVE 3	
453	23.77
473	24.40
523	25.95
573	27.45
623	28.91
673	30.33
723	31.70
773	33.04
CURVE 3 (cont.)	
873	34.33
873	35.58
823	36.79
973	37.95
1023	39.07
1073	40.15
1123	41.19
1173	42.18
1223	43.14
CURVE 4	
273.15	8.7
369.15	12.4
453.15	15.5
453.15	24.7
516.15	27.0
575.15	29.0
CURVE 5	
473.15	25.06
523.15	26.6
573.15	28.28
623.15	29.70
673.15	31.04
723.15	32.22
773.15	33.44
823.15	34.68
CURVE 6	
80	0.995
100	1.714
120	2.497
140	3.303
160	4.113
180	4.910
200	5.704
220	6.472
240	7.231
260	7.995
273.15	8.495
280	8.753
290	9.135
CURVE 7	
80	0.993*
100	1.710*
120	2.490*
140	3.294*
160	4.104
180	4.91*
200	5.710*
220	6.503*
240	7.286*
260	8.076
273.15	8.591
280	8.862
290	9.257
CURVE 8	
273	8.49*
323	10.29
373	12.10
423	13.90
453	14.97
473	25.90
573	28.37
673	30.84
773	33.31
873	35.78
973	38.25
1073	40.72
1173	43.19
1273	45.16
CURVE 9	
273	8.61*
323	10.62
373	12.43
423	14.24
453	15.33
473	25.74
573	28.55
673	31.26
773	33.88
873	36.41
973	38.83
1073	41.16
1173	43.40
1273	45.54
CURVE 10	
273	8.18
323	9.97
373	11.76
423	13.55
453	14.62
473	24.24
573	27.25
673	30.11
773	32.82
873	35.38
973	37.80
1073	40.08
1173	42.20*
1273	44.19
CURVE 11	
475.6	26.73
501.0	27.68
626.2	32.91
676.0	33.28
790.3	35.44
793.8	35.55
802.0	35.87
896.4	37.86
897.5	38.47
932.9	40.44
991.4	40.41
1060.5	43.62
1082.0	43.60
1085.0	44.15
1299.8	50.15
1308.4	48.24
1491.3	55.31
1613.6	56.34
1703.1	59.07
CURVE 12	
23	0.095
73	0.862
98	1.73
123	2.77
148	3.72
173	4.74
198	5.71*
223	6.67
248	7.78
CURVE 12 (cont.)	
273	8.66*
293	9.66
323	10.59*
348	11.49
373	12.24
398	13.21
423	14.01
CURVE 13	
359.8	12.16
393.7	13.36
432	14.74
451.5	15.54*
456.5	19.76
486.8	26.54
536.3	28.30
597.0	30.39
632	31.02
655	32.10
657	32.28
697	33.29
698	33.40
763	34.90
815	35.99
877.4	37.53
918	38.61
983	39.97
1045.2	41.53
1102.4	42.62
1103.5	42.68
1146.5	43.64
1203.1	45.13
1246.5	46.05
1278.2	46.99
1312.0	48.03
1318.7	48.21
1342.0	48.96
1372.0	49.67
CURVE 14	
359.8	12.2*
393.7	13.36*
432	14.7*
451.5	15.5*
461.5	30.2
633.2	32.8
CURVE 14 (cont.)	
785.9	35.3
944.8	38.8
1097.6	43.2
1243.7	47.2
1376.5	49.0
1414.3	51.3
CURVE 15	
453	25.3*
473	25.8*
523	27.0
573	28.3*
623	29.6
673	30.8*
723	32.2*
773	33.5
823	34.8
873	36.1
923	37.6
973	39.1
1023	40.6
1073	42.2
1123	43.8
1173	45.5
1223	47.3
1273	49.0
CURVE 16	
86.15	1.34
194.85	5.40
273.15	8.55*
372.45	12.7
CURVE 17	
2.0	0.084
2.6	0.084
3.2	0.084
4.2	0.084
5.7	0.084
7.6	0.084
8.9	0.086*
10.3	0.086
11.9	0.088
14.0	0.092*
15.1	0.092

* Not shown in figure.

TABLE 5. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Temperature Dependence) (continued)

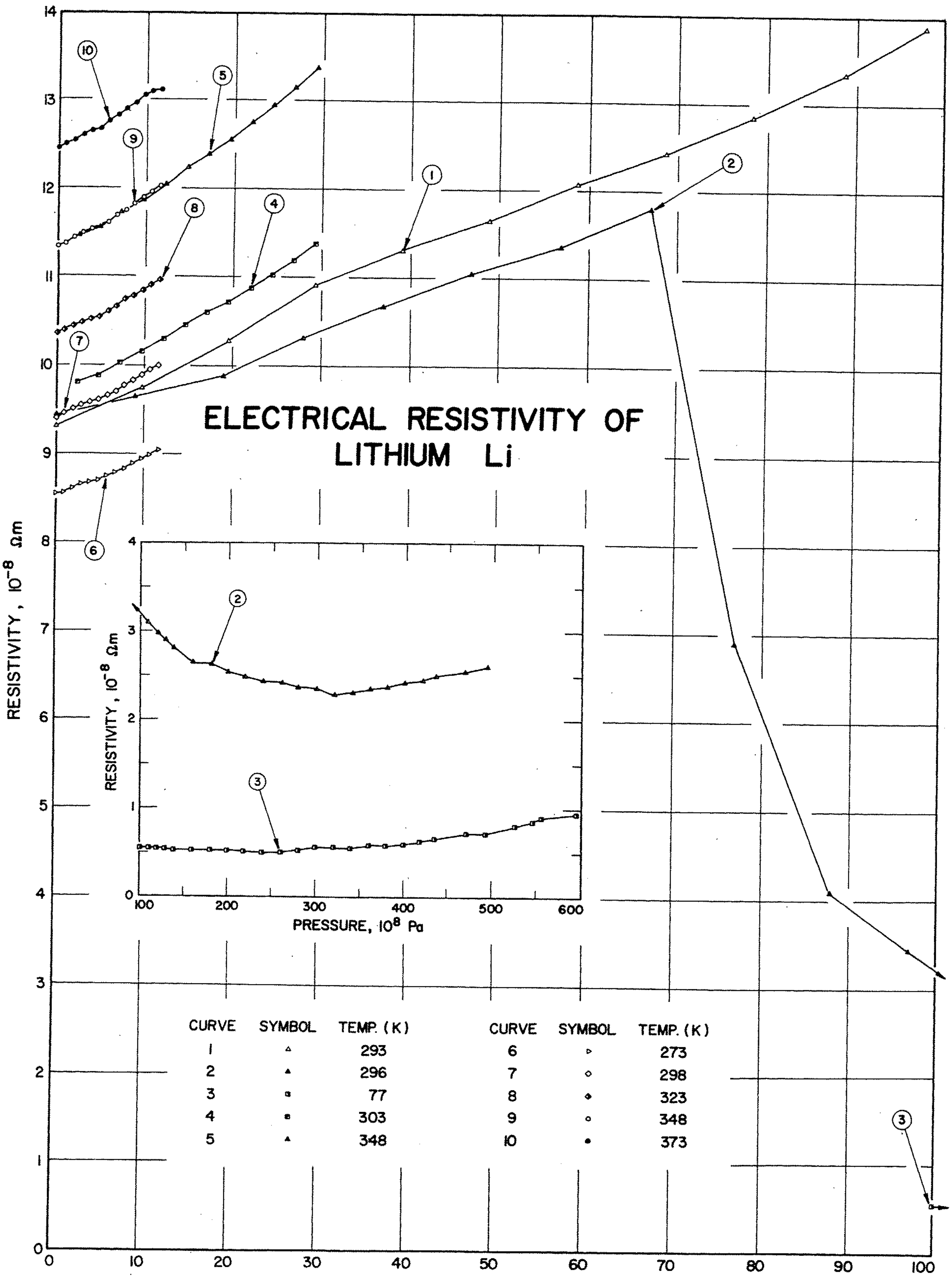
T	ρ
CURVE 17 (cont.)	
17.5	0.100
20.3	0.114
24.2	0.124
27.7	0.138
34.9	0.190
43.0	0.285
51.2	0.419
61.2	0.646
68.7	0.817
78.9	1.200
89.7	1.584
293	8.98
CURVE 18	
1.4	0.049
2.5	0.049
3.5	0.049
4.5	0.049
5.6	0.049*
6.1	0.049*
7.5	0.049
8.5	0.049
8.6	0.049*
8.8	0.049*
9.0	0.049*
9.6	0.050
10.1	0.049*
10.3	0.050*
11.1	0.050
12.1	0.051
13.0	0.051
14.0	0.052
15.9	0.054
16.6	0.054*
17.6	0.056
18.3	0.057*
19.1	0.058
20.2	0.060
20.3	0.061*
24.3	0.070
25.5	0.080
30.6	0.100
34.1	0.125
39.7	0.175
45.3	0.237
49.9	0.297
53.6	0.366
CURVE 18 (cont.)	
54.7	0.409
55.4	0.441*
56.0	0.436
57.3	0.467*
58.2	0.516*
59.9	0.494
62.8	0.661*
63.9	0.634
68.6	0.732
72.8	0.881*
76.8	1.045
79.6	1.144*
79.6	1.183*
81.3	1.142*
82.8	1.256*
83.8	1.308*
86.0	1.415
87.3	1.415*
89.9	1.517
293	9.17
CURVE 19	
4.2	0.009
80	1.047*
80	1.034
CURVE 20	
4.2	0.0256
CURVE 21	
4.2	0.03
CURVE 22	
4.2	0.0155
295	9.52*
CURVE 23	
4.2	0.0106
CURVE 24*	
4.2	0.0106
CURVE 25	
4.2	0.0109
CURVE 26*	
4.2	0.0106
CURVE 27	
4.2	0.0082
CURVE 28	
273	8.55*
CURVE 29	
1.67	0.007311
1.95	0.007312*
2.45	0.007303
2.70	0.007318*
3.02	0.007318
3.18	0.007308*
3.45	0.007301*
3.77	0.007311*
3.97	0.007300
4.34	0.007333*
4.45	0.007314*
4.740	0.007367
5.01	0.007330*
5.48	0.007359
6.02	0.007385*
6.48	0.007401*
6.99	0.007416
7.47	0.007431
7.99	0.007456
8.47	0.007479*
8.99	0.00751
9.48	0.00754*
10	0.00759
6.78	0.007406*
7.68	0.007442*
8.83	0.007510*
9.75	0.00759*
10.58	0.00768*
11.92	0.00787
12.96	0.00812
13.89	0.00844*
14.93	0.00882
CURVE 29 (cont.)	
15.91	0.00925*
16.94	0.00977
17.94	0.01042*
18.86	0.01107*
19.95	0.01199
22.0	0.01407
24.0	0.01680
26.04	0.02025*
27.92	0.02446
29.95	0.02946
31.89	0.03567
34.04	0.04288
36.0	0.0520
37.92	0.0619
CURVE 30	
12.27	0.0383
13.61	0.0392*
14.42	0.040*
15.59	0.041
16.52	0.043*
17.50	0.0445
19.77	0.049*
21.43	0.052
23.22	0.057*
23.93	0.062
27.04	0.072
30.20	0.088
35.72	0.124
41.78	0.206
55.97	0.424
66.83	0.688
78.16	1.028*
295	9.63*
CURVE 31	
11.32	0.0702
12.73	0.071*
14.26	0.073
16.67	0.076*
18.11	0.079
19.81	0.082*
21.08	0.0854
22.18	0.089*
24.38	0.097
27.16	0.1077
CURVE 31 (cont.)	
29.51	0.124
35.72	0.170
74.98	0.979
295	9.25
CURVE 32	
4.2	0.0264*
80	1.021*
90	1.368
100	1.740*
110	2.127
120	2.523*
130	2.924
140	3.329*
150	3.734*
160	4.139*
170	4.537
180	4.937*
190	5.334
200	5.730*
210	6.114
220	6.497*
230	6.879
240	7.258*
250	7.639
260	8.020*
270	8.401
280	8.78*
290	9.160*
300	9.536
310	9.926
320	10.306
CURVE 33	
4.2	0.011*
80	1.006*
90	1.353*
100	1.725*
110	2.112
120	2.508*
130	2.909*
140	3.314*
150	3.719*
160	4.124*
170	4.522*
180	4.922*
CURVE 33 (cont.)	
190	5.322
200	5.715*
210	6.099*
220	6.482*
230	6.864*
240	7.243*
250	7.624
260	8.005*
270	8.386*
280	8.765*
290	9.145*
300	9.521*
310	9.911
320	10.291*
CURVE 34	
4.2	0.021
80	1.016*
90	1.363*
100	1.735*
110	2.122*
120	2.514*
130	2.919
140	3.524*
150	3.729*
160	4.134*
170	4.532*
180	4.932*
190	5.332*
200	5.725*
210	6.109
220	6.492*
230	6.874*
240	7.253*
250	7.634*
260	8.015
270	8.396*
280	8.775*
290	9.155*
300	9.53*
310	9.92*
320	10.19*
CURVE 35	
273	8.75
303	10.08

* Not shown in figure.

TABLE 5. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Temperature Dependence) (continued)

T	ρ
CURVE 35 (cont.)	
333	11.22
363	12.35
393	13.66
423	14.96
443	15.74
CURVE 36	
473	25.2
573	29.2
673	32.5
773	35.8
CURVE 37	
299.9	9.64
316.5	10.26
341.8	11.06
372.1	12.19*
421.5	14.05
436.8	14.64
449.6	15.16
452.6	15.29*
CURVE 38	
454.6	24.25
456.8	25.18
463.8	25.61
472.4	25.81*
474.3	26.13
476.8	26.19*
503.5	27.11
531.3	28.09
582.6	29.65
589.9	29.96
642.6	31.55
696.8	33.10
752.1	34.54
806.3	35.88
862.6	37.29
917.4	38.49
971.5	39.90
1026.0	41.09
1081.8	42.53
1137.6	43.8
CURVE 39	
454	23.40
475	24.62
500	25.36
525	26.11
550	26.85
575	27.60
600	28.34
623	29.03
CURVE 40	
543.5	27.68
621.5	29.62*
624.1	30.02
674.3	31.56
714.2	32.35
769.1	33.90
845.3	35.90
851.3	35.55
871.9	36.27
957.0	38.42
1044.3	40.74
1047.1	40.36
1127.9	42.75
1214.6	44.44
1243.9	44.70
CURVE 41	
564.5	27.18
602.5	28.38*
673.1	30.69
682.8	30.26
740.6	31.89
806.3	33.89
899.3	36.17
1029.0	38.90
1034.4	39.67
1181.6	42.62
1279.4	43.96
CURVE 42	
1.60	0.0293
2.00	0.0293
3.00	0.0293
4.16	0.0294
5.21	0.0295
6.00	0.0295
CURVE 42 (cont.)	
7.30	0.0295
8.10	0.0296
9.19	0.0297
10.20	0.0299
11.39	0.0301
12.28	0.0304
13.51	0.0310
14.78	0.0317
16.04	0.0328
17.73	0.0345
20.43	0.0405
CURVE 43*	
20.42	0.060
80.13	1.06
90.89	1.41
273.16	8.55
CURVE 44	
1.19	0.0475
4.21	0.0485
20.41	0.0578
77.74	1.04
86.32	1.28*
273.16	8.55*
CURVE 45	
453.7	23.89
500.0	25.23
600.0	28.17
700.0	31.28
800.0	34.59*
900.0	38.09
1000.0	41.83
1100.0	45.80
1200.0	50.04
1300.0	54.58
1400.0	59.47
1500.0	64.72
1600.0	70.38
1700.0	76.50
1800.0	83.14
1900.0	90.39
2000.0	98.34
2200.0	116.5*
2400.0	139.0*
CURVE 45 (cont.)	
2600.0	167.4*
2800.0	204.1*
3000.0	254.1*
3200.0	325.3*
3400.0	435.5*
3600.0	627.5*
3800.0	1049.6*
4000.0	2782.0*

* Not shown in figure.



CINDAS PRESSURE, 10^8 Pa FIGURE 4

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Pressure Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Pressure Range, 10^8 Pascal	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	30	Bridgman, P.W.	1952	A	0-98	~293		Pure; the specimen was squeezed and cut to final dimension under a heavy oil; the solid medium transmitting pressure within the cell is AgCl; relative resistance data were reported as a function of pressure; electrical resistivity data were obtained by using the compressibility and the recommended value of electrical resistivity at one atm pressure and 293 K.
2	31	Stager, R.A. and Drickamer, H.G.	1963	A	9-500	296		Commercial purity specimen; resistance as a function of pressure were reported; electrical resistivity data were obtained by using compressibility data and the recommended value of electrical resistivity at 296 K and one atm pressure.
3	31	Stager, R.A. and Drickamer, H.G.	1963	A	100-600	77		The above specimen; measured at 77 K after first pressing to 100 x 10^8 Pascal at 296 K and then cooling.
4	32	Bridgman, P.W.	1930	A	0-29.4	303		Pure; the specimen was obtained from Kahlbaum; it was extruded into a wire about 0.030 in. in diameter; the relative electrical resistance as a function of pressure data were reported.
5	32	Bridgman, P.W.	1930	A	0-29.4	348		The above specimen.
6	33	Bridgman, P.W.	1921	A	0-11.76	273		0.7 Al, trace of Fe; specimen was obtained from Merck; relative electrical resistance were reported.
7	33	Bridgman, P.W.	1921	A	0-11.76	298		The above specimen.
8	33	Bridgman, P.W.	1921	A	0-11.76	323		The above specimen.
9	33	Bridgman, P.W.	1921	A	0-11.76	348		The above specimen.
10	33	Bridgman, P.W.	1921	A	0-11.76	373		The above specimen.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Pressure Dependence)

[Temperature, T, K; Pressure, P, 10^8 Pa; Resistivity, ρ, 10^{-8} Ωm]

P	ρ
CURVE 1 T = 293	
0.0	9.326
9.8	9.75
19.6	10.29
29.4	10.92
39.2	11.32
49.0	11.66
58.8	12.08
68.6	12.44
78.4	12.85
88.2	13.35
98.0	13.89
CURVE 2 T = 296	
0	9.44
9	9.65
19	9.88
28	10.32
37	10.68
47	11.06
57	11.37
67	11.81
77	6.90
88	4.09
97	3.43
108	3.10
119	2.98
128	2.90
137	2.81
159	2.65
180	2.63
199	2.54
218	2.49
239	2.44
260	2.42
278	2.37
298	2.36
319	2.29
340	2.31
359	2.36
379	2.38
399	2.43
420	2.45
435	2.51
CURVE 2 (cont.) T = 296	
468	2.56
494	2.61
CURVE 3 T = 77	
100	0.554
110	0.550
119	0.546
128	0.543
138	0.539
159	0.533
180	0.528
199	0.524
218	0.518
239	0.515
260	0.510
280	0.527
299	0.564
320	0.562
339	0.559
360	0.586
379	0.585
399	0.612
418	0.640
435	0.665
471	0.723
494	0.721
526	0.806
546	0.861
567	0.918
595	0.941
CURVE 4 T = 303	
2.45	9.81
4.9	9.88
7.35	10.03
9.8	10.16
12.25	10.30
14.7	10.46
17.15	10.60
19.6	10.72
22.05	10.88
CURVE 4 (cont.) T = 303	
24.5	11.03
26.95	11.20
29.4	11.39
CURVE 5 T = 348	
2.45	11.47
4.9	11.56
7.35	11.73
9.8	11.88
12.25	12.05
14.7	12.24
17.15	12.40
19.6	12.56
22.05	12.76
24.5	12.95
26.95	13.16
29.4	13.38
CURVE 6 T = 273	
0.00	8.55
0.98	8.56
1.96	8.61
2.94	8.66
3.92	8.68
4.90	8.70
5.88	8.75
6.86	8.79
7.84	8.83
8.82	8.89
9.80	8.94
10.78	8.99
11.76	9.06
CURVE 7 T = 298	
0.00	9.42
0.98	9.47
1.96	9.52
2.94	9.56
3.92	9.59
CURVE 7 (cont.) T = 298	
4.90	9.62
5.88	9.67
6.86	9.71
7.84	9.79
8.82	9.84
9.80	9.90
10.78	9.96
11.72	10.01
CURVE 8 T = 323	
0.00	10.36
0.98	10.40
1.96	10.45
2.94	10.49
3.92	10.53
4.90	10.55
5.88	10.62
6.86	10.68
7.84	10.76
8.82	10.80
9.80	10.86
10.78	10.92
11.72	10.98
CURVE 9 T = 348	
0.00	11.35
0.98	11.38
1.96	11.45
2.94	11.50
3.92	11.54
4.90	11.56*
5.88	11.62
6.86	11.70
7.84	11.76
8.82	11.83
9.80	11.91
10.78	11.97
11.76	12.03
CURVE 10 T = 373	
0.00	12.46
0.98	12.50
1.96	12.56
2.94	12.62
3.92	12.66
4.90	12.68
5.88	12.77
6.86	12.84
7.84	12.91
8.82	12.98
9.80	13.07
10.76	13.13
11.76	13.21

* Not shown in figure.

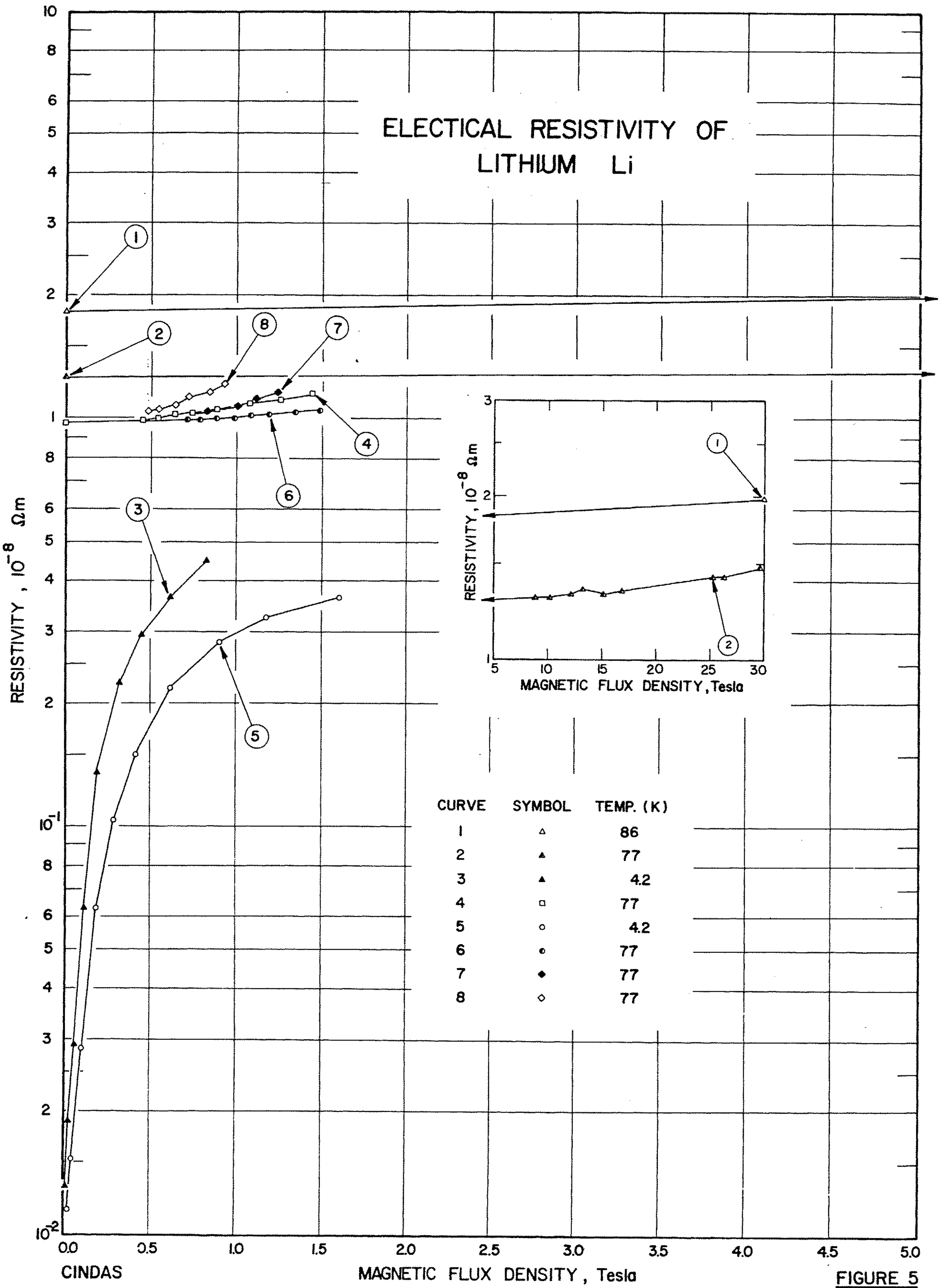

ELECTICAL RESISTIVITY OF LITHIUM Li
RESISTIVITY, 10^{-8} Ωm
MAGNETIC FLUX DENSITY, Tesla
CURVE SYMBOL TEMP. (K)
1 △ 86
2 ▲ 77
3 ▲ 4.2
4 □ 77
5 ○ 4.2
6 ◐ 77
7 ◆ 77
8 ◇ 77
CINDAS

FIGURE 5

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Magnetic Flux Density Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Magnetic Flux Density Range, Tesla	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	34	Kapitza, P.	1929		0, 30	86	Li_I	99.9 pure; specimen was obtained from Kahlbaum; magnetoresistance measurements were made in a transverse magnetic field; R/Rr = 0.195, where Rr is the resistance at room temperature.
2	34	Kapitza, P.	1929		0-30	77	Li_{II}	99.9 pure; specimen was obtained from Kahlbaum; magnetoresistance measurements were made in a transverse magnetic field; R/Rr = 0.137, where Rr is the resistance at room temperature.
3	35	Gugan, D. and Jones, B.K.	1963	A	0-0.83	4.2		Pure; -phase mixture; specimen dimension 1.0 mm x 50 cm; the specimen was prepared from an ingot of low sodium content lithium originally obtained from the Lithium Corp. of America; the specimen was prepared by extrusion under liquid paraffin at room temperature, and they were rinsed with Analar benzene; the specimen was annealed at room temperature for a week; the residual resistance ratio $R_{293\ K}/R_{4.2\ K}$ = 985; the magnetoresistance measurement was in a transverse field; data were extracted from the smooth curve.
4	35	Gugan, D. and Jones, B.K.	1963	A	0-1.43	77		Same as the above specimen and conditions.
5	35	Gugan, D. and Jones, B.K.	1963	A	0-1.60	4.2		Same as the above specimen; similar conditions except it was measured in a longitudinal field.
6	35	Gugan, D. and Jones, B.K.	1963	A	0-1.49	77		Same as the above specimen and conditions.
7	35	Gugan, D. and Jones, B.K.	1963	A	0.5-1.24	77		Similar to the above specimen except it was pure bcc phase.
8	35	Gugan, D. and Jones, B.K.	1963	A	0.49-0.93	77		Same as the above specimen and similar conditions except it was measured in a transverse field.
9	36	Justi, E.	1948	A	0, 3.04	20.4		Pure; resistance ratio $R_{20.6\ K}/R_{273.15\ K}$ = 0.0243; measured in a transverse magnetic field.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF LITHIUM Li (Magnetic Flux Density Dependence)

[Temperature, T, K; Magnetic Flux Density, B, Tesla; Electrical Resistivity, ρ, 10^{-8} Ωm]

B	ρ
CURVE 1, T = 86	
0.0	1.8185
30.0	1.9822
CURVE 2, T = 77	
0.0	1.2777
8.9	1.3033
10.3	1.3033
12.1	1.3394
13.1	1.3567
15.1	1.3290
16.7	1.343
25.3	1.4222
26.4	1.4222
29.6	1.4849
CURVE 3, T = 4.2	
0.014	0.0109
0.023	0.0131
0.037	0.0190
0.052	0.0292
0.102	0.0633
0.187	0.131
0.323	0.225
0.445	0.296
0.615	0.367
0.829	0.451
CURVE 4, T = 77	
0.000	0.975
0.455	0.994
0.535	1.00
0.640	1.01
0.742	1.02
0.884	1.05
1.06	1.08
1.25	1.11
1.43	1.16
CURVE 5, T = 4.2	
0.029	0.0117
0.047	0.0154
0.090	0.0287
0.178	0.0628
0.285	0.104
0.404	0.150
0.623	0.219
0.900	0.283
1.17	0.324
1.60	0.365
CURVE 6, T = 77	
0.000	0.975*
0.709	0.992
0.788	0.996
0.884	1.001
0.983	1.006
1.06	1.012
1.18	1.021
1.33	1.034
1.49	1.050
CURVE 7, T = 77	
0.459	0.999*
0.535	1.01*
0.623	1.02*
0.735	1.04*
0.821	1.05
1.00	1.08
1.10	1.11
1.24	1.16
CURVE 8, T = 77	
0.492	1.037
0.535	1.050
0.584	1.066*
0.646	1.087
0.705	1.113
0.784	1.137*
CURVE 8 (cont.), T = 77	
0.840	1.169
0.925	1.211
CURVE 9, T = 20.4	
0.00	0.2078
3.04	0.2306

* Not shown in figure.

4.2. Sodium

Sodium, with atomic number 11, is a soft, silver-white, lustrous alkali metal. It is a very reactive element and never found free in nature. Except at low temperatures it has a body-centered cubic crystalline structure, with a density of 0.971 g cm^{-3} at 293 K. It melts at 371.0 K and boils at about 1156 K. Its critical temperature has been estimated to be about 2733 K. Sodium contracts on freezing in a normal manner. The volume change on melting is about 2.71% at one atmosphere. Sodium undergoes a partial martensitic transformation to hexagonal close-packed structures at about 36 K and therefore has a mixed phase below this temperature. Sodium has only one stable isotope, ^{23}Na, but six other radioactive isotopes are known to exist. The metal is the sixth most abundant element in the continental crust of the earth (2.36% by weight.)

Sodium is the metal which the quasi-free electron model describes the best. Its Fermi surface is not influenced by zone boundaries and therefore is spherical. Electrical resistivity measurements indicate that, despite the martensitic transformation, sodium retains its spherical Fermi surface.

a. Temperature Dependence

There are 65 sets of experimental data available for the electrical resistivity of sodium. The information on specimen characterization and measurement conditions for each of the data sets is given in table 11. The data are tabulated in table 12 and shown in figures 6 and 7. Determinations of the electrical resistivity of sodium for the solid and liquid phases cover continuously the temperature range from 1.8 to 1366 K.

There are 27 experimental data sets obtained below 100 K. Among these, White and Woods [37] (Curve 38) give the lowest residual resistivity. There are 17 sets of intrinsic resistivity available. Dugdale and Gugan [38] (curves 45 and 46) have reported the intrinsic resistivity of the separate bcc and hcp phases between 16 and 52 K. The resistivity of the hcp phase is lower than that of the bcc phase. In deriving the smoothed most probable values of intrinsic resistivity from the available data, the following overlapping temperature ranges were considered: below 14 K, 9–21 K, 14–30 K, 20–50 K, 30–100 K, 40–100 K, 50–100 K, etc. Within each range, a least-mean-square fraction error fit with the semiempirical equation $\rho_i = aT^b$ was made to all the available intrinsic resistivity data. The resulting values for adjacent ranges were intercompared and the values were corrected for thermal linear expansion. These preliminary values were then fitted with the cubic spline function equation (7) to generate the final recommended intrinsic resistivity values. The coefficients of equation (7) obtained are given in the following table:

Temperature range, K	a	b	c	d
1 – 8.26	−8.523	5.582	−0.572	0.299
8.26– 11.04	−3.654	5.288	0.252	−10.15
11.04– 12.29	−3.003	4.874	−3.537	21.47
12.29– 36.71	−2.783	4.684	−0.546	−17.98
36.71– 65.89	−0.873	2.947	−3.109	3.606
65.89– 73.44	−0.265	2.066	−0.361	−10.52
73.44–100	−0.170	1.962	−1.849	1.554

Below 15 K, the intrinsic resistivity ρ_i approximately follows Bloch's T^5 law. Because martensitic transformation effects of sodium affects the electrical resistivity values [38], the values below 40 K are provisional and are for a specimen of mixed phases.

There are 24 data sets in the temperature region from 100 K to the melting point 371 K. They agree with each other within 10%. Dugdale and Gugan [8] reported electrical resistivities at constant volume (curve 22), which they deduced from their measurements. These are lower than those at zero pressure (curve 23). Only one set of data were measured on single crystals by Fritsch and Luscher [39] (curve 30), and there is little difference in electrical resistivity values between the polycrystalline specimens and the single crystal specimen. A least-mean-square error fit to the totality of experimental data in this range was made with a third order polynomial. The resulting values were corrected for thermal linear expansion and then fitted with the cubic spline function equation (7) to obtain the final recommended values in this temperature range. The coefficients of equation (7) obtained are as follows:

Temperature range, K	a	b	c	d
73.44–371	−0.170	1.962	−1.849	1.554

There are 27 data sets available for the liquid state. Endo [40] (curve 25), Lien and Silversten [41] (curve 18), and Swalin [42] (curve 48) have investigated the electrical resistivity at constant volume conditions and they agree with one another within 5%. The rest of the data are apparently measured at the saturated vapor pressure. At least nine sets of experimental values below 1300 K agree to within 10%. Semyachikin and Solov'ev [18] (curve 31) give the highest values while Freeman and Robertson [9] (curve 19) give the lowest values. Grosse [5] derived electrical resistivity (curve 65) values in the range from the melting point to his estimated critical temperature, 2800 K, by fitting the data of Kapelner and Bratton [43] (curve 17) to a hyperbolic equation. All the experimental data sets except those measured at constant volume were used here for the cubic spline function equation (7) to obtain the final recommended values. The coefficients of equation (7) are as follows:

Temperature range, K	a	b	c	d
371 –1548.9	0.974	1.440	−0.365	1.041
1548.9–2000	1.996	2.219	1.602	24.77

The resistivity values represented by this equation are not corrected for thermal linear expansion of the container, which in most cases is not specified.

At the melting point (371 K), the electrical resistivity of sodium in the liquid state is about 40% higher than that of the solid state.

The recommended values for the total and intrinsic electrical resistivities are listed in table 10, and those for the total electrical resistivity are also shown in figures 5 and 6. The recommended values for the liquid state are for the saturated liquid. The recommended values for the total resistivity for the solid state are for a 99.99+% pure sodium and those at temperatures below 40 K are applicable only to a specimen with residual resistivity $\rho_0 = 0.000887 \times 10^{-8}\Omega$ m. The recommended values from 1 K to 371 K are corrected for thermal linear expansion. The correction amounts to −1.48% at 1 K, −1.2% at 100 K and 0.56% at 371 K. The uncertainty of the recommended total electrical resistivity is believed to be within ±20% from 1 K to 40 K, within ±5% from 40 K to 1500 K, and ±10% from 1500 K to 2000 K. Above 50 K the uncertainty of the recommended values for the intrinsic resistivity is about the same as that of the total electrical resistivity; below 50 K this uncertainty is higher than that of the total electrical resistivity.

b. Pressure Dependence

There are 16 sets of experimental data available for the electrical resistivity of sodium as a function of pressure. The information on specimen characterization and measurement conditions for each of the data sets is given in table 13. The data are tabulated in table 14 and shown in figure 8.

The available data and information for the pressure dependence of electrical resistivity of sodium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

c. Magnetic Flux Density Dependence

There are 21 sets of experimental data available for the electrical resistivity of sodium under the influence of magnetic field. The information on specimen characterization and measurement information for each of the data sets is given in table 15. The data are tabulated in table 16 and shown in figure 9.

The available data and information for the magnetic flux density dependence of electrical resistivity of sodium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

TABLE 10. RECOMMENDED ELECTRICAL RESISTIVITY OF SODIUM (Temperature Dependence)

[Temperature, T, K; Total Resistivity, ρ, $10^{-8}\ \Omega$ m; Intrinsic Resistivity, ρ_i, $10^{-8}\ \Omega$m]

Solid						Liquid	
T	ρ	ρ_i	T	ρ	ρ_i	T	ρ
1	8.87 x 10^{-4}*		35	0.117*	0.116*	371	9.43
2	8.87 x 10^{-4}*	1.3 x 10^{-7}*	40	0.172*	0.171*	400	10.50
3	8.88 x 10^{-4}*	1.1 x 10^{-6}*	45	0.233	0.232	500	14.36
4	8.92 x 10^{-4}*	5.0 x 10^{-6}*	50	0.300	0.299	600	18.56
5	9.03 x 10^{-4}*	1.59 x 10^{-5}*	60	0.447	0.446	700	23.20
6	9.28 x 10^{-4}*	4.12 x 10^{-5}*	70	0.615	0.614	800	28.38
7	9.80 x 10^{-4}*	9.26 x 10^{-5}*	80	0.796	0.795	900	34.19
8	0.00107*	1.87 x 10^{-4}*	90	0.978	0.977	1000	40.73
9	0.00123*	3.49 x 10^{-4}*	100	1.158	1.157	1100	48.12
10	0.00149*	6.03 x 10^{-4}*	150	2.03	2.03	1200	56.45
11	0.00186*	0.00097*	200	2.89	2.89	1300	65.85
12	0.00237*	0.00148*	250	3.86	3.86	1400	76.44
13	0.00303*	0.00214*	273.15	4.33	4.33	1500	88.37
14	0.00391*	0.00302*	293	4.77	4.77	1600	101.8*
15	0.00503*	0.00414*	300	4.93	4.93	1700	117.1*
16	0.00644*	0.00555*	350	6.23	6.23	1800	135.1*
18	0.0102*	0.00934*	371	6.86	6.86	1900	157.1*
20	0.0156*	0.0147*				2000	184.4*
25	0.0370*	0.0361*					
30	0.0711*	0.0702*					

* Provisional values.

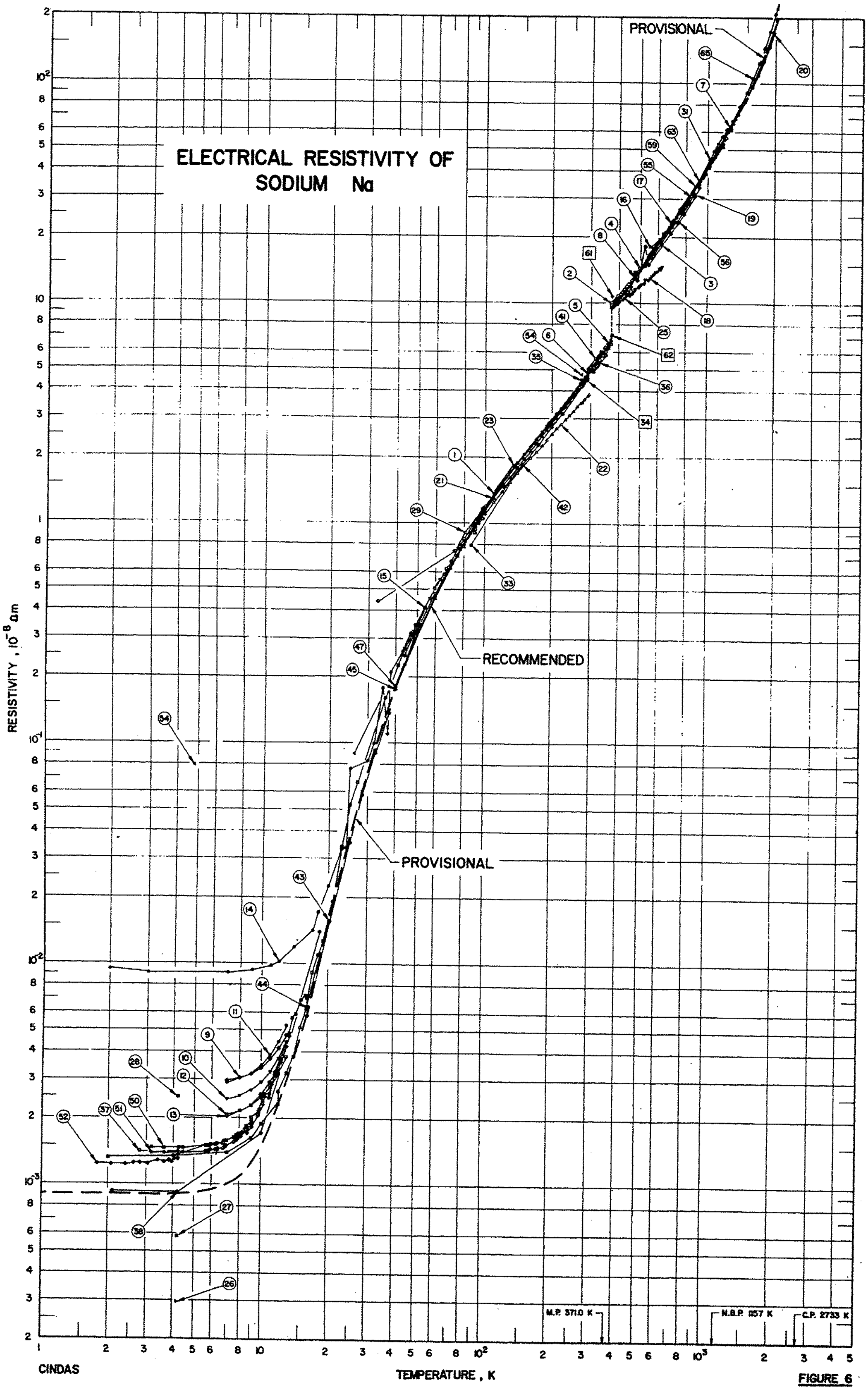

ELECTRICAL RESISTIVITY OF SODIUM Na
PROVISIONAL
RECOMMENDED
PROVISIONAL
RESISTIVITY, 10^{-8} Ωm
TEMPERATURE, K
M.P. 371.0 K
N.B.P. 1157 K
C.P. 2733 K
CINDAS

FIGURE 6

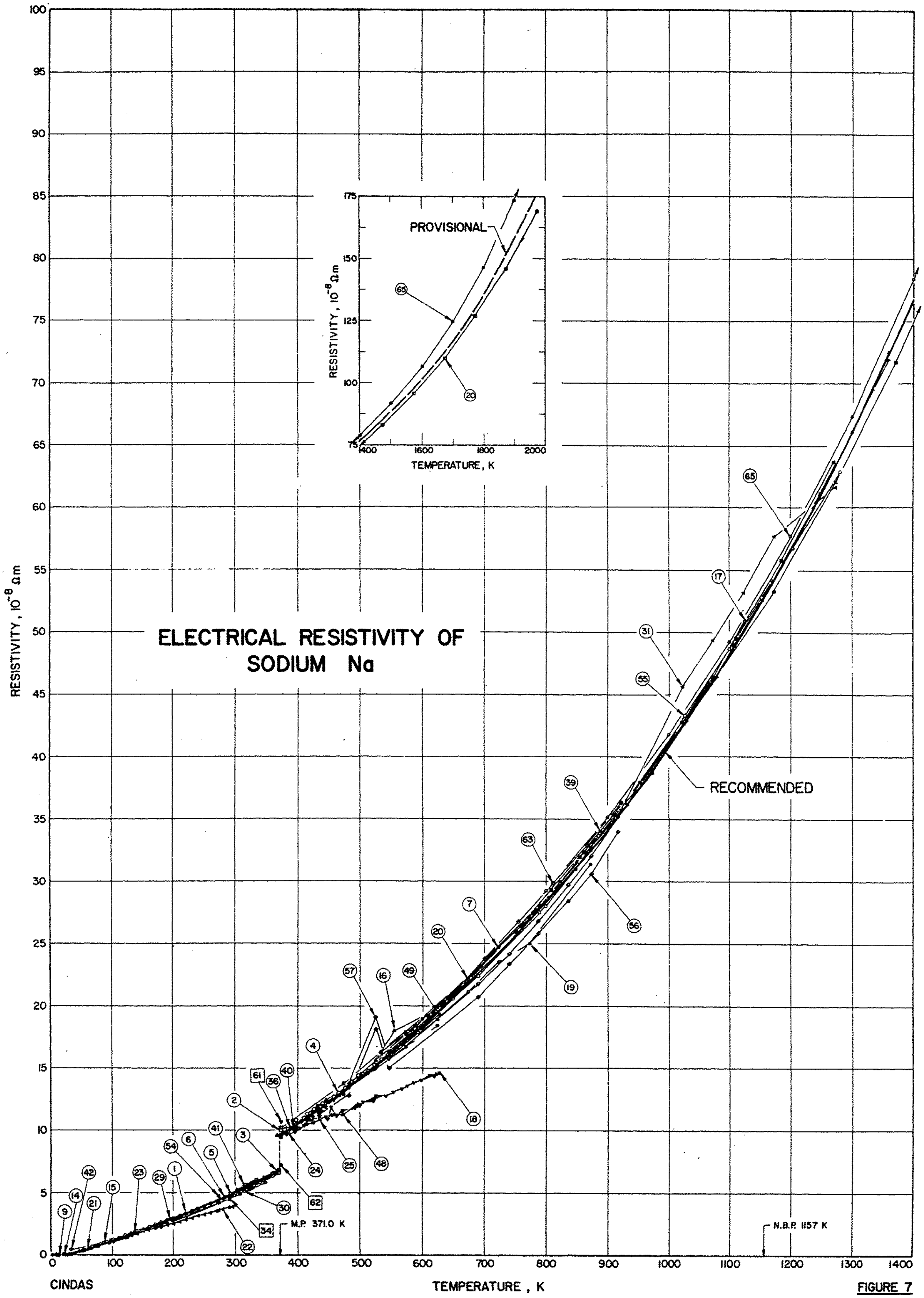

ELECTRICAL RESISTIVITY OF
SODIUM Na
RESISTIVITY, 10^{-8} Ωm
TEMPERATURE, K
PROVISIONAL
RECOMMENDED
M.P. 371.0 K
N.B.P. 1157 K
CINDAS

FIGURE 7

TABLE 11. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Temperature Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	44	Bradshaw, F.J. and Pearson, S.	1956	A	78-370		0.0025 K and < 0.0005 O_2; specimen was obtained from the Atomic Energy Research Establishment, Harwell; nickel tube 0.5 mm in diameter, 0.025 mm wall thickness and 16 mm long; was used to contain sodium.
2	45	Hennephof, J., Van Der Lugt, W., and Wright, G.W.	1971	B	373.15-398		99.95 pure specimen was supplied by Koch Light Co.; resistivity was a linear function of temperature from melting point to 125 C; described by $d\rho/dT = 0.034 \times 10^{-8}$ Ωm/K.
3	46	Bornemann, K. and Rauschenplat, G.	1912		367-623		Pure; liquid state.
4	47	Addison, C.C., Creffield, G.K., Hubberstey, P., and Pulham, R.J.	1969	B	371-570		Pure; <0.04 Ca, <0.001 O; liquid state; specimen was contained in AISA 321 stainless steel tubes 0.146 and 0.148 cm diameter, 11.249 and 12.427 cm long; density at 390.95 K is 0.927 g cm^{-3}.
5	47	Addison, C.C., et al.	1969	B	292-370		Similar to above specimen except it was in solid state; density at 390.95 K is 0.9514 g cm^{-3}.
6	48	Savenchenko, V.A. and Shpil'rain, E'.E'.	1969	A	283-357		0.006 H_2, 0.0049 O_2, 0.0042 Mn, 0.002 Fe, Ni, 0.0014 N_2, 0.001 Ca, Si, Ti, V, 0.0004 Cr, 0.0003 Li, Mg, Cu, 0.0001 Al, Cd, Zr, 0.00001 Cs; the specimen was obtained from the Institute of the Chemistry and Technology of Rare Elements and Raw Minerals; measurements made in a stainless steel tube 10.5 cm in external diameter, 0.4 mm wall thickness.
7	48	Savenchenko, V.A. and Shpil'rain, E'.E'.	1969	A	384-1271		Similar to above specimen except liquid state.
8	49	Aksenova, L.I. and Belashchenko, D.K.	1971		383-473		99.9 pure; liquid state; measurements made with capillary cell.
9	50	Holzhauser, W.	1970	G	7.0-13	1a	Specimen consisted of 41% hexagonal close packed crystal structure, the remainder being body center cubic; electrical resistivity data obtained from $\rho = \rho_0 + aT^5$ with $\rho_0 = 2.88 \times 10^{-11}$ Ωm, $a = 5.13 \times 10^{-17}$ Ωm/K^5.
10	50	Holzhauser, W.	1970	G	7.0-13	1b	Specimen consisted of 19% hexagonal close packed crystal structure, the remainder being body center cubic; electrical resistivity data obtained from $\rho = \rho_0 + aT^5$ with $\rho_0 = 2.35 \times 10^{-11}$ Ωm, $a = 5.61 \times 10^{-17}$ Ωm/K^5.
11	50	Holzhauser, W.	1970	G	7.0-13	4a	Specimen consisted of 8% hexagonal close packed crystal structure, the remainder being body center cubic; electrical resistivity data obtained from $\rho = \rho_0 + aT^5$ with $\rho_0 = 2.80 \times 10^{-11}$ Ωm, $a = 6.63 \times 10^{-17}$ Ωm/K^5.
12	50	Holzhauser, W.	1970	G	7.0-13	3a	Specimen consisted of 52% hexagonal close packed crystal structure, the remainder being body center cubic; electrical resistivity data obtained from $\rho = \rho_0 + aT^5$ with $\rho_0 = 2.00 \times 10^{-11}$ Ωm, $a = 4.84 \times 10^{-17}$ Ωm/K^5.
13	50	Holzhauser, W.	1970	G	7.0-13	3b	Specimen consisted of 12% hexagonal close packed crystal structure, the remainder being body center cubic; electrical resistivity data obtained from $\rho = \rho_0 + aT^5$ with $\rho_0 = 1.95 \times 10^{-11}$ Ωm, $a = 6.13 \times 10^{-17}$ Ωm/K^5.
14	51	Berman, R. and MacDonald, D.K.C.	1951		2-46	Na I	Approximately 0.01 to 0.1 Al and Ca; supplied by British-Thomson-Houston Research Lab.; cast under vacuum in soft glass tubes.
15	51	Berman, R. and MacDonald, D.K.C.	1951		2-90	Na II	Trace of Ag; supplied by Messers. Philips Ltd., Mitcham; cast under vacuum in soft glass tubes.
16	16	Tepper, F., Zelenk, J., Roehlich, F., and May, V.	1965	A	302-1360		Pure; density 0.8997, 0.8255, 0.8119, 0.7881, 0.7640, 0.7381 and 0.6967 g cm^{-3} at 483.8, 804.1, 873.1, 972.7, 1085, 1189 and 1384 K, respectively.

TABLE 11. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
17	43	Kapelner, S.M. and Bratton, W.D.	1962	B	371-1126		< 0.0375 Cs, K, < 0.015 Li, 0.0066 Fe, 0.0048 N_2, 0.0032 O_2, 0.0022 N_2 and < 0.001 Cr; specimen was purchased from U.S. Industrial Chemical Co.; purified by melting and forcing molten liquid through a 20 μ stainless steel filter under purified argon; the tube was heated to about 550 C and then held for 2 hr prior to measurements.
18	41	Lien, S.Y. and Silversten, J.M.	1969	A	373-623		99.95 pure; specimen was supplied by A. D. Mackay Inc.; the electrical resistivity specimen cell was made from precision quartz capillary open on one end, four tungsten current and potential leads were sealed into the capillary; measurements at constant volume.
19	9	Freedman, J.F. and Robertson, J.F.	1961	B	373-873		0.01 K, 0.003 Cl, 0.002 Li, Cs, 0.0125 others; sample was supplied by E.I. DuPont de Nemours Co.; specimen in liquid state; 304 stainless steel was the cell material, 0.349 in. diameter, 20 in. length.
20	52	Solov'ev, A.N.	1963		373-1973		Pure; density 0.928 g cm^{-3} at 373 K, 0.706 g cm^{-3} at 1273 K; data above 1293 K were extrapolated.
21	8	Dugdale, J.S. and Gugan, D.	1962	A	50-295	Na(6)	Pure; specimen was supplied by Messers A. D. Mackay and Co., New York; specimen was made in the form of base wire, 0.5 mm in diameter, 1 mm in length; $R_{4.2}/R_{300} = 3.0 \times 10^{-4}$; electrical resistivity was measured at zero pressure.
22	8	Dugdale, J.S. and Gugan, D.	1962	A	50-295	Na(6)	Same as the above specimen except the electrical resistivity was obtained at constant volume.
23	8	Dugdale, J.S. and Gugan, D.	1962	A	44-273.15	Na(4)	Pure; specimen was supplied by N. V. Phillips, Eindhoven Co.; specimen in glass capillary; $R_{4.2}/R_{300} = 2.0 \times 10^{-4}$; electrical resistivity was measured at zero pressure.
24	40	Endo, H.	1963	A	373-448		Pure; sample was supplied by A. D. Mackay Ltd.; specimen container was made of soft glass and consisted to a capillary tube (I.D. 0.7 mm) between two bulbs equipped with platinum electrode; electrical resistivity was measured at constant pressure condition.
25	40	Endo, H.	1963	A	373-448		Same as above specimen except electrical resistivity was obtained at constant volume.
26	53	Stern, R., Natale, G.G., and Rudnick, I.	1966	A	4.2-273	Na 1	High purity polycrystalline sample, vacuum distilled; annealed; 0.104 cm in diameter and 11.05 cm in length.
27	53	Stern, R., et al.	1966	A	4.2-273	Na 2	Similar to above specimen; 0.109 cm in diameter, 11.55 cm in length.
28	53	Stern, R., et al.	1966	A	4.2-273	Na 3	Similar to above specimen; unannealed.
29	54	McLennan, J.C. and Niven, C.D.	1927	B	20.6-273		Pure.
30	39	Fritsch, G. and Lüscher, E.	1969	B	308-371		99.99 pure; < 0.017 K, < 0.021 Mg, < 0.0012 Fe, and < 0.00087 Ca; single crystal specimen with crystal axis 7° to [100] direction; specimen was put in V2A steel tube 0.1 mm wall, 6 mm diameter; 12 cm long.
31	18	Semgachkin, B.E. and Solov'ev, A.N.	1964	A	373-1273		Pure; TU 1664-50 sample was placed in an 0.8/0.5 mm capillary, 600 mm long.
32*	55	Packard, D.R. and Verhoeven, J.D.	1968	→	373-473		99.99 pure; electrical resistivity was measured by capillary-receiver technique.
33	19	Guntz, A. and Bronieski, W.	1909		86-323		Pure; solid specimen.

* Not shown in figure.

TABLE 11. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
34	56	Hackspill, L.	1910	A	290.15	1	Pure; distilled sample was placed in a tube about 1-2 cm in diameter, 10-20 cm long.
35	56	Hackspill, L.	1910	A	273.15, 291.15	2	Similar to the above specimen.
36	56	Hackspill, L.	1910	A	93-389	3	Similar to the above specimen.
37	37	White, G.K. and Woods, S.B.	1956	A	2.1-18.6	Na 3	Pure; cast in soft glass; 0.13 mm in diameter, $\rho_0/\rho_{295} = 3 \times 10^{-3}$.
38	37	White, G.K. and Woods, S.B.	1956	A	2.1-18.6	Na 4	Pure; cast in soft glass; 0.35 mm in diameter.
39	17	Roehlieh, F. and Tepper, F.	1965	A	379-1366		Pure; specimen was placed in a Hayne-25 alloy cylindrical cell 0.5 in. O.D. with wall thickness 0.065 in. and 26 in. long.
40	57	Regel, A.R.	1958		273-473		Pure; data were extracted from the smooth curve.
41	58	Hornbeck, J.W.	1913		279-361		Pure; supplied by Eimer and Amend.
42	15	Bidwell, C.C.	1926		33-348		Pure; 0.2921 cm in diameter, 51.3 cm long, extruded bare wires.
43	38	Dugdale, J.S. and Gugan, D.	1960	A	16-37.35	Na(7)	Pure; specimen was obtained from Messers A. D. Mackay and Co., New York; $R_{4.2}/R_{273} = 3.8 \times 10^{-4}$; by cooling the annealed sample to 4 K and measuring its resistance up to 40 K ideal electrical resistivity data were extracted from table.
44	38	Dugdale, J.S. and Gugan, D.	1960	A	16-37.35	Na(7)	Same as above specimen, subsequently twice warming to 80 K and cooling to 4 K.
45	38	Dugdale, J.S. and Gugan, D.	1960	A	16-52	ideal B.C.C. Na	Pure; body center cubic phase; ideal electrical resistivity was calculated from 16 K to 40 K.
46*	38	Dugdale, J.S. and Gugan, D.	1960	A	16-52	ideal H.C.P. Na	Pure; hexagonal close packed phase; ideal resistivity was calculated from 16 to 52 K.
47	59	Cook, J.G., Van der Meer, M.P., and Laubitz, M.J.	1972		40-360	NRC 3	0.004 K, 0.0015 Si, < 0.001 Zr, Rb, 0.0005 Ca, < 0.0005 B, Co, Sn, Pb, Y, Ti, Mo, Bi, < 0.0003 Ba, 0.0003 Fe, Ba, 0.0002 Al, Cu, 0.0001 Mg, <0.0001 Mn, Cr, Ni, V, Be, Ag, Sn, Li; specimen was obtained from Mine Safety Appliance Corp.
48	42	Swalin, R.A.	1967		371-623		Pure; liquid state electrical resistivity were calculated under constant volume condition.
49	42	Swalin, R.A.	1967		371-623		Pure; liquid state electrical resistivity were calculated under constant pressure (1 atm) condition.
50	23, 60	MacDonald, D.K.C., White, G.K., and Woods, S.B.	1955, 1956	G	2.5-16	Na 1	Pure; specimen was cast in a fine soft glass capillary, 0.9 mm in diameter, 7 cm long continuous with a 50 cm long helically wound tube of about 0.2 mm I.D.; $\rho_0/\rho_{295} = 3.60 \times 10^{-4}$.
51	23, 60	MacDonald, D.K.C., et al.	1955, 1956	G	2.5-16	Na 2	Similar to the above specimen except the capillary was 0.5 mm in diameter, 7 cm in length and $\rho_0/\rho_{295} = 2.92 \times 10^{-4}$.
52	61, 62	Garland, J.C. and Bower, R.	1968, 1969	A	1.8-4.2		Pure; specimen was prepared by drawing molten sodium into a teflon tube, the voltage and current probes were then inserted through the side of tube; $\rho_{290}/\rho_0 = 3800$, ρ_0 was obtained by using $\rho_{293} = 4.73 \times 10^{-8}$ Ωm.
53*	63	Greenfield, A.J.	1964	A	371		99.999$^+$ pure; liquid state; density 0.929 g cm^{-3}.
54	64	Collman, R.R., Blewitt, T.H., Klabunde, C.E., Redman, J.K., and McDonald, D.L.	1961		4.8, 273		Pure; specimen was prepared by casting it under vacuum in a 0.125 in. O.D. and 0.004 in. wall and 1.50 in. long stainless steel tube.

* Not shown in figure.

TABLE 11. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
55	65	Evangelisti, R. and Isacchini, F.	1965	A	371-1273	Na	Pure; specimen in liquid state was placed in a type 316 stainless steel container.
56	66	Belashchenko, D.K. and Vol'deit, A.V.	1972	A	393-917	1	0.005 Cd; specimen was placed in a molybdenum glass on 1 Kh18N9T stainless steel capillaries, the inner diameter was 1-2 mm, the length of the column was 40 mm; specimens were heat treated for the establishment of a steady state, at the end of heating treatment the sample was quenched in oil; electrical resistivity data were extracted from the smooth curve.
57	66	Belashchenko, D.K. and Vol'deit, A.V.	1972	A	393-917	2	0.39 Cd; other specifications similar to the above specimen.
58*	22	Krautz, E.	1950	A	273	Na	Pure.
59*	67	Northup, E.F.	1911	B	293.15, 373.15		Pure; specimen was supplied by Merck; sample was filled in a glass tube with platinum potential and current terminals; electrical resistivity data were obtained by comparing the electrical resistance of mercury and sodium.
60*	68	Van der Lugt, W., Devin, J.F., Hennephof, J., and Leenstra, M.R.	1973	B	373.15, 473.15	Na	Pure.
61	69	Tamaki, S., Ross, R.G., Cusack, N.E., and Endo, H.	1973	A	373.15	Na	Pure; liquid state; the electrical resistivity was measured at pressure equal to 1 bar.
62	69	Tamaki, S., et al.	1973	A	373.15	Na	Same as above specimen; the electrical resistivity was measured at pressure equal to 4 kbar.
63	70	Bonilla, C.F., Lee, D., and Foley, P.J.	1965	V	533-922	Na	0.002 N_2, 0.0015 Cl, 0.006 SO_4, 0.0003 Fe, 0.0001 P_3O_4, and 0.0001 heavy metals; liquid state specimen was contained in a 316 stainless steel tube with O.D. of 7/16 in., wall of 0.018 in. and about 8 in. long; Chromel-Alumel thermocouples were used to measure the temperature.
64*	71	Savchenko, V.A. and Shpil'rain, E.E.	1974	A	372-556		Pure; 0.0002 H_2; experimental data can be fitted by the equation $\rho = 6.69 + 26.092 \times 10^{-3} (T-273) + 39.201 \times 10^{-6} (T-273)^2 - 39.962 \times 10^{-9} (T-273)^3 + 43.854 \times 10^{-12} (T-273)^4 - 12.634 \times 10^{-15} T^5$ (10^{-8} Ωm) where T is in units of K.
65	5	Grosse, A.V.	1966		372-2800		Calculated electrical resistivity; by fitting the data of Kapelener and Bratton to a hyperbolic equation $(\sigma' + b)(T' + b) = a$, where $\sigma' = \rho_{m.p.}/\rho$ and $T' = (T - T_{m.p.})/(T_{c.p.} - T_{m.p.})$, a = 0.132 and b = 0.118.

* Not shown in figure.

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Temperarature Dependence)

[Temperature, T, K; Resistivity, ρ, 10^{-8} Ωm]

T	ρ
CURVE 1	
70	0.676
80	0.854
90	1.033
100	1.211
110	1.389
120	1.567
130	1.743
140	1.919
150	2.095
160	2.271
170	2.450
180	2.629
190	2.808
200	2.988
210	3.174
220	3.361
230	3.550
240	3.741
250	3.934
260	4.132
270	4.333
273.15	4.396
280	4.535
290	4.739
300	4.945
310	5.159
320	5.374
330	5.598
340	5.830
350	6.070
360	6.319
370	6.571
CURVE 2	
373.2	10.00
398.2	10.85
CURVE 3	
367	6.75
371	9.60*
373	9.65
423	11.4
473	13.18
523	14.90
573	16.70
623	18.44
CURVE 4	
371	9.79
375	9.90*
379	9.98*
385	10.1
397	10.5
405	10.7
409	11.0
414	11.3
425	11.7
435	11.9
439	12.2
450	12.3
457	12.7
465	13.0
475	13.4
486	13.9
497	14.4
513	14.8
522	15.3
534	15.7
544	16.1
559	16.7
566	17.0
570	17.1
CURVE 5	
292	4.95
330	5.79
347	6.21
359	6.51
362	6.57
364.5	6.61
366	6.65*
367	6.67*
368.5	6.70*
370	6.84
CURVE 6	
283.4	4.64
290.4	4.82
291.0	4.80*
291.0	4.82*
291.9	4.85*
293.2	4.88*
318.0	5.43
329.4	5.68*
CURVE 6 (cont.)	
351.2	6.20*
352.0	6.21*
353.2	6.27*
354.0	6.23*
354.6	6.26
357.4	6.28
CURVE 7	
384.0	10.1*
473.4	13.4*
545.9	16.3
546.3	16.4*
616.8	19.5
639.4	20.6
723.6	24.7
751.0	26.0
809.8	29.3
855.7	31.9
862.8	32.3
953.1	37.9
1023.4	42.8
1111.5	49.5
1186.6	55.8
1270.6	63.7
CURVE 8	
383	10.1*
423	11.4
473	13.2
CURVE 9	
7	0.00297
8	0.00305
9	0.00318
10	0.00339
11	0.00371
12	0.00416
13	0.00478
CURVE 10	
7	0.00244
8	0.00253
9	0.00268
10	0.00291
CURVE 10 (cont.)	
11	0.00325
12	0.00375
13	0.00443
CURVE 11	
7	0.00291
8	0.00302*
9	0.00319*
10	0.00346
11	0.00387
12	0.00445
13	0.00526
CURVE 12	
7	0.00208
8	0.00216
9	0.00229
10	0.00248
11	0.00278
12	0.00320
13	0.00379
CURVE 13	
7	0.00253
8	0.00215
9	0.00231
10	0.00256
11	0.00293
12	0.00347
13	0.00423
CURVE 14	
2	0.00943
3	0.00943
7	0.00943
9	0.00954
11	0.0098
12	0.0103
14	0.0119
17	0.0143
18	0.0172
20	0.0227
23	0.0333
24	0.0337
CURVE 14 (cont.)	
25	0.0769
30	0.0833
32	0.10
35	0.179
38	0.212
43	0.263
46.7	0.317
CURVE 15	
2	0.00132*
4	0.00134
7	0.00139
9	0.00163
10	0.00188
12	0.00231
12	0.00265
13	0.00321
14	0.00383
15	0.00518
16	0.00613
16	0.007
17	0.00919
18	0.0109
19	0.0129
21	0.0192
23	0.034
25	0.0526
27	0.067
32	0.10*
36	0.161
41	0.227
44	0.270
46	0.294
48	0.323
CURVE 16	
302	5.23
324	5.72
356	6.54*
365	6.70*
370	6.82*
406	11.04*
413	11.10
431	11.99
444	12.42
501	14.54
CURVE 16 (cont.)	
525	15.61
542	16.25*
554	18.01
630	20.09
668	21.86
726	24.76*
790	28.01
850	31.54
913	35.31
945	37.35
1009	41.76
1079	46.44
1108	48.94
1171	54.16
1238	60.10
1300	66.17
1334	69.59
1360	72.48
CURVE 17	
371.2	9.64
424.5	11.44*
482.5	13.78
585.7	17.98
693.9	23.16
804.4	28.68
908.7	34.91
1012.8	41.86
1072.8	46.40
1126.0	51.00
CURVE 18	
372.95	9.56
382.05	9.67
396.55	9.88
403.35	10.16
420.25	10.38
444.35	11.03
447.55	10.89
453.15	11.88
461.65	11.17
471.85	11.41
471.85	11.61
492.75	11.79
499.45	11.95
505.05	12.27

* Not shown in figure.

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Temperature Dependence) (continued)

T	ρ
CURVE 18 (cont.)	
521.75	12.31
526.35	12.77
542.05	12.71
553.35	13.03
567.45	13.33
575.95	13.55
586.95	13.82
598.35	13.98
611.45	14.44
618.55	14.32
627.85	14.62
CURVE 19	
373.15	9.44
423.15	11.10
473.15	12.90
523.15	14.78
573.15	16.78
623.15	18.92
673.15	21.12
723.15	23.50
773.15	26.00
823.15	28.56
873.15	31.36
CURVE 20	
373.15	10.20
473.15	13.79
573.15	17.88
673.15	22.18
773.15	27.00
873.15	32.50
973.15	38.76
1073.15	46.15
1173.15	53.30
1273.15	62.09
1373.15	71.7
1473.15	83.1
1573.15	95.6
1673.15	110
1773.15	127
1873.15	146
1973.15	169
CURVE 21	
50	0.3169
60	0.4568
CURVE 21 (cont.)	
70	0.6307*
80	0.8050
90	0.9752
100	1.1455
110	1.3151
120	1.4840
130	1.6534
140	1.8235
150	1.9942
160	2.1656
170	2.3387
180	2.5138
190	2.6925
200	2.8742
210	3.0599
220	3.2472
230	3.4357
240	3.6261
250	3.8215
260	4.0223
270	4.2663*
273.15	4.2893*
280	4.4318
290	4.6437
295	4.7501
CURVE 22	
50	0.3142*
60	0.4689*
70	0.62678*
80	0.7876*
90	0.94882*
100	1.108
110	1.264*
120	1.416
130	1.5652
140	1.7123
150	1.8573
160	2.0004
170	2.1428
180	2.2838
190	2.4249
200	2.5662
210	2.7077
220	2.8481
230	2.9865
240	3.1234
250	3.2617
260	3.4013
CURVE 22 (cont.)	
270	3.5394
273.15	3.5823
280	3.6756
290	3.8132
295	3.8822
CURVE 23	
44.00	0.251
50.10	0.349
59.63	0.509
76.41	0.805*
89.50	1.043*
97.12	1.173
136.00	1.858
180.50	2.654*
273.15	4.395*
CURVE 24	
371.6	9.50*
384.8	9.89
398.3	10.35
413.6	10.86
425.2	11.31*
436.0	11.63
443.2	11.91
CURVE 25	
384.8	9.82*
398.3	10.13*
413.3	10.49
424.4	10.66
435.9	10.90
443.1	11.09*
CURVE 26	
4.2	0.000295
77.6	0.8075
273	4.28*
CURVE 27	
4.2	0.000585
77.6	0.8075*
273	4.28*
CURVE 28	
4.2	0.0025
77.6	0.8075*
273	4.28*
CURVE 29	
20.6	0.09
81	0.91
195	2.9
273	4.3*
CURVE 30	
308.55	5.13*
314.25	5.17
321.65	5.49
331.05	5.71*
339.25	5.77*
347.65	6.11*
352.85	6.26*
364.25	6.51*
369.75	6.60*
370.45	6.81*
371.05	9.56*
373.05	9.69*
CURVE 31	
373.15	10.01*
423.15	11.78*
473.15	13.63*
523.15	15.56*
573.15	17.70
623.15	19.90
673.15	22.22*
723.15	24.70*
773.15	27.23*
823.15	29.94
873.15	32.76
923.15	35.72
973.15	38.87*
1023.15	45.64
1073.15	49.36
1123.15	53.21
1173.15	57.7
1273.15	61.57
CURVE 32*	
371.15	9.70
CURVE 32 (cont.)*	
422.15	11.52
472.15	13.29
CURVE 33	
86.15	0.8
194.85	2.86
273.00	4.30*
323.15	5.33*
CURVE 34	
290.15	4.5
CURVE 35	
273.15	4.5
291.15	4.9*
CURVE 36	
93	1.0
198	2.8*
273	4.2
291	4.6*
308	4.9
328	5.4
389	10.2
CURVE 37	
2.8	0.00142
4.2	0.00136
4.2	0.00140
8.2	0.00172
CURVE 38	
2.1	0.000930
4.2	0.000920
10.0	0.00172
18.35	0.0140
CURVE 39	
379.26	9.87
584.8	17.8*
755	25.9
888	34.06
1030	42.90
CURVE 39 (cont.)	
1134	52.58
1248	61.16
1360	71.89
CURVE 40	
273.15	4.19*
313.15	5.15*
353.15	6.13*
371.15	6.50*
393.15	10.17
433.15	11.49
476.15	12.92*
CURVE 41	
278.9	4.66*
294.7	5.06
315.3	5.63
334.6	6.04
361.3	6.63*
CURVE 42	
33	0.442
73	0.750
98	1.066
123	1.493
148	1.869
173	2.304
198	2.762
223	3.185
273	4.255
293	4.717*
323	5.291
348	5.85
CURVE 43	
16.10	0.00584
20.35	0.01563
25.00	0.03546
28.55	0.05844
32.55	0.09095
37.55	0.13837
CURVE 44	
16.10	0.00640
20.35	0.01664

* Not shown in figure.

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Temperature Dependence) (continued)

T	ρ
CURVE 44 (cont.)	
25.00	0.03702
28.55	0.06046
32.55	0.09342
37.35	0.14137
CURVE 45	
16	0.0067
18	0.011
20	0.0165
22	0.0237
24	0.0329
26	0.0445
28	0.0583
30	0.0736
32	0.0908
36	0.1094
36	0.1296
40	0.1762
44	0.2296
48	0.287
52	0.3475
CURVE 46*	
16	0.0035
18	0.0064
20	0.0103
22	0.0158
24	0.0232
26	0.0329
28	0.0448
30	0.0583
32	0.0738
34	0.0909
36	0.1094
40	0.152
42	0.1758
44	0.2007
46	0.2266
48	0.254
50	0.282
52	0.311
CURVE 47	
40	0.1822
50	0.3217
60	0.4783

T	ρ
CURVE 47 (cont.)	
70	0.6428
80	0.8109*
90	0.9806*
100	1.115*
120	1.491*
140	1.835*
160	2.181*
180	2.534*
200	2.897*
220	3.270*
240	3.657*
260	4.056*
273	4.330*
280	4.475*
300	4.915*
320	5.365*
340	5.849*
360	6.359*
CURVE 48	
367.1	9.60
369.3	9.50*
370.3	9.62*
382.7	9.79
394.8	9.94*
397.0	10.19
402.8	10.20*
412.7	10.32*
416.0	10.44*
429.3	10.84
435.6	10.82*
442.9	11.05*
445.5	10.90*
453.4	11.17
458.1	11.29
469.3	11.47*
472.7	11.28
472.9	11.45*
493.8	11.95
496.1	12.08
498.5	11.97*
519.4	12.44
522.0	12.54
540.1	12.82*
555.4	12.98*
567.5	13.26*
576.6	13.52*
587.5	13.86*

T	ρ
CURVE 48 (cont.)	
598.5	14.01*
613.2	14.50*
620.0	14.45
CURVE 49	
371.8	9.52*
378.0	9.74*
381.4	9.89*
387.6	10.04*
393.1	10.23*
405.1	10.60*
405.1	10.71*
416.8	11.03*
421.7	11.27
423.1	11.18*
433.5	11.64*
445.6	12.03*
457.0	12.44
467.0	12.83
476.4	13.29*
482.8	13.45
499.7	14.21
513.4	14.60
527.3	15.18
548.7	15.95
571.2	17.07*
626.4	18.35
CURVE 50	
3.17	0.001474
3.63	0.001475
4.25	0.001478
4.44	0.001477
5.65	0.001500
5.74	0.001502
5.83	0.001506
5.94	0.001524
6.28	0.001523
6.32	0.001525
6.32	0.001534
6.76	0.001555
6.78	0.00156
6.86	0.00157
6.99	0.00158
7.59	0.00164
7.75	0.00168
7.83	0.00169

T	ρ
CURVE 50 (cont.)	
7.89	0.0017
8.15	0.00174*
8.57	0.00185
8.67	0.00181
9.08	0.00191
9.08	0.00196
9.08	0.00201
9.70	0.00214
9.82	0.00220
10.21	0.00239
10.37	0.00258
10.91	0.00257
11.19	0.00294*
11.64	0.00324
11.83	0.00337*
12.33	0.00369
13.40	0.00486
13.83	0.00570
14.39	0.00594
15.10	0.00690
15.81	0.00718
CURVE 51	
3.17	0.001391
3.63	0.001392
4.25	0.001395*
4.44	0.001394
5.65	0.001417
5.74	0.001419
5.83	0.001423
5.94	0.001441
6.28	0.001440
6.32	0.001442
6.32	0.001451
6.76	0.001472
6.78	0.00148
6.86	0.00149
6.97	0.00150
7.59	0.00156
7.75	0.00160
7.83	0.00161
7.89	0.00162
8.15	0.00166
8.57	0.00177
8.67	0.00173
9.08	0.00183
9.08	0.00188
9.08	0.00193*

T	ρ
CURVE 51 (cont.)	
9.70	0.00206
9.82	0.00212*
10.21	0.00231
10.37	0.00250
10.91	0.00249
11.19	0.00286
11.64	0.00316
11.83	0.00329*
12.25	0.00361
13.40	0.00478
13.83	0.00562*
14.39	0.00586*
15.10	0.00682*
15.81	0.0071*
CURVE 52	
1.79	0.001244
2.06	0.001239
2.40	0.001238
2.62	0.001254
2.80	0.001256
3.05	0.001249
3.38	0.001284
3.62	0.001270
3.80	0.001284
3.94	0.001277
4.06	0.001310
4.20	0.001315
CURVE 53*	
371	9.57
CURVE 54	
4.8	0.0794
273	4.76
CURVE 55	
369	6.8*
374	9.9*
411	11.0*
473	13.4*
497	14.1
552	16.3
592	17.9
648	20.6

T	ρ
CURVE 55 (cont.)	
689	22.4
751	25.7
789	27.8
798	28.0
848	31.0
885	33.7
932	36.2
971	38.8*
1027	43.3
1100	48.7
1153	52.8
1204	56.8
1280	62.9
CURVE 56	
373	9.6*
434	11.2*
482	12.8
546	15.0
525	18.1
689	20.7
740	23.4
787	25.8
835	28.4
873	30.6
917	34.0
CURVE 57	
373	9.6*
434	11.7*
482	13.4*
546	15.8
525	19.1
689	21.8
740	24.2
789	26.8
835	29.7
873	32.0
917	35.2
CURVE 58*	
273	4.34
CURVE 59*	
293.15	4.875
373.15	9.705

* Not shown in figure.

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Temperature Dependence) (continued)

T	ρ
CURVE 60*	
373.15	9.6
473.15	13.4
CURVE 61	
373.15	10.7
CURVE 62	
373.15	7.2
CURVE 63	
533	16.27
589	18.41
644	20.75
700	23.80
755	26.80
811	29.84
866.5	32.90
922	36.31
CURVE 64*	
372.4	9.64
378.4	9.83
388.4	10.15
392.1	10.29
440.5	11.97
443.3	12.09
452.1	12.44
496.0	14.10
515.3	14.93
542.1	16.02
567.4	17.08
573.5	17.28
656.2	20.96
CURVE 65	
400	10.52*
500	14.57*
600	18.99
700	23.85*
800	29.22
900	35.16
1000	41.79
1100	49.24
CURVE 65 (cont.)	
1200	57.65
1300	67.24
1400	78.26
1500	91.07
1600	106.1
1700	124.1
1800	145.9
1900	173.0
2000	207.4
2100	252.7*
2200	314.9*
2300	405.8*
2400	551.0*
2500	820.0*
2600	1488.0*
2700	6033.0*

* Not shown in figure.

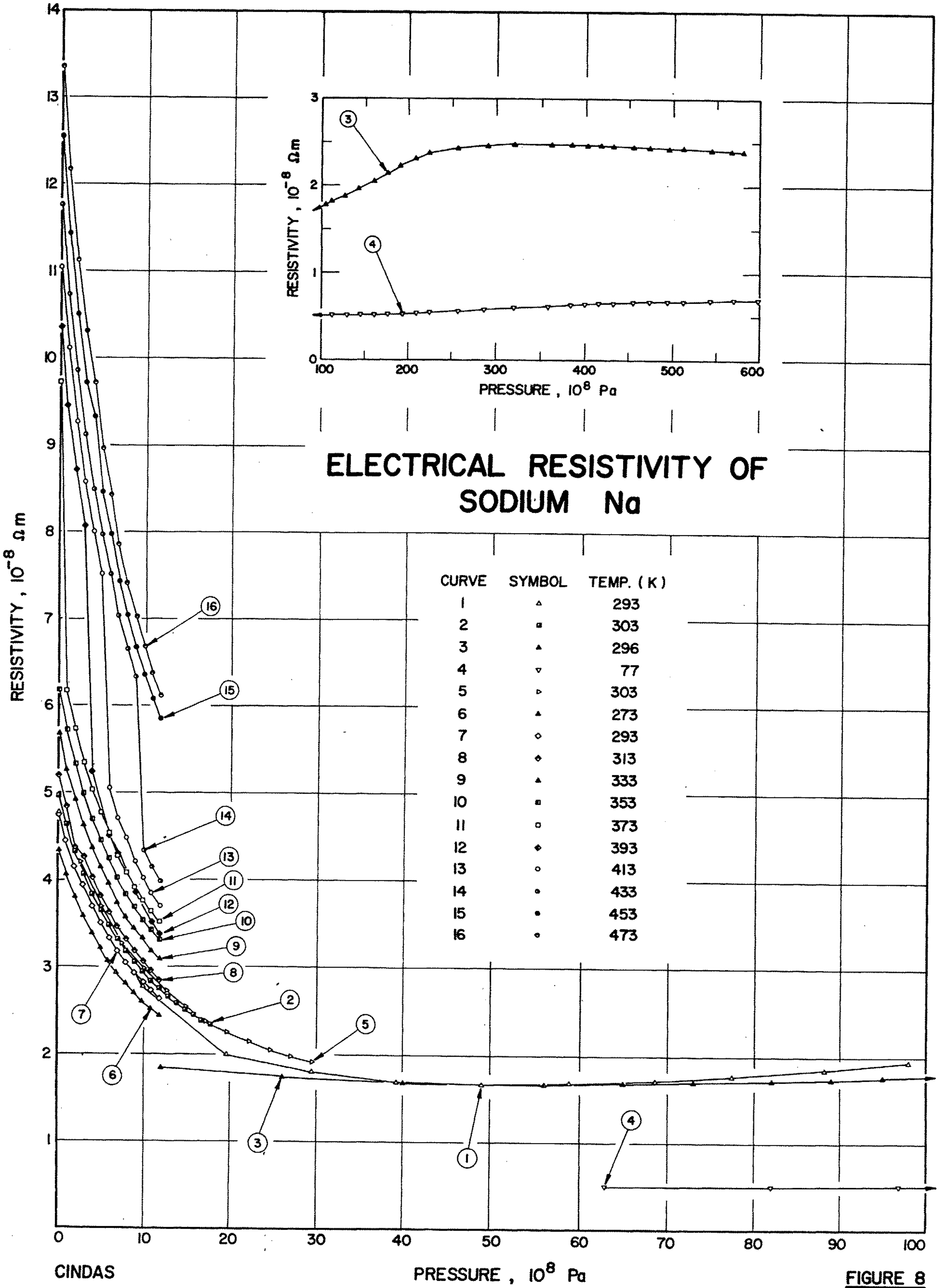

ELECTRICAL RESISTIVITY OF
SODIUM Na
CURVE SYMBOL TEMP. (K)
1 △ 293
2 ▫ 303
3 ▲ 296
4 ▽ 77
5 ▷ 303
6 ▲ 273
7 ◇ 293
8 ◆ 313
9 ▲ 333
10 ▪ 353
11 ▫ 373
12 ◆ 393
13 ○ 413
14 ○ 433
15 ● 453
16 ○ 473
RESISTIVITY, 10^{-8} Ω m
PRESSURE, 10^8 Pa
CINDAS

FIGURE 8

TABLE 13. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Pressure Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Pressure Range, 10^8 Pa	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	30	Bridgman, P.W.	1952	A	0-98	293	Na	Pure; the solid medium transmitting pressure within the cell is AgCl; the relative resistance data were reported at room temperature; electrical resistivity were obtained by using compressibility data and electrical resistivity data at zero pressure.
2	72	Bridgman, P.W.	1930	A	0-17.64	303	Na	Pure; solid, bar wires.
3	31	Stager, R.A. and Drickamer, H.G.	1963	A	12-600	296		Commercial purity specimen; resistance as a function of pressure were reported.
4	31	Stager, R.A. and Drickamer, H.G.	1963	A	50-600	77		The above specimen; after first pressing to 50 kbar at room temperature then cooled and measured at 77 K.
5	32	Bridgman, P.W.	1938	A	0-29.4	303		Pure; specimen was extruded into wire about 1.3 mm in diameter; the relative electrical resistance as a function of pressure data were reported.
6	33	Bridgman, P.W.	1921	A	0-11.76	273		Pure; bare wire specimens with diameter of 0.015 in. and 0.030 in.; relative electrical resistance were reported.
7	33	Bridgman, P.W.	1921	A	0-11.76	293		The above specimen.
8	33	Bridgman, P.W.	1921	A	0-11.76	313		The above specimen.
9	33	Bridgman, P.W.	1921	A	0-11.76	333		The above specimen.
10	33	Bridgman, P.W.	1921	A	0-11.76	353		The above specimen.
11	33	Bridgman, P.W.	1921	A	0-11.76	373		The above specimen.
12	33	Bridgman, P.W.	1921	A	0-11.76	393		The above specimen.
13	33	Bridgman, P.W.	1921	A	0-11.76	413		The above specimen.
14	33	Bridgman, P.W.	1921	A	0-11.76	433		The above specimen.
15	33	Bridgman, P.W.	1921	A	0-11.76	453		The above specimen.
16	33	Bridgman, P.W.	1921	A	0-11.76	473		The above specimen.

TABLE 14. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Pressure Dependence)

[Temperature, T, K; Pressure, P, 10^8 Pa; Resistivity, ρ, 10^{-8} Ωm]

CURVE 1
T = 293

P	ρ
0.0	4.789
9.8	2.785
19.6	2.001
29.4	1.818
39.2	1.690
49.0	1.662
58.8	1.680
68.6	1.715
78.4	1.777
88.2	1.848
98.0	1.943

CURVE 2
T = 303

P	ρ
0.00	4.972
0.98	4.643
1.96	4.330
2.94	4.071
3.92	3.848
4.90	3.652
5.88	3.480
6.86	3.326
7.84	3.187
8.82	3.065
9.80	2.950
10.78	2.846
11.76	2.750
12.74	2.663
13.72	2.587
14.70	2.517
15.68	2.453
16.66	2.394
17.64	2.341

CURVE 3
T = 296

P	ρ
12	1.859
26	1.753
40	1.690
56	1.675
65	1.689
73	1.700
82	1.728

CURVE 3 (cont.)
T = 296

P	ρ
89	1.738
95	1.765
104	1.784
111	1.823
127	1.883
142	1.971
160	2.054
176	2.147
191	2.233
208	2.312
224	2.379
257	2.434
290	2.463
320	2.482
361	2.476
384	2.471
402	2.465
418	2.463
432	2.457
455	2.450
473	2.444
495	2.436
512	2.430
544	2.415
567	2.401
581	2.403

CURVE 4
T = 77

P	ρ
63	0.507
82	0.504
97	0.509
112	0.510
129	0.511
145	0.523
161	0.525
177	0.534
194	0.532
210	0.548
225	0.548
257	0.569
287	0.584
320	0.600
359	0.613

CURVE 4 (cont.)
T = 77

P	ρ
384	0.639
400	0.647
416	0.651
433	0.653
455	0.668
474	0.671
494	0.672
512	0.675
543	0.688
570	0.694
599	0.692

CURVE 5
T = 303

P	ρ
2.45	4.202
4.90	3.695
7.35	3.270
9.80	2.973
12.25	2.723
14.70	2.533
17.15	2.380
19.60	2.253
22.05	2.143
24.50	2.056
26.95	1.983
29.40	1.926

CURVE 6
T = 273

P	ρ
0.00	4.350
0.98	4.066
1.96	3.814
2.94	3.591
3.92	3.399
4.90	3.225
5.88	3.071
6.86	2.933
7.84	2.812
8.82	2.707
9.80	2.602
10.78	2.523
11.76	2.447

CURVE 7
T = 293

P	ρ
0.00	4.763
0.98	4.445
1.96	4.166
2.94	3.955
3.92	3.709
4.90	3.518
5.88	3.346
6.86	3.194
7.84	3.059
8.82	2.942
9.80	2.833
10.78	2.735
11.76	2.647

CURVE 8
T = 313

P	ρ
0.00	5.207
0.98	4.850
1.96	4.386
2.94	4.270
3.92	4.036
4.90	3.825
5.88	3.636
6.86	3.467
7.84	3.321
8.82	3.190
9.80	3.070
10.78	2.962
11.76	2.865

CURVE 9
T = 333

P	ρ
0.00	5.689
0.98	5.277
1.96	4.929
2.94	4.630
3.92	4.371
4.90	4.157
5.88	3.963
6.86	3.747
7.84	3.587
8.82	3.443
9.80	3.310
10.78	3.191
11.76	3.086

CURVE 10
T = 353

P	ρ
0.00	6.189
0.98	5.723
1.96	5.330
2.94	4.994
3.92	4.706
4.90	4.469
5.88	4.257
6.86	4.023
7.84	3.844
8.82	3.692
9.80	3.548
10.78	3.420
11.76	3.306

CURVE 11
T = 373

P	ρ
0.00	9.735
0.98	6.180
1.96	5.740
2.94	5.357
3.92	5.035
4.90	4.771
5.88	4.542
6.86	4.287
7.84	4.095
8.82	3.929
9.80	3.776
10.78	3.640
11.76	3.522

CURVE 12
T = 393

P	ρ
0.00	10.368
0.98	9.472
1.96	8.720
2.94	8.075
3.92	5.258
4.90	4.781*
5.88	4.620
6.86	4.309
7.84	4.072*
8.82	3.865
9.80	3.677*

CURVE 12 (cont.)
T = 393

P	ρ
10.78	3.523
11.76	3.386

CURVE 13
T = 413

P	ρ
0.00	11.05
0.98	10.12
1.96	9.27
2.94	8.583
3.92	8.003
4.90	7.527
5.88	5.053
6.86	4.711
7.84	4.480
8.82	4.224
9.80	4.017
10.78	3.850
11.76	3.700

CURVE 14
T = 433

P	ρ
0.00	11.770
0.98	10.740
1.96	9.360
2.94	9.120
3.92	8.501
4.90	7.982
5.88	7.527
6.86	7.041
7.84	6.665
8.82	6.344
9.80	4.340
10.78	4.151
11.76	3.988

CURVE 15
T = 453

P	ρ
0.00	12.550
0.98	11.440
1.96	10.510
2.94	9.710
3.92	9.033

* Not shown in figure.

TABLE 14. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Pressure Dependence) (continued)

P	ρ
CURVE 15 (cont.)	
T = 453	
4.90	8.471
5.88	7.982
6.86	7.448
7.84	7.041
8.82	6.694
9.80	6.375
10.78	6.095
11.76	5.857
CURVE 16	
T = 473	
0.00	13.360
0.98	12.180
1.96	11.140
2.94	10.312
3.92	9.722
4.90	8.973
5.88	8.441
6.86	7.868
7.84	7.426
8.82	7.039
9.80	6.694
10.78	6.388
11.76	6.120

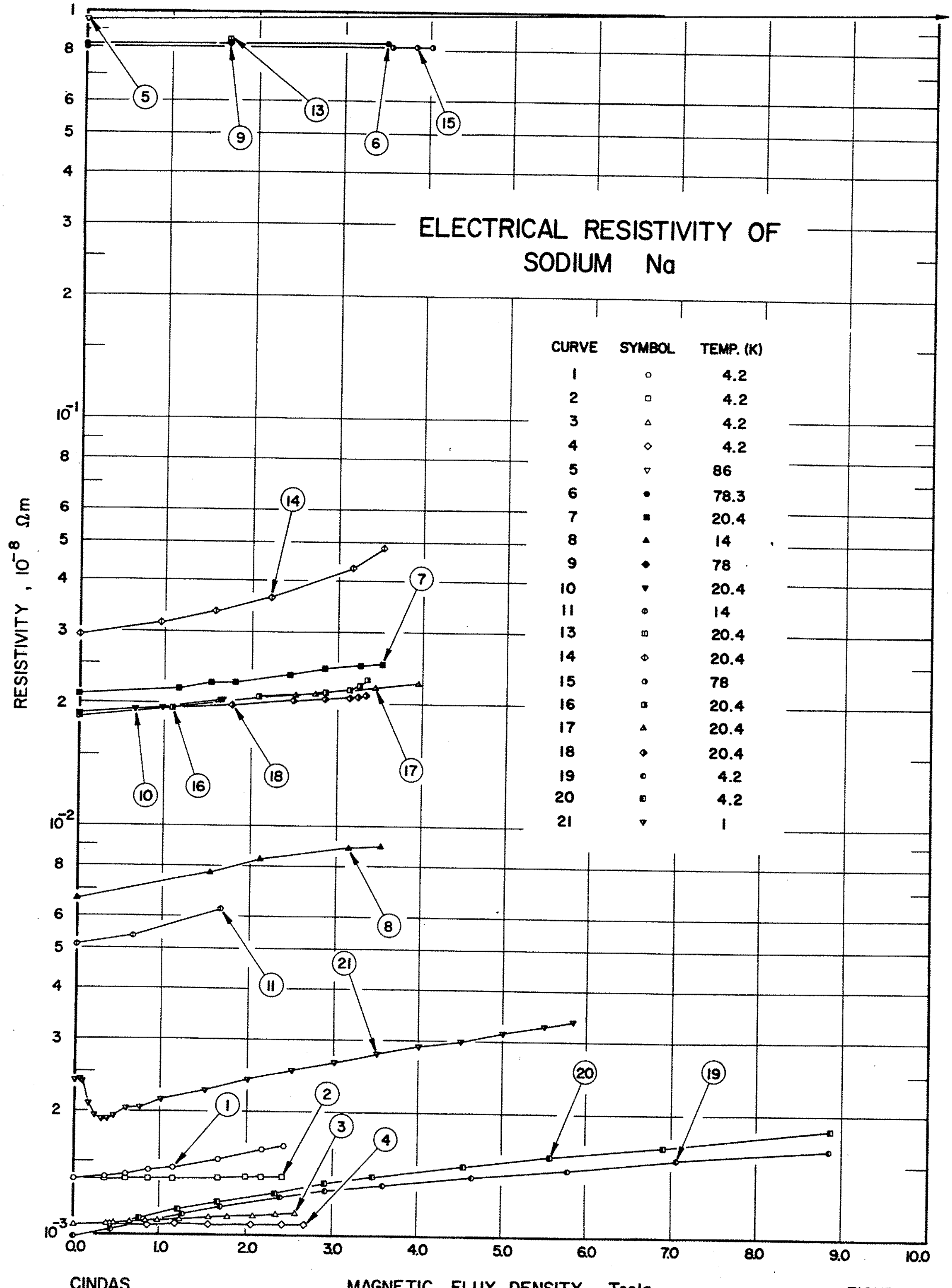

ELECTRICAL RESISTIVITY OF SODIUM Na
CURVE SYMBOL TEMP. (K)
1 ○ 4.2
2 □ 4.2
3 △ 4.2
4 ◇ 4.2
5 ▽ 86
6 ● 78.3
7 ■ 20.4
8 ▲ 14
9 ◆ 78
10 ▼ 20.4
11 ⦶ 14
13 ⊞ 20.4
14 ◇ 20.4
15 ○ 78
16 □ 20.4
17 △ 20.4
18 ◆ 20.4
19 ○ 4.2
20 □ 4.2
21 ▽ 1
RESISTIVITY, 10^{-8} Ωm
MAGNETIC FLUX DENSITY, Tesla
CINDAS

FIGURE 9

TABLE 15. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Magnetic Flux Density Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Magnetic Flux Density Range, Tesla	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	73	MacDonald, D.K.C.	1957		0-2.41	~4.2	Na, No. 1	Pure; the specimen was cast under high vacuum into a soft glass mold; platinum electrodes were used; $R_{4.2\,K}/R_{294\,K} = 2.85 \times 10^{-4}$; resistance was measured with the plane of specimen perpendicular to magnetic field H.
2	73	MacDonald, D.K.C.	1957		0-2.41	~4.2	Na, No. 1	Same as the above specimen; the resistance was measured with the plane of specimen parallel to magnetic field H.
3	73	MacDonald, D.K.C.	1957		0-2.54	~4.2	Na, No. 2	Pure; the specimen was cast under high vacuum into a soft glass mold; platinum electrons were used; $R_{4.2\,K}/R_{294\,K} = 2.2 \times 10^{-4}$; resistance was measured with the plane of specimen perpendicular to magnetic field H.
4	73	MacDonald, D.K.C.	1957		0-2.65	~4.2	Na, No. 2	Same as the above specimen; the resistance was measured with the plane of specimen parallel to the magnetic field H.
5	34	Kapitza, P.	1929		0, 30	86		Pure; specimen was obtained from Kahlbaum; magneto resistance measurements were made in a transverse magnetic field; R/R_r = 0.2, where R_r is the resistance at room temperature.
6	36	Justi, E.	1948	A	0, 3.5	78.4	Na 4	Pure; $R_{78.4\,K}/R_{273.15\,K} = 0.1894$; measured in a transverse field.
7	36	Justi, E.	1948	A	0-3.51	20.4	Na 4	Same as the above specimen and conditions; $R_{20.4\,K}/R_{273.15\,K} = 0.00483$.
8	36	Justi, E.	1948	A	0-3.51	14.0	Na 4	Same as the above specimen and conditions; $R_{14.0\,K}/R_{273.15\,K} = 0.00152$.
9	36	Justi, E.	1948	A	0, 1.65	78	Na 5	Similar to the above specimen and conditions; $R_{78\,K}/R_{273.15\,K} = 0.01893$.
10	36	Justi, E.	1948	A	0-1.65	20.4	Na 5	Same as the above specimen and conditions; $R_{20.4\,K}/R_{273.15\,K} = 0.00435$.
11	36	Justi, E.	1948	A	0-1.65	14.0	Na 5	Same as the above specimen and conditions; $R_{14.0\,K}/R_{273.15\,K} = 0.00117$.
12*	36	Justi, E.	1948	A	0, 1.65	78	Na 5	Same as the above specimen; it was measured in a longitudinal magnetic field.
13	36	Justi, E.	1948	A	0, 1.65	20.4	Na 5	Same as the above specimen; it was measured in a longitudinal magnetic field.
14	36	Justi, E.	1948	A	0-3.51	20.4	Na 10	Similar to the above specimen; $R_{20.4\,K}/R_{273.15\,K} = 0.00675$; it was measured in a transverse field.
15	36	Justi, E.	1948	A	0-4.02	78	Na 11	Similar to the above specimen; $R_{78\,K}/R_{273.15\,K} = 0.186$.
16	36	Justi, E.	1948	A	0-3.32	20.4	Na 11 mitt.	Similar to the above specimen; $R_{20.4\,K}/R_{273.15\,K} = 0.00432$.
17	36	Justi, E.	1948	A	0-3.95	20.4	Na 11 max	Similar to the above specimen and conditions.
18	36	Justi, E.	1948	A	0-3.32	20.4	Na 11 min	Similar to the above specimen and conditions.
19	74	Babiskin, J. and Siebenmann, P.G.	1969		0-9	4.2		Pure; wire sample 1 to 1.5 in. long and were helically wound on a 3-in. diameter form; $R_{300\,K}/R_{4.2\,K} = 5000$; data were extracted from the smooth curve.

* Not shown in figure.

TABLE 15. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Magnetic Flux Density Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Magnetic Flux Density Range, Tesla	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
20	74	Babiskin, J. and Siebenmann, P.G.	1969		0-9	4.2		Similar to the above specimen except it was distorted, i.e., about 25% of the total length.
21	75	Babiskin, J. and Sie Siebenmann, P.G.	1957		0-5.8	1		Pure Na; the sodium was contained in a soft-glass capillary with bulbous ends through which two currents and two potential probes of platinum were sealed; the sodium capillary was 80 μ (microns) in diameter and 1.1 cm long; since the sodium solidified slowly from one end during its preparation, it is to be a single crystal or nearly so; the sodium specimen was obtained through S. B. Woods of National Research Council of Canada; the magnetic field was produced by a Bitter Solenoid and it was known to 1% and uniform over the specimen to better than 0.1%; the specimen length was aligned perpendicular to H to within 1°.

TABLE 16. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SODIUM Na (Magnetic Flux Density Dependence)

[Temperature, T, K; Magnetic Flux Density, B, Tesla; Resistivity, ρ, 10^{-8} Ωm]

B	ρ
CURVE 1	T = 4.2
0.00	0.001371
0.35	0.001385
0.60	0.001408
0.87	0.001440
1.13	0.001469
1.65	0.001539
2.15	0.001613
2.41	0.001659
CURVE 2	T = 4.2
0.00	0.001371*
0.35	0.001372
0.60	0.001373
0.87	0.001375
1.13	0.001376
1.65	0.001379
1.98	0.001381
2.15	0.001382
2.40	0.001383
CURVE 3	T = 4.2
0.00	0.001058
0.38	0.001066
0.46	0.001068
0.65	0.001073
0.83	0.001078
0.98	0.001082
1.21	0.001089
1.55	0.001100
1.77	0.001107
2.08	0.001118
2.32	0.001126
2.54	0.001135
CURVE 4	T = 4.2
0.00	0.001058*
0.43	0.001059
0.85	0.001060
1.17	0.001061
1.54	0.001063
CURVE 4 (cont.)	T = 4.2
2.03	0.001065
2.40	0.001066
2.65	0.001067
CURVE 5	T = 86
0.0	0.9578
30.0	1.0248*
CURVE 6	T = 78.3
0.00	0.8239
3.50	0.8290
CURVE 7	T = 20.4
0.00	0.0210
1.15	0.02188
1.52	0.02262
1.80	0.02268
2.43	0.0236
2.83	0.0243
3.26	0.0248
3.51	0.0250
CURVE 8	T = 14.0
0.00	0.00661
1.52	0.00771
2.10	0.00832
3.13	0.00888
3.51	0.00897
CURVE 9	T = 78
0.00	0.8235*
1.65	0.8246
CURVE 10	T = 20.4
0.00	0.01892
0.65	0.01940
0.97	0.01957
1.65	0.02046
CURVE 11	T = 14.0
0.00	0.00509
0.65	0.00538
1.65	0.00623
CURVE 12*	T = 78
0.00	0.8235
1.65	0.8240
CURVE 13	T = 20.4
0.00	0.8235*
1.65	0.8474
CURVE 14	T = 20.4
0.00	0.02936
0.936	0.03155
1.56	0.03378
2.20	0.03629
3.15	0.04163
3.51	0.04413
CURVE 15	T = 78
0.00	0.8090
3.54	0.8119
3.84	0.8123
4.02	0.8124
CURVE 16	T = 20.4
0.00	0.01879
CURVE 16 (cont.)	T = 20.4
1.08	0.01950
2.08	0.02087
2.83	0.02137
3.12	0.02161
3.24	0.02225
3.32	0.02307
CURVE 17	T = 20.4
0.00	0.01879*
1.60	0.02027
2.50	0.02100
2.72	0.02118
3.11	0.02161
3.43	0.02195
3.95	0.02251
CURVE 18	T = 20.4
0.00	0.01879*
1.08	0.01937*
1.77	0.01983
2.49	0.02037
2.83	0.02057
3.12	0.02075
3.24	0.02088
3.32	0.02100
CURVE 19	T = 4.2
0.00	0.0009898
0.42	0.001044
0.81	0.001088
1.25	0.001129
1.69	0.001178
2.37	0.001233
2.90	0.001281
3.58	0.001327
4.65	0.001397
5.79	0.001464
7.06	0.001538
8.84	0.001647
CURVE 20	T = 4.2
0.00	0.0009898*
0.41	0.001050*
0.76	0.001098
1.20	0.001151
1.65	0.001203
2.31	0.001273
2.90	0.001333
3.47	0.001393
4.54	0.001488
5.59	0.001571
6.90	0.001678
8.86	0.001835
CURVE 21	T = 10
0.00	0.002394
0.05	0.002394
0.07	0.002381
0.14	0.002088
0.21	0.001965
0.30	0.001910
0.37	0.001910
0.45	0.001942
0.60	0.002029
0.76	0.002038
1.00	0.002134
1.50	0.002267
2.00	0.002404
2.50	0.002532
3.00	0.002659
3.50	0.002797
4.00	0.002915
4.50	0.003043
5.00	0.003167
5.50	0.003299
5.83	0.003381

* Not shown in figure.

4.3. Potassium

Potassium, with atomic number 19, is a silvery, soft, very reactive alkali metal, easily cut with a knife. Next to lithium, it is the second lightest known metal. It has a body-centered cubic crystalline structure with a density of 0.862 g cm^{-3} at 293 K. It melts at 336.35 K and boils at about 1047 K. Its critical temperature has been determined to be 2280.8±3 K. Naturally occurring potassium is composed of two stable isotopes, ^{39}K (93.10%) and ^{41}K (6.88%), and one radioactive isotope ^{40}K (0.00118%), which has a half-life of 1.28 × 10^{9} years. The radioactivity of ^{40}K presents no appreciable hazard. Potassium has six other radioactive isotopes known to exist. The metal is the eighth most abundant element in the continental crust of the earth (2.09% by weight).

a. Temperature Dependence

There are 49 sets of experimental data available for the temperature dependence on the electrical resistivity of potassium. The information on specimen characterization and measurement conditions for each of the data sets is given in table 18. The data are tabulated in table 19 and shown in figures 10 and 11. Determinations of the electrical resistivity of potassium for the solid, liquid, and gas phases cover the continuous temperature range from 1 to 2366 K.

There are 21 data sets obtained below 100 K. Among these, three sets are single data points at liquid helium temperature. Dugdale [76] (curve 1) gave the lowest residual resistivity, ρ_0 = 0.00087 × 10^{-8}Ω m. Dugdale and Gugan [8] tabulated electrical resistivities at constant volume (curve 17), which are lower than those at zero pressure (curve 18). Thirteen sets of intrinsic electrical resistivity values are obtained by subtraction of residual resistivity ρ_0 from the measured resistivity. In deriving the smoothed most probable values of intrinsic resistivity from the available data, the following overlapping temperature ranges were considered: below 10 K; 5–20 K; 10–40 K; 20–80 K; 30–150 K; etc. Within each range, a least-mean-square fraction error fit of the equation $\rho_i = aT^b$ was made to all the available intrinsic resistivity data. The resulting values for adjacent ranges were intercompared and the values were corrected for thermal linear expansion. These preliminary values were then fitted with the cubic spline function equation (7) to generate the final recommended values. The coefficients of equation (7) obtained in the fitting are given in the following table:

Temperature range, K	a	b	c	d
1 – 2.86	−6.796	5.219	0.164	−0.186
2.86– 6.42	−4.391	5.252	−0.092	0.442
6.42– 7.14	−2.547	5.350	0.372	−182.8
7.14– 8.00	−2.316	4.193	−25.19	198.8
8.00– 10.50	−2.147	3.157	4.027	−16.89
10.50–100	−1.745	3.399	−1.978	0.603

Below [illegible] approximately [illegible]

There are 16 data sets in the temperature region from 100 K to the melting point, 336.35 K. Dugdale and Gugan [8] also tabulated electrical resistivities at constant volume (curve 17), which are lower than those at zero pressure (curve 18). A least-mean-square-error fit to the totality of experimental data except those measured at constant volume in this range was made with a third order polynomial. The resulting values were corrected for thermal linear expansion, and then fitted the cubic spline function of equation (7) to obtain the final recommended values in this temperature range. The coefficients of equation (7) obtained are as follows:

Temperature range, K	a	b	c	d
10.5 –270.65	−1.745	3.399	−1.978	0.603
270.65–336.35	−0.807	1.418	0.574	22.28

There are 23 data sets available for the liquid state. Endo [40] (curve 29), and Lien and Silversten [41] (curve 30) also tabulated the electrical resistivities at constant volume. Freyland and Hansel [77] (curves 41 to 44) have measured the electrical resistivity at several constant pressure conditions from the melting point up to the critical temperature and above. The rest of the data are apparently measured at the saturated vapor pressure. Below 1000 K they agree with one another within 10%; the error may be somewhat higher above 1000 K. Roehlich and Tepper [17] (curve 26) give the highest value while Solov'ev [52] (curve 31) gives the lowest values. Below 1300 K, all the experimental data except those measured at constant volume and at constant pressure were fitted by a logarithmic third order polynomial. Above 1300 K, the resistivity values were obtained by extrapolating the fitted values and following the experimental trend. These values were then fitted with the cubic spline function equation (7) to generate the final recommended values. The coefficients of equation (7) obtained are as follows:

Temperature range, K	a	b	c	d
336.35–1090.3	1.146	1.154	0.494	0.287
1090.3 –2000	1.901	1.882	0.933	13.67

At the melting point (336.35 K), the electrical resistivity of potassium in the liquid state is about 50% higher than that of the solid state.

The recommended values for the total and intrinsic electrical resistivity are listed in table 17, and those for the total electrical resistivity are also shown in figures 9 and 10. The recommended values for the liquid state are for the saturated liquid. The recommended values of the total resistivities for the solid state are for a 99.99+% pure potassium and those at temperatures below 40 K are only applicable to a specimen with residual resistivity ρ_0 = 0.00085 × 10^{-8}Ωm. The recommended values from 1 K to 336.8 K are corrected for thermal linear expansion. The correction amounts to −1.74% at 1 K, −1.1% at 135 K, and 0.35% at 336.35 K. Because there is a strong indication for deviation from the Matthiesen's rule for the electrical resistivity of potassium [128], the values of ρ and ρ_i below 30 K are considered provisional. The uncertainty of the recommended total electrical resistivity is believed to be within ±20% from 1 K to 30 K, within ±50% from 40 K to 1500 K and within ±10% from 1500 K to 2000 K. Above 30 K the uncertainty of the recommended values for the intrinsic resistivity is about the same as that of the total electrical resistivity; below 30 K this uncertainty is higher than that of the total electrical resistivity.

b. Pressure Dependence

There are 12 sets of experimental data available for the electrical resistivity of potassium as a function of pressure. The information on specimen characterization and measurement conditions for each of the data sets is given in table 20. The data are tabulated in table 21 and shown in figure 12.

The available data and information for the pressure dependence of electrical resistivity of potassium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

c. Magnetic Flux Density Dependence

There are 35 sets of experimental data available for the electrical resistivity of potassium under the influence of magnetic field. The information on specimen characterization and measurement information for each of the data sets is given in table 22. The data are tabulated in table 23 and shown in figure 13.

The available data and information for the magnetic flux density dependence of electrical resistivity of potassium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

TABLE 17. RECOMMENDED ELECTRICAL RESISTIVITY OF POTASSIUM
(Temperature Dependence)

[Temperature, T, K; Total Resistivity, ρ, 10^{-8} Ωm; Intrinsic Resistivity, ρ_i, 10^{-8} Ωm]

Solid						Liquid	
T	ρ	ρ_i	T	ρ	ρ_i	T	ρ
1	0.00085*		35	0.379	0.378	336.35	13.95
2	0.00086*	6.1×10^{-6}*	40	0.480	0.479	350	14.64
3	0.00091*	5.1×10^{-5}*	45	0.583	0.582	400	17.18
4	0.00109*	2.3×10^{-4}*	50	0.689	0.688	500	22.91
5	0.00161*	0.00076*	60	0.905	0.904	600	29.58
6	0.00284*	0.00199*	70	1.12	1.12	700	37.31
7	0.00523*	0.00437*	80	1.34	1.34	800	46.20
8	0.00804*	0.00719*	90	1.56	1.56	900	56.36
9	0.0114*	0.0106*	100	1.79	1.79	1000	67.94
10	0.0160*	0.0152*	150	2.99	2.99	1100	81.05
11	0.0218*	0.0209*	200	4.26	4.26	1200	96.04
12	0.0286*	0.0278*	250	5.74	5.74	1300	114.0
13	0.0366*	0.0357*	273.15	6.49	6.49	1400	136.3
14	0.0455*	0.0446*	293	7.20	7.20	1500	164.6
15	0.0554*	0.0545*	300	7.47	7.47	1600	201.4*
16	0.0661*	0.0652*	336.35	9.22	9.22	1700	249.7*
18	0.0900*	0.0891*				1800	313.8*
20	0.117*	0.116*				1900	399.6*
25	0.195*	0.194*				2000	575.3*
30	0.283*	0.282*					

* Provisional values.

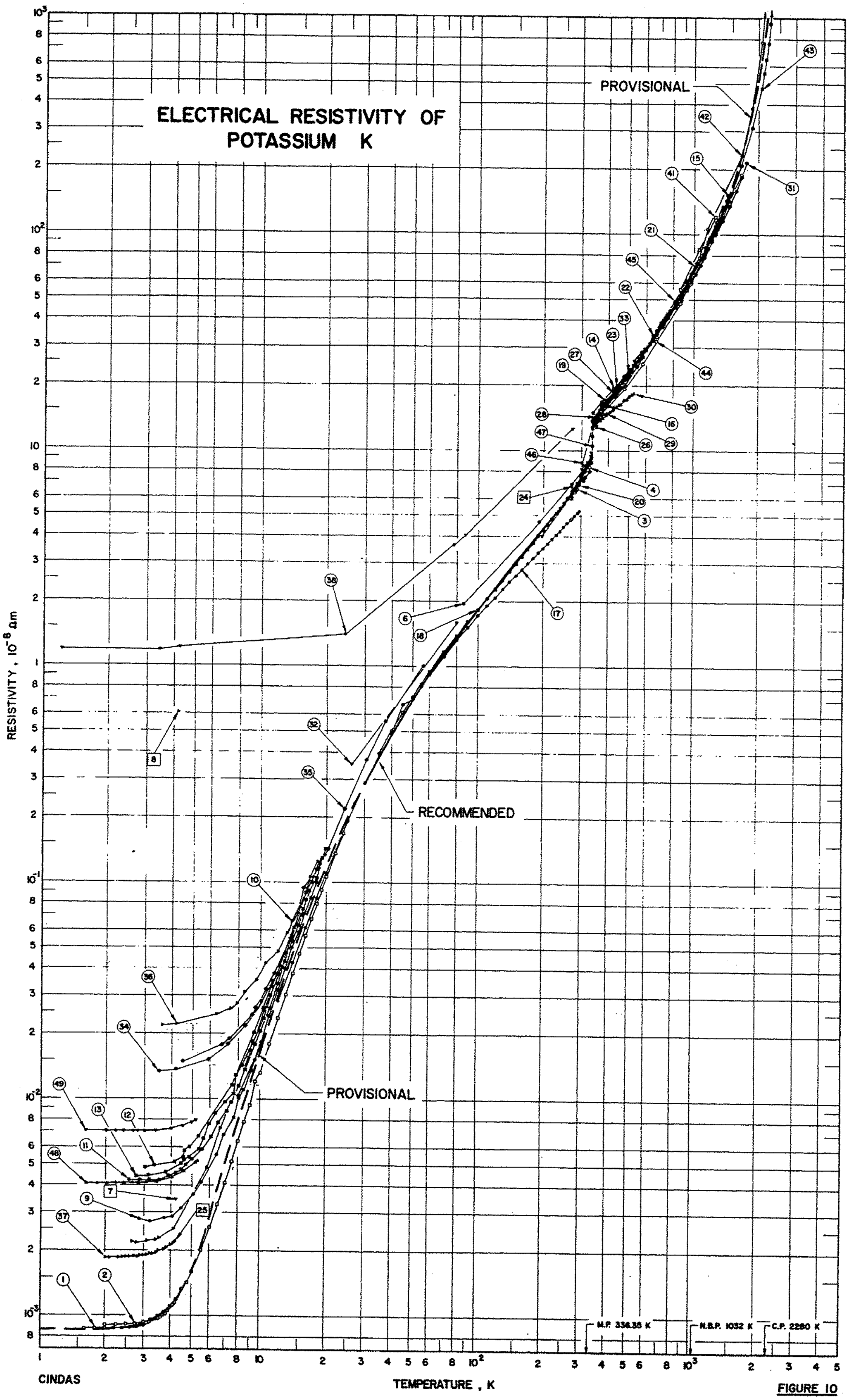
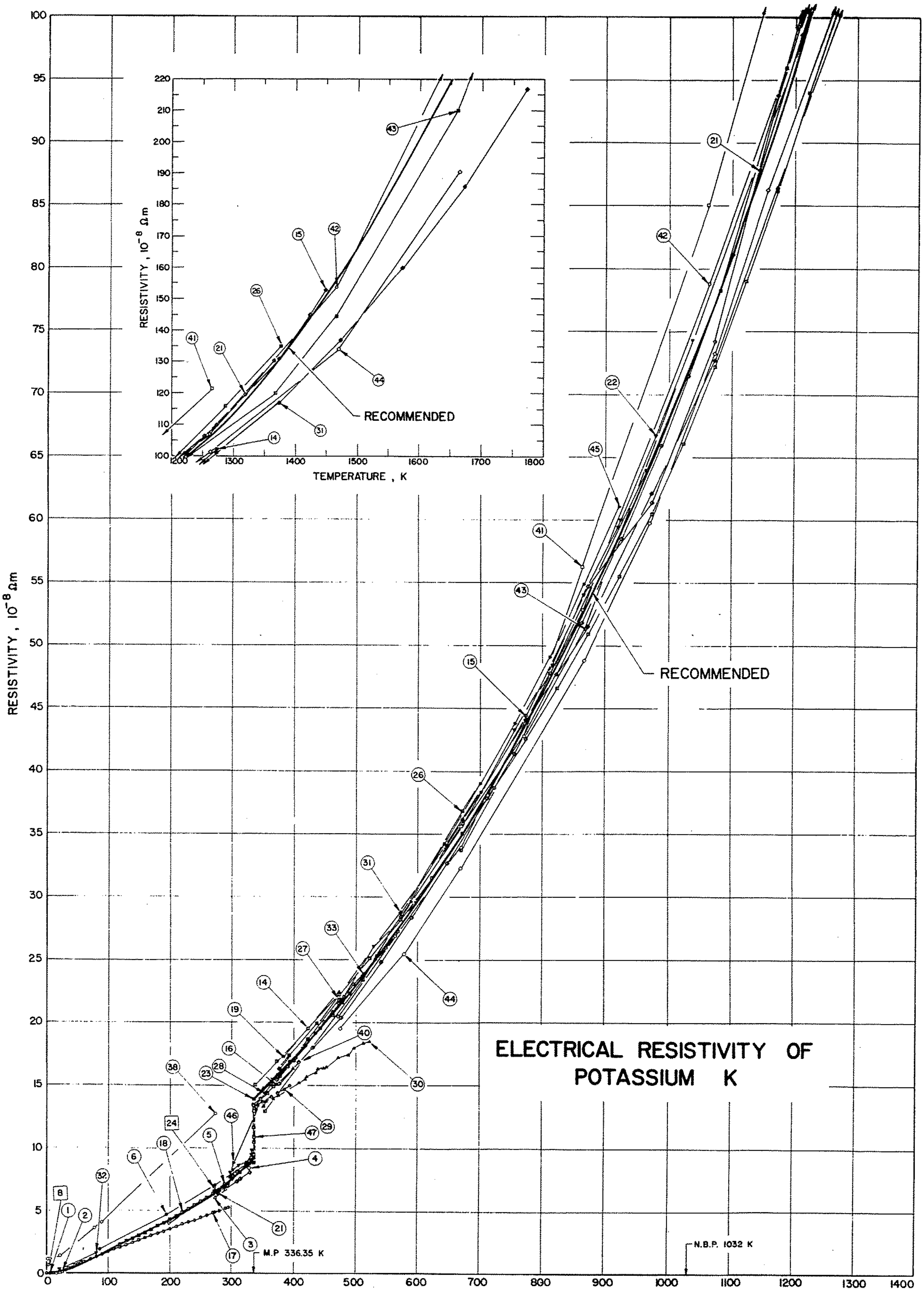

ELECTRICAL RESISTIVITY OF
POTASSIUM K
PROVISIONAL
RECOMMENDED
PROVISIONAL
RESISTIVITY, 10^{-8} Ωm
TEMPERATURE, K
M.P. 336.35 K
N.B.P. 1032 K
C.P. 2280 K
CINDAS

FIGURE 10



ELECTRICAL RESISTIVITY OF POTASSIUM K
RESISTIVITY, 10^{-8} Ω m
TEMPERATURE, K
RECOMMENDED
M.P 336.35 K
N.B.P. 1032 K
CINDAS

FIGURE 11

TABLE 18. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Temperature Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	76	Gugan, D.	1971		1.2-4.2	K3(c)	Pure; low sodium grade material was supplied by Mine Safety Appliance Co.; polycrystalline wire specimen 1 mm in diameter and 20 cm long; sample was fully annealed at 250 K.
2	78	Ekin, J.W. and Maxfield, B.W.	1971	C	1-25		High purity polycrystalline wire specimen was extruded from the potassium obtained from Mine Safety Appliance, Ltd.
3	56	Hackspill, L.	1910	A	273, 291	1	Pure.
4	56	Hackspill, L.	1910	A	292, 328	2	Pure.
5	56	Hackspill, L.	1910	A	198, 289	3	Pure.
6	19	Gantz, A. and Bronieswki, W.	1909		86-323		Pure.
7	79	Natale, G.G. and Rudnick, I.	1968	A	4.2	K1	99.98 pure; specimen was obtained from M.S.R. Research Corp.; sample 0.208 cm in diameter and 10.4 cm in length; unannealed; $\rho_{273}/\rho_{4.2}$ = 1790.
8	79	Natale, G.G. and Rudnick, I.	1968	A	4.2	K11	Similar to the above specimen except the length was 10.3 cm; $\rho_{273}/\rho_{4.2}$ = 10.
9	79	Natale, G.G. and Rudnick, I.	1968	A	2.5-20	K1B	Similar to the above specimen; sample length 10.9 cm and was annealed at 105 K for 1 hr; $\rho_{273}/\rho_{4.2}$ = 1708.
10	79	Natale, G.G. and Rudnick, I.	1968	A	2.5-20	K12	Similar to the above specimen; sample length 9.8 cm; $\rho_{273}/\rho_{4.2}$ = 2440.
11	79	Natale, G.G. and Rudnick, I.	1968	A	2.5-20	K13	Similar to the above specimen; sample length 9.6 cm; unannealed; $\rho_{273}/\rho_{4.2}$ = 1342.
12	79	Natale, G.G. and Rudnick, I.	1968	A	2.5-20	K18	Similar to the above specimen; sample length 10.0 cm; $\rho_{273}/\rho_{4.2}$ = 1187.
13	79	Natale, G.G. and Rudnick, I.	1968	A	2.5-20	K19	Similar to the above specimen; $\rho_{273}/\rho_{4.2}$ = 1276.
14	18	Semyachkin, B.E. and Solov'ev, A.N.	1964	A	338-1273		Pure; TUMK HP 2010-5 sample was placed in an 0.8/0.5 mm 1Kh 18Ng T steel capillary, 60 mm in length.
15	80, 81	Lemmon, A.W. Jr., Deem, H.W., Eldridge, E.A., Hall, E.H., Matolich, J. Jr., and Walling, J.F.	1963		301-1448		0.1 Na, 0.0053 O_2, 0.003 Li, 0.005 Rb, 0.001 Cs, Zr, Fe, Co.
16	45	Hennephof, J., Van der Lugt, W., and Wright, G.W.	1971	B	373.2-398		Pure; resistivity was a linear function of temperature from melting point up to 125 C; described by $d\rho/dT = 0.053 \times 10^{-8}\ \Omega m\ K^{-1}$.
17	8	Dugdale, J.S. and Gugan, D.	1962	A	8-295.1	K(3), K(4)	Pure; specimens were obtained from Mine Safety Appliance Ltd., Toronto; the specimens were made in the form of bare wires about 100 cm long and 0.5 mm in diameter; electrical resistivity was obtained at constant density condition; $\rho(0)/\rho(293) = 8.10^{-4}$.
18	8	Dugdale, J.S. and Gugan, D.	1962	A	8-295.1	K(3), K(4)	Similar to the above specimens except the electrical resistivity was measured at zero pressure condition.
19	49	Akenova, L.I. and Belaschenko, D.K.	1971		383-473		99.9 pure; measurements made in capillary cell; liquid state specimen.
20	58	Hornbeck, J.W.	1913		278-331		Pure; trace of Na; supplied by Eimer and Amend.
21	16	Tepper, F., Zelenak, J., Roehlich, F., and May, V.	1965	A	296-1365		Pure; liquid state specimen; density 0.7851, 0.7434, 0.7161, 0.6889, 0.6664, 0.6276, 0.6024, and 0.5861 g cm^{-3} at 520.5, 701.3, 827.7, 944.3, 1048, 1206, 1302, and 1374 K respectively.

TABLE 18. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
22	43	Kapelner, S.M. and Bratton, W.D.	1962	B	298-1037		0.32 Na, 0.02 Fe, and 0.04 O_2; molten specimen contained in 347 stainless steel tube; specimen was supplied by Fisher Scientific Co.
23	57	Regel, A.R.	1958		273-433		Pure; data were extracted from the smooth curve.
24	22	Krautz, E.	1950	A	273		Pure.
25	82	Archibald, M.A., Dunick, J.E., and Jericho, M.H.	1967		4.2		99.9$^+$ pure; specimen was supplied by J. T. Baker Chemical Co.; sample was placed in a nylon tube with 1 mm bore.
26	17	Roehlich, F. and Tepper, F.	1965	A	341-1366		Pure; specimen was placed in a Hayne-25 alloy cylindrical cell 0.5" in O.D., 0.063" in wall thickness, and 26" in length.
27	46	Bornemann, K. and Rauschenplat, G.	1912		337-623		Pure potassium; liquid state.
28	40	Endo, H.	1963	A	330-390		Pure; sample was supplied by A. D. Mackay Ltd.; specimen container was made of soft glass capillary tube (I.D. 0.3 mm); electrical resistivity was measured at constant pressure condition.
29	40	Endo, H.	1963	A	330-390		Same as above specimen except the electrical resistivity was obtained at constant volume.
30	41	Lien, S.Y. and Silversten, J.M.	1969	A	373-623		99.95 pure; sample was supplied by A. D. Mackay Inc.; specimen cell was made from precision quartz capillary open on one end; constant volume.
31	52	Solov'ev, A.N.	1963		373-1773		Pure; liquid state specimen; density 0.829 g cm^{-3} at 337 K, 0.676 g cm^{-3} at 973 K; electrical resistivity data above 973 K were extrapolated.
32	54	McLennan, J.C. and Niven, C.D.	1927	B	20.6-273		Pure.
33	83	Itami, T. and Shimoji, M.	1970	A	373-533		99.98 pure; the measuring cell was made of balio glass and four tungsten wires were sealed as the current and potential probes.
34	23	MacDonald, D.K.C., White, G.K., and Woods, S.B.	1955	A	3.5-12.6	K1	Pure; specimen was obtained from the Pure Metals Research Committee of the United Kingdom; specimen was melted in vacuo and run into soft-glass tubes with platinum leads sealed in; sample effective diameter 1.3 mm; $\rho_0/\rho_{295} = 1.88 \times 10^{-3}$.
35	23	MacDonald, D.K.C., et al.	1955	A	4.5-56.4	K2	Similar to the above specimen except the effective diameter was 2.1 mm and $\rho_0/\rho_{295} = 1.95 \times 10^{-3}$.
36	23	MacDonald, D.K.C., et al.	1955	A	3.6-17.5	K4	Similar to the above specimen except the effective diameter was 1.3 mm and $\rho_0/\rho_{295} = 3.08 \times 10^{-3}$.
37	61, 62	Gorland, J.C. and Bower, R.	1968	A	2-4.2		Pure; specimen was prepared by cold-extruding vacuum distilled potassium under oil; copper wire current and voltage probes were then inserted into the extruded wire; residual resistivity was obtained by using $\rho_{290} = 7.10 \times 10^{-8}$ Ωm.
38	29	Messiner, W. and Voigt, B.	1930	→	1.22-273	K2	Pure; specimen was obtained by melting in vacuum; sample diameter 4.8 mm and 123 mm long; the resistance was measured by compensation method with a mirror galvanometer.
39*	67	Northup, E.F.	1911	B	293.15, 373.15		Pure; specimen was supplied by Merck; sample was filled in a glass tube supplied with platinum potential and current terminals; the electrical resistivity data were obtained by comparison with the electric resistance data of mercury and potassium.

* Not shown in figure.

TABLE 18. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
40	68	Van der Lugt, W., Devin, J.F., Hennephof, J., and Leenstra, M.R.	1972	B	338.15, 408.15		Pure.
41	77	Freyland, W.F. and Hansel, F.	1972		337-1265		Pure; liquid potassium was filled in a cylindrical tungsten-rhenium container with thin wall; the electrical resistivity of the fluid metal within the cell is measured parallel to the known resistance of the surrounding metallic container; measurement was taken at pressure equal to 10 bar.
42	77	Freyland, W.F. and Hansel, F.	1972		471-2173		Same as the above specimen; the electrical resistivity was measured at pressure equal to 160 bar.
43	77	Freyland, W.F. and Hansel, F.	1972		670-2366		Same as the above specimen; the electrical resistivity was measured at pressure equal to 230 bar.
44	77	Freyland, W.F. and Hansel, F.	1972		475-1665		Same as the above specimen; the electrical resistivity was measured at pressure equal to 310 bar.
45	70	Bonilla, C.F., Lee, D.I., and Foley, P.J.	1965	V	533-922		99.97 pure, 0.005 each Na, O_2; specimen was obtained from MSA Research Corp; liquid state specimen was contained in a 316 type stainless steel tube with 7/16 in. O.D., wall 0.018 in. and about 8 in. long; chromel-alumel thermocouples were used to measure the temperature.
46	84	Kurnakow, N.S. and Nikitinsky, A.J.	1914	B	273-373		Pure; Thomson double bridge was used for measuring the electrical resistivity; the specimen was filled in a glass tube and immersed in Vaslin thermostat; mercury was filled in the test tube for calibration.
47	47	Addison, C.C., Creffield, G.K., and Pulham, R.J.	1971		302-569		99.9 purity specimen (Koch-Light) was washed free of protective oil with light petroleum and purified before use by filtration at just above the melting point through a sintered glass pad; the specimen was contained in a steel capillary of known cross-sectional area and length.
48	85	Aleksandrov, B.N., Lomonos, O.I., and Semenova, E.D.	1973	A	1.6-5.2	K1	99.99 purity specimen was contained in glass capillaries of diameter 1.2 mm and length 45 mm, into which were sealed potential and current leads in the form of platinum or molybdenum wire; relative resistivity data were reported; data were extracted from figure.
49	85	Aleksandrov, B.N., et al.	1973	A	1.6-5.2	K2	Similar to the above specimen.

TABLE 19. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Temperature Dependence)

[Temperature, T, K; Resistivity, ρ, 10^{-8} Ωm]

T	ρ
CURVE 1	
0.0	0.00087*
1.6	0.00087018
1.8	0.00087044
2.0	0.0008711
2.2	0.00087253
2.4	0.0008754
2.6	0.0008804
2.8	0.000889
3.0	0.0009019
3.2	0.0009326
3.3	0.0009467*
3.4	0.0009667
3.5	0.0009728
3.6	0.0009813
3.7	0.0010025
3.8	0.0010263
3.9	0.0010624
4.0	0.0010913*
4.1	0.0011232
4.2	0.0011577
CURVE 2	
2.00	0.0009016
2.25	0.0009041
2.50	0.0009085
2.75	0.000917
3.00	0.00093
3.25	0.00095
3.50	0.00099
3.75	0.001042
4.00	0.001108
4.25	0.001194
4.50	0.001303
4.75	0.001436
5.00	0.001595
5.50	0.002
6.00	0.00255
6.50	0.00324
7.00	0.00408
7.50	0.00511
8.00	0.00632
8.50	0.00772
9.00	0.00933
9.50	0.00121
10.00	0.0132
11.00	0.0179
12.00	0.0236
CURVE 2 (cont.)	
13.00	0.0302
14.00	0.0379
15.00	0.0467
16.00	0.0566
17.00	0.0676
18.00	0.0795
19.00	0.0925
20.00	0.1069
22.00	0.1369
24.00	0.1699
CURVE 3	
273	6.0
291	6.7
CURVE 4	
292	6.7*
328	8.4
CURVE 5	
198	4.0
273	6.3
289	7.1
CURVE 6	
86.0	1.96
194.8	4.70
273.0	7.01
323.1	8.65
CURVE 7	
4.2	0.00341
CURVE 8	
4.2	0.61
CURVE 9	
2.85	0.00277
3.18	0.0027
CURVE 9 (cont.)	
3.74	0.0028
4.04	0.00285
4.43	0.0031
5.08	0.0036
5.50	0.0041
6.47	0.0055
6.93	0.0068
7.67	0.0082
8.04	0.0100
8.45	0.0110
9.14	0.0135
9.48	0.0152
10.05	0.0183
10.94	0.0243
12.00	0.0320
12.94	0.040
13.80	0.050
14.89	0.059
15.74	0.072
16.98	0.085
18.03	0.100
18.49	0.117
19.68	0.135
CURVE 10	
2.65	0.00218
2.78	0.00216
3.10	0.0022
3.40	0.00223
3.53	0.00227
4.12	0.0025
5.86	0.0048
6.71	0.0073
8.93	0.0155
10.45	0.0256
13.84	0.0664
15.07	0.0771
16.79	0.1078
18.28	0.1266
CURVE 11	
2.56	0.0042
2.86	0.0042
3.17	0.0042
3.52	0.0042
3.88	0.0044
CURVE 11 (cont.)	
4.18	0.0045*
4.44	0.0047
4.69	0.00495
4.98	0.00522
5.55	0.00582
6.05	0.00665
6.55	0.00776
7.11	0.00873
7.50	0.00966
8.05	0.01159
8.59	0.01374
8.85	0.01538*
9.44	0.01791
10.00	0.02065
11.09	0.02649
12.00	0.03412
12.82	0.04335
13.96	0.0537
14.93	0.0638
15.67	0.0752
16.63	0.092
18.07	0.105
18.62	0.123
19.95	0.144
CURVE 12	
3.02	0.0048
3.33	0.0049
4.14	0.0051
4.56	0.00538
4.59	0.00574
4.86	0.00597
5.33	0.0067
7.57	0.0116
9.40	0.0203
10.35	0.0264
11.05	0.0333
12.25	0.0415
14.22	0.062
16.07	0.090
17.02	0.101
18.03	0.116
19.10	0.130
CURVE 13	
2.76	0.00437
CURVE 13 (cont.)	
2.80	0.00438*
3.12	0.0044
3.78	0.00457
4.46	0.0050
4.59	0.0052
4.83	0.00532
5.37	0.00583
5.61	0.00652
5.98	0.00764
6.38	0.00859
7.05	0.00963
7.67	0.0106
7.83	0.0128
8.38	0.0143
9.00	0.0168
9.27	0.0185
10.47	0.0236
11.12	0.0302
12.08	0.0378
13.06	0.0474
13.80	0.0568
15.38	0.0705
16.18	0.0834
CURVE 14	
338	15.0
373	16.9
423	19.5
473	22.2*
523	25.1
573	28.2
623	31.5
673	35.1
723	38.7
773	42.6
823	46.6
873	50.9
923	55.5
973	60.5
1023	66.1
1073	72.2*
1123	79.0
1173	86.2*
1223	94.0
1273	102.3
CURVE 15	
301	7.52
373	15.4
473	21.5
573	28.4*
673	35.8*
773	44.4
873	54.3
973	66.4
1033	74.2
1173	93.8
1273	110.0
1373	131.0
1423	145.0
1448	153.0
CURVE 16	
373.2	15.0
398.0	16.3
CURVE 17	
8	0.0103
10	0.0177
12	0.0284
14	0.0428
16	0.0618
18	0.0849
20	0.110
25	0.193
30	0.289
35	0.389
40	0.494
45	0.668
50	0.709
55	0.817
60	0.925
70	1.114
80	1.334
90	1.524
100	1.724
110	1.914
120	2.094
130	2.284
140	2.464
150	2.644
160	2.824
170	3.004

* Not shown in figure.

TABLE 19. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Temperature Dependence) (continued)

T	ρ
CURVE 17 (cont.)	
180	3.184
190	3.364
200	3.544
210	3.724
220	3.904
230	4.084
240	4.264
250	4.444
260	4.624
270	4.814
273.15	4.864
280	4.994
290	5.184
295.1	5.274
CURVE 18	
8	0.0103*
10	0.0177*
12	0.0284*
14	0.0428*
16	0.0618*
18	0.0849*
20	0.110*
25	0.193*
30	0.289*
35	0.393
40	0.500
45	0.611
50	0.723
55	0.835
60	0.948
70	1.174
80	1.394
90	1.614
100	1.844
110	2.064
120	2.294
130	2.534
140	2.764
150	3.004
160	3.254
170	3.504
180	3.754
190	4.024
200	4.284
210	4.554
220	4.834
230	5.124
CURVE 18 (cont.)	
240	5.424
250	5.724
260	6.034
270	6.344
273.15	6.454
280	6.674
290	7.014*
295.1	7.194
CURVE 19	
383	17.3
423	19.4*
473	22.4
CURVE 20	
278.0	6.492*
278.0	6.442
293.8	7.015
293.9	7.035*
294.1	6.980*
330.6	8.353*
331.0	8.338*
CURVE 21	
296	7.02*
309	7.32
314	7.54
329	8.05
376	15.05
431	17.96
476	20.31
541	24.83
591	28.34
648	32.64
712	37.84
755	41.43
822	47.70
863	51.81
926	58.51
988	65.94
1031	71.44
1102	81.18
1144	87.82
1210	98.61
1253	106.63
1319	119.87
1365	130.61
CURVE 22	
298.5	8.07
302.6	8.24
311.5	8.59
324.6	8.82
331.5	9.47
332.4	9.81
352.6	14.77
365.1	15.48
414.0	17.90
478.2	21.86
529.6	26.06
597.1	29.57
646.8	34.11
702.4	38.32
755.1	43.30
816.0	48.47
866.6	54.04
920.1	59.47
924.6	60.02
979.9	66.75
1037.4	74.30
CURVE 23	
273.15	6.54
313.15	8.05
336.15	8.86
336.15	13.84
393.15	17.38
437.15	19.93
CURVE 24	
273	6.88
CURVE 25	
4.2	0.0022
CURVE 26	
354	12.9
512	23.36
672	36.83
811	47.75
964	64.00
1081	78.23
1186	96.01
1287	115.8
1376	135.1
CURVE 27	
373	15.49*
423	18.70
473	21.80
523	25.00*
573	28.20*
623	31.40*
337	13.16
CURVE 28	
336.1	13.21*
353.2	14.33
363.3	15.03
372.7	15.59*
393.0	16.89
CURVE 29	
342.8	13.39
350.6	13.65
363.5	14.05
374.2	14.34
384.5	14.63
393.4	14.97
CURVE 30	
336.55	13.1
351.05	13.3
355.65	13.7
367.75	13.87
375.35	14.19
387.05	14.67
408.15	15.17
418.95	15.43
420.05	15.60
435.85	15.94
438.15	16.21
448.85	16.30
452.05	16.40
454.05	16.48*
456.05	16.46*
472.85	17.17
488.45	17.37
497.75	17.93
512.25	18.33
514.75	18.27*
522.85	18.49
CURVE 31	
337	13.78
373	16.30
473	22.35
573	28.75
673	36.15
773	44.1
873	51.15
973	62.1
1073	72.7
1173	86.4
1273	101.0
1373	117.0
1473	137.0
1573	160.0
1673	186.0
1773	217.0
CURVE 32	
20.6	0.35
80	1.6
191	4.0*
273	6.1*
CURVE 33	
374.25	15.67
390.35	16.43
403.65	17.19
419.05	18.16
435.45	19.13
449.55	20.03
463.35	20.88
481.55	22.04
497.85	23.07
513.25	23.85
532.05	25.01
CURVE 34	
3.5	0.0134
4.2	0.0137
5.9	0.0152
7.2	0.0179
8.6	0.0219
10.1	0.0284
11.4	0.0353
12.6	0.0408
CURVE 35	
4.5	0.0149
6.8	0.0178
7.3	0.0190
9.2	0.0245
9.5	0.0265
10.7	0.0323
11.6	0.0382
13.7	0.0551
15.7	0.0745
20.4	0.1435
24.3	0.2199
30.7	0.3678
37.5	0.5583
56.4	1.0138
CURVE 36	
3.6	0.0219
4.2	0.0221
6.4	0.0247
7.4	0.0261
7.9	0.0276
8.5	0.0312
9.6	0.0355
10.6	0.0424
12.0	0.0480
13.2	0.0588
14.8	0.0725
17.5	0.107
CURVE 37	
2.01	0.00185
2.10	0.00185
2.18	0.00185*
2.30	0.00185
2.39	0.00186
2.49	0.00187
2.58	0.00187
2.71	0.00188
2.81	0.00188
2.89	0.00189
2.99	0.00190
3.03	0.00191*
3.09	0.00191
3.13	0.00192*
3.20	0.00192
3.30	0.00194
3.33	0.00195*

* Not shown in figure.

TABLE 19. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Temperature Dependence) (continued)

T	ρ
CURVE 37 (cont.)	
3.39	0.00195
3.45	0.00196*
3.49	0.00198
3.54	0.00198*
3.60	0.00199*
3.64	0.00201*
3.70	0.00202
3.73	0.00203*
3.74	0.00203*
3.80	0.00205
3.84	0.00206*
3.86	0.00208*
3.95	0.00211*
4.00	0.00212
4.04	0.00213*
4.07	0.00215*
4.11	0.00216
4.15	0.00219*
4.18	0.0022*
CURVE 38	
1.22	1.182
3.44	1.182
4.21	1.202
20.42	1.409
77.60	3.653
87.81	4.075
273.16	12.75
CURVE 39*	
293.15	7.118
373.15	15.275
CURVE 40	
338.15	13.1*
408.15	16.8
CURVE 41	
336.8	12.98
670	35.65
771	42.76
864	56.23
1062	85.11
1265	121.61
CURVE 42	
471	20.46
563	26.98
670	33.96
864	52.84
1064	78.88
1261	107.15
1466	153.81
1667	233.88
1865	388.15
2070	788.85
2122	1185.75*
2173	3104.60*
CURVE 43	
670	33.8
869	51.4
1367	120.2
1466	144.5
1662	210.4
1862	311.1
2065	480.8
2126	563.6
2169	653.1
2222	772.6
2267	959.4
2327	1224.0*
2366	1496.0*
CURVE 44	
475	19.50
578	25.47
669	32.28
867	48.86
969	59.98
1072	73.28
1157	86.30
1263	101.6
1469	135.2
1665	190.9
CURVE 45	
533	25.2
589	29.6
644	34.2
700	39.0
CURVE 45 (cont.)	
755	43.8
811	49.1
866.5	54.9
922	61.1
CURVE 46	
273	6.60*
298	7.71
303	8.82
348	14.43
373	15.80
CURVE 47	
302	7.87
310	8.13
321	8.57*
331	9.03
335	9.22
336	9.55*
336	10.59
336	10.95
336	11.70
336	13.50
347	13.94
357	14.49
368	14.98
378	15.72
400	16.96
418	18.04*
443	19.51
464	20.69
479	21.64
491	22.35
512	23.67
534	25.11*
549	25.97
569	27.28
CURVE 48	
1.61	0.004045
1.82	0.004045
2.02	0.004045
2.21	0.004044
2.40	0.004063
2.62	0.004077
CURVE 48 (cont.)	
2.80	0.004094
3.00	0.004108
3.19	0.004150*
3.40	0.004189
3.59	0.004203*
3.81	0.004258*
4.00	0.004317
4.21	0.004402*
4.31	0.004466*
4.43	0.004503*
4.49	0.004575*
4.57	0.004620
4.66	0.004681*
4.71	0.004721*
4.82	0.004768*
4.90	0.004831*
4.97	0.004870*
5.04	0.004929
5.10	0.004965*
5.18	0.005035
CURVE 49	
1.62	0.007012
2.00	0.007027
2.21	0.007028
2.42	0.007027
2.63	0.007028
2.79	0.007043
3.00	0.007050
3.20	0.007068*
3.37	0.007120
3.58	0.007119*
3.78	0.007193*
4.00	0.007242
4.21	0.007336*
4.35	0.007390*
4.43	0.007424*
4.51	0.007489*
4.58	0.007526
4.67	0.007564*
4.77	0.007606*
4.83	0.007676*
4.91	0.007738*
4.97	0.007779*
5.03	0.007828
5.11	0.007907*
5.17	0.007969

* Not shown in figure.

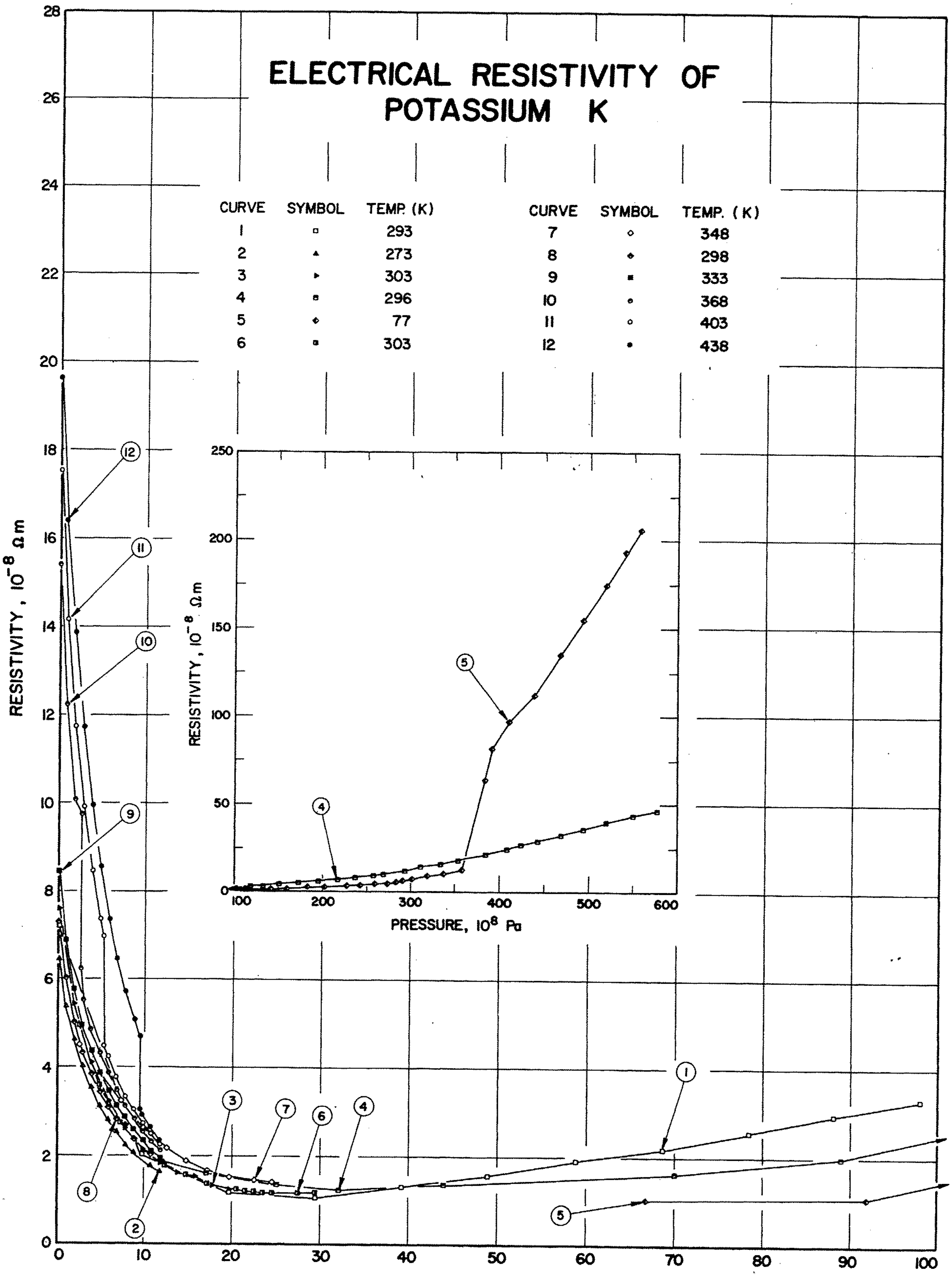

ELECTRICAL RESISTIVITY OF
POTASSIUM K
CURVE SYMBOL TEMP. (K)
1 ▫ 293
2 ▴ 273
3 ▸ 303
4 ▫ 296
5 ◊ 77
6 ▫ 303
7 ◇ 348
8 ◆ 298
9 ▪ 333
10 ∘ 368
11 ○ 403
12 • 438
RESISTIVITY, 10^{-8} Ω m
PRESSURE, 10^8 Pa
CINDAS

FIGURE 12

TABLE 20. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Pressure Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Pressure Range, 10^8 Pa	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	30	Bridgman, P.W.	1952	A	0-98	293		Pure; AgCl is the material to transmit pressure; the relative resistance data were reported; the electrical resistivity data were obtained by using the recommended value of electrical resistivity at 293 K and one atm pressure, the compressibility data and the relative resistance data.
2	86	Bridgman, P.W.	1925	A	0-11.76	273		Pure; solid, 1.5 mm diameter bare wire sample was extruded under Nijol.
3	72	Bridgman, P.W.	1930	A	0-19.60	303		Pure; solid, bare wires.
4	31	Stager, R.A. and Drickamer, H.G.	1963	A	12-578	296		Commercial purity specimen; the resistance as function of pressure was reported.
5	31	Stager, R.A. and Drickamer, H.G.	1963	A	67-558	77		Same as the above specimen.
6	32	Bridgman, P.W.	1938		0-29.4	303		Pure; specimen was obtained from Kahlbaum; it was extruded to bare wire; the relative electrical resistance as a function of pressure data were reported.
7	32	Bridgman, P.W.	1938		0-24.5	348		Same as the above specimen.
8	33	Bridgman, P.W.	1921		0-11.76	298		Pure; specimen was contained in a glass capillary; relative electrical resistance were reported.
9	33	Bridgman, P.W.	1921		0-11.76	333		Same as the above specimen.
10	33	Bridgman, P.W.	1921		0-11.76	368		Same as the above specimen.
11	33	Bridgman, P.W.	1921		0-11.76	403		Same as the above specimen.
12	33	Bridgman, P.W.	1921		0-11.76	438		Same as the above specimen.

TABLE 21. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Pressure Dependence)

[Temperature, T, K; Pressure, P, 10^8 Pa; Resistivity, ρ, 10^{-8} Ωm]

P	ρ
CURVE 1	**T = 293**
0.0	7.205
9.8	2.052
19.6	1.191
29.4	1.129
39.2	1.258
49.0	1.525
58.8	1.852
68.6	2.186
78.4	2.562
88.2	2.963
98.0	3.392
CURVE 2	**T = 273**
0.00	6.453
0.98	5.392
1.96	4.634
2.94	4.031
3.92	3.538
4.90	3.133
5.88	2.800
6.86	2.520
7.84	2.285
8.82	2.078
9.80	2.020*
10.78	1.761
11.76	1.633
CURVE 3	**T = 303**
0.00	7.600
1.96	5.495
3.92	4.115
5.88	3.239
7.84	2.619
9.80	2.184
11.76	1.860
13.72	1.626
15.68	1.581
17.64	1.334
19.60	1.250
CURVE 3	**T = 303**
0.00	7.600
1.96	5.495
3.92	4.115
5.88	3.239
7.84	2.619
9.80	2.184
11.76	1.860
13.72	1.626
15.68	1.581
17.64	1.334
19.60	1.250
CURVE 4	**T = 296**
12	1.850
17	1.602
25	1.366
32	1.249
44	1.343
70	1.627
89	1.985
119	2.543
133	2.930
151	3.337
173	4.137
195	5.125
218	6.160
237	7.173
257	8.499
269	9.437
294	11.48
313	13.11
335	15.45
355	17.89
385	20.95
409	24.00
425	26.24
443	28.57
469	32.00
494	35.75
520	39.65
550	43.16
578	46.33
CURVE 5	**T = 77**
67	1.016
92	1.098
113	1.212
142	1.486
160	1.707
183	2.146
203	2.507
228	3.096
243	3.644
260	4.174
274	4.692
284	5.371
292	6.133
302	7.370
320	9.007
338	10.74
359	12.39
384	63.69
392	81.64
411	96.44
439	116.4
468	135.9
493	154.7
519	174.1
541	193.7
558	206.3
CURVE 6	**T = 303**
0.00	7.600*
2.45	4.951
4.90	3.608
7.35	2.723
9.80	2.165*
12.25	1.788
14.70	1.535
17.15	1.370
19.60	1.257*
20.58	1.230
21.56	1.208
22.54	1.191
23.52	1.178
24.50	1.169
25.48	1.167*
CURVE 6 (cont.)	**T = 303**
26.46	1.169*
27.44	1.173
28.42	1.181*
29.40	1.192
CURVE 7	**T = 348**
2.45	4.520
7.35	3.365
9.80	2.658
12.25	2.191
14.70	1.885
17.15	1.683
19.60	1.546
22.54	1.479
24.50	1.469
CURVE 8	**T = 298**
0.00	7.279
0.98	6.011
1.96	5.079
2.94	4.372
3.92	3.857
4.90	3.457
5.88	3.106
6.86	2.814
7.84	2.710
8.82	2.365
9.80	2.176*
10.78	2.016
11.76	1.876*
CURVE 9	**T = 333**
0.00	8.434
0.98	6.893
1.96	5.791
2.94	4.966
3.92	4.366
4.90	3.888
5.88	3.477
CURVE 9 (cont.)	**T = 333**
6.86	3.139
7.84	2.850
8.82	2.597
9.80	2.365
10.78	2.167
11.76	1.997
CURVE 10	**T = 368**
0.00	15.40
0.98	12.21
1.96	10.08
2.16	9.789
2.16	6.293
2.94	5.560
3.92	4.874
4.90	4.324
5.88	3.853
6.86	3.465
7.84	3.121
8.82	2.829
9.80	2.553
10.78	2.318
11.76	2.119
CURVE 11	**T = 403**
0.00	17.58
0.98	14.19
1.96	11.71
2.94	9.90
3.92	8.442
4.90	7.382
5.32	6.966
5.32	4.498
5.88	4.230
6.86	3.797
7.84	3.385
8.82	3.055
9.80	2.735
10.78	2.464
11.76	2.233
CURVE 12	**T = 438**
0.00	19.62
0.98	16.40
1.96	13.83
2.94	11.71
3.92	9.948
4.90	8.574
5.88	7.380
6.86	6.450
7.84	5.701
8.82	5.066
9.52	4.695
9.52	3.029
9.80	2.924
10.78	2.615
11.76	2.355

* Not shown in figure.

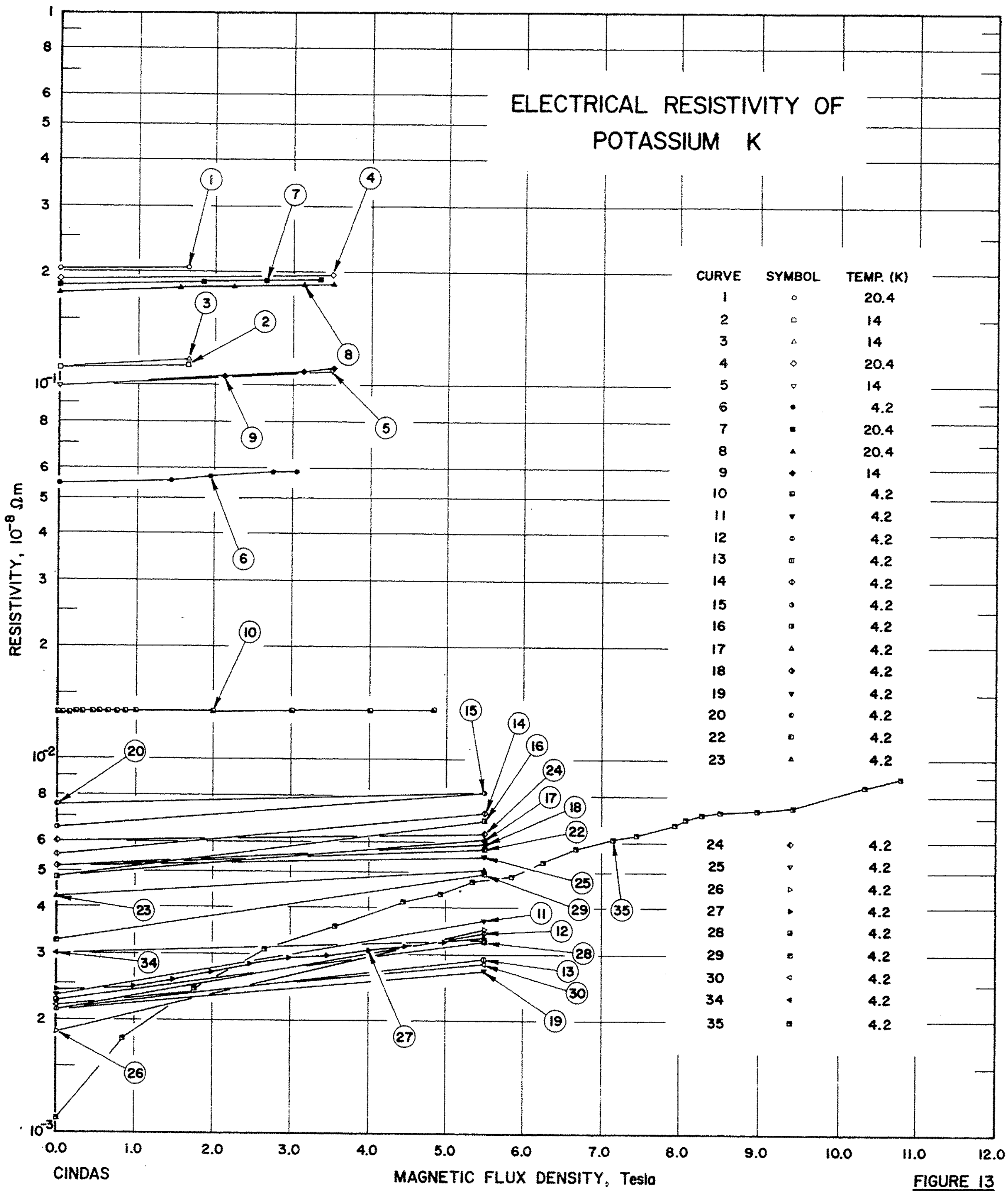

ELECTRICAL RESISTIVITY OF POTASSIUM K
CURVE SYMBOL TEMP. (K)
1 ○ 20.4
2 □ 14
3 △ 14
4 ◇ 20.4
5 ▽ 14
6 ● 4.2
7 ■ 20.4
8 ▲ 20.4
9 ◆ 14
10 4.2
11 ▼ 4.2
12 4.2
13 4.2
14 4.2
15 4.2
16 4.2
17 △ 4.2
18 4.2
19 ▼ 4.2
20 4.2
22 4.2
23 ▲ 4.2
24 ◇ 4.2
25 ▽ 4.2
26 ▷ 4.2
27 ▶ 4.2
28 4.2
29 4.2
30 ◁ 4.2
34 ◀ 4.2
35 4.2
RESISTIVITY, 10^{-8} Ω m
MAGNETIC FLUX DENSITY, Tesla
CINDAS

FIGURE 13

TABLE 22. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Magnetic Flux Density Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Magnetic Flux Density Range, Tesla	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	36	Justi, E.	1948	A	0, 1.65	20.4	K5	Pure; 1 mm width, 40 mm long; $R_{20.4\ K}/R_{273.15\ K} = 0.02835$; measured in a transverse magnetic field.
2	36	Justi, E.	1948	A	0, 1.65	14.0	K5	Same as the above specimen; $R_{14\ K}/R_{273.15\ K} = 0.0155$.
3	36	Justi, E.	1948	A	0, 1.65	14.0	K5	Same as the above specimen except measured in a longitudinal magnetic field.
4	36	Justi, E.	1948	A	0, 3.5	20.4	K6	Pure; $R_{20.4\ K}/R_{273.15\ K} = 0.02673$; measured in a transverse magnetic field.
5	36	Justi, E.	1948	A	0, 3.5	14.0	K6	Same as the above specimen; $R_{14\ K}/R_{273.15\ K} = 0.0138$.
6	36	Justi, E.	1948	A	0-3.05	4.22	K6	Same as the above specimen; $R_{4.22\ K}/R_{273.15\ K} = 0.00756$.
7	36	Justi, E.	1948	A	0-3.33	20.4	K6	Same as the above specimen; $R_{20.4\ K}/R_{273.15\ K} = 0.02604$.
8	36	Justi, E.	1948	A	0-3.51	20.4	K11	Pure; $R_{20.4\ K}/R_{273.15\ K} = 0.0247$; measured in a transverse magnetic field.
9	36	Justi, E.	1948	A	0-3.51	14.0	K11	Same as the above specimen; $R_{14.0\ K}/R_{273.15\ K} = 0.0138$.
10	74	Babiskin, J. and Siebenmann, P.G.	1969		0-5	4.2		Pure; 1 mm in diameter and 1 mm long wire specimen; $R_{300\ K}/R_{4.2\ K} = 560$; measured in a transverse magnetic field; data were extracted from the smooth curve.
11	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	1	99.95 pure; single crystal specimen; 1 mm thickness and elliptical surface with 4 mm semiminor axes; the specimen was obtained from Mine Safety Appliance Co.; the disk normal and magnetic field was in [100] direction; residual resistance ratio RRR = 3.1×10^3; the magnetic resistance was deduced from helicon resonance.
12	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	2	Similar to the above specimen and conditions except RRR = 3.4×10^3.
13	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	3	Similar to the above specimen and conditions.
14	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	4	Similar to the above specimen and conditions except RRR = 1.3×10^3.
15	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	5	Similar to the above specimen and conditions except RRR = 1.1×10^3.
16	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	6	Similar to the above specimen and conditions except RRR = 1.5×10^3.
17	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	7	Similar to the above specimen and conditions.
18	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	8	Similar to the above specimen and conditions except RRR = 1.4×10^3.
19	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	9	Similar to the above specimen and conditions except RRR = 3.4×10^3 and the magnetic field and specimen normal was in the [110] direction.
20	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	10	Similar to the above specimen and conditions except RRR = 0.9×10^3.

TABLE 22. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Magnetic Flux Density Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Magnetic Flux Density Range, Tesla	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
21*	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	11	Similar to the above specimen and conditions except RRR = 1.3 x 10^3.
22	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	12	Similar to the above specimen and conditions except RRR = 1.4 x 10^3.
23	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	13	Similar to the above specimen and conditions except RRR = 1.7 x 10^3.
24	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	14	Similar to the above specimen and conditions except RRR = 1.2 x 10^3.
25	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	15	Similar to the above specimen and conditions except RRR = 1.4 x 10^3.
26	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	16	Similar to the above specimen and conditions except RRR = 3.9 x 10^3 and the specimen normal and the magnetic field was in [111] direction.
27	87	Penz, P.A. and Bowers, R.	1968	→	0-5.5	4.2	17	Similar to the above specimen and conditions except RRR = 3.0 x 10^3.
28	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	18	Similar to the above specimen and conditions except RRR = 3.2 x 10^3.
29	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	19	Similar to the above specimen and conditions except RRR = 2.2 x 10^3 and the specimen normal and the magnetic field was in [123] direction.
30	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	20	Similar to the above specimen and conditions except RRR = 3.3 x 10^3.
31*	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	21	Similar to the above specimen and conditions except RRR = 3.9 x 10^3.
32*	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	22	Similar to the above specimen and conditions except RRR = 1.4 x 10^3.
33*	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	23	Similar to the above specimen and conditions except RRR = 1.2 x 10^3.
34*	87	Penz, P.A. and Bowers, R.	1968	→	0, 5.5	4.2	24	Similar to the above specimen and conditions except RRR = 2.4 x 10^3.
35	87	Penz, P.A. and Bowers, R.	1968	→	0-11	4.2		99.95 pure; polycrystalline specimen about 1 mm thick was used; the magnetic resistance was measured in a Bitter solenoid at the NML.

* Not shown in figure.

TABLE 23. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF POTASSIUM K (Magnetic Flux Density Dependence)

[Temperature, T, K; Magnetic Flux Density, B, Tesla; Electrical Resistivity, ρ, 10^{-8} Ωm]

B	ρ
CURVE 1	T = 20.4
0.00	0.2040
1.65	0.2060
CURVE 2	T = 14.0
0.00	0.1117
1.65	0.1138
CURVE 3	T = 14.0
0.00	0.1117*
1.65	0.1167
CURVE 4	T = 22.4
0.00	0.1926
3.50	0.1977
CURVE 5	T = 14.0
0.00	0.09942
3.50	0.1089
CURVE 6	T = 4.22
0.00	0.05446
1.43	0.05589
1.93	0.05690
2.75	0.05830
3.05	0.05849
CURVE 7	T = 20.4
0.00	0.1876
1.83	0.1899
2.64	0.1904
3.33	0.1918
CURVE 8	T = 20.4
0.00	0.1779
1.545	0.1812
2.22	0.1831
3.13	0.1856
3.51	0.1869
CURVE 9	T = 14.0
0.00	0.09942*
2.10	0.1057
3.13	0.1089
3.51	0.1109
CURVE 10	T = 4.2
0.00	0.01336
0.05	0.01337
0.12	0.01339
0.21	0.01341
0.30	0.01343
0.43	0.01344
0.52	0.01345
0.64	0.01345
0.75	0.01346
0.86	0.01346
1.00	0.01347
2.00	0.01349
3.01	0.01352
4.01	0.01355
4.84	0.01358
CURVE 11	T = 4.2
0.0	0.00232
5.5	0.00370
CURVE 12	T = 4.2
0.0	0.00212
5.5	0.00343
CURVE 13	T = 4.2
0.0	0.00212*
5.5	0.00292
CURVE 14	T = 4.2
0.0	0.00554
5.5	0.00720
CURVE 15	T = 4.2
0.0	0.00655
5.5	0.00819
CURVE 16	T = 4.2
0.0	0.00480
5.5	0.00682
CURVE 17	T = 4.2
0.0	0.00480*
5.5	0.00610
CURVE 18	T = 4.2
0.0	0.00515
5.5	0.00592
CURVE 19	T = 4.2
0.0	0.00212*
5.5	0.00271
CURVE 20	T = 4.2
0.0	0.00753
5.5	0.00806*
CURVE 21*	T = 4.2
0.0	0.00554
5.5	0.00610
CURVE 22	T = 4.2
0.0	0.00515*
5.5	0.00577
CURVE 23	T = 4.2
0.0	0.00424
5.5	0.00504
CURVE 24	T = 4.2
0.0	0.00600
5.5	0.00630
CURVE 25	T = 4.2
0.0	0.00515*
5.5	0.00545
CURVE 26	T = 4.2
0.0	0.00185
5.5	0.00351
CURVE 27	T = 4.2
0.00	0.00240
0.99	0.00243
1.48	0.00256
1.99	0.00269
2.49	0.00281
2.99	0.00293
3.47	0.00297
4.00	0.00308
4.47	0.00313
CURVE 27 (cont.)	T = 4.2
4.97	0.00324
5.50	0.00336
CURVE 28	T = 4.2
0.0	0.00225
5.5	0.00326
CURVE 29	T = 4.2
0.0	0.00327
5.5	0.00494
CURVE 30	T = 4.2
0.0	0.00218
5.5	0.00284
CURVE 31*	T = 4.2
0.0	0.00185
5.5	0.00327
CURVE 32*	T = 4.2
0.0	0.00515
5.5	0.00581
CURVE 33*	T = 4.2
0.0	0.0060
5.5	0.006305
CURVE 34	T = 4.2
0.0	0.00300
5.5	0.00330*
CURVE 35	T = 24.0
0.00	0.00109
0.85	0.00179
1.76	0.00242
2.67	0.00310
3.57	0.00358
4.46	0.00414
4.92	0.00436
5.33	0.00470
5.83	0.00484
6.27	0.00531
6.68	0.00579
7.17	0.00608
7.46	0.00627
7.93	0.00667
8.10	0.00694
8.30	0.00716
8.52	0.00723
8.99	0.00735
9.43	0.00743
10.32	0.00853
10.79	0.00893

* Not shown in figure.

4.4. Rubidium

Rubidium, with atomic number 37, is a silvery-white soft alkali metal. It has a body-centered cubic crystalline structure with a density of 1.532 g cm^{-3} at 293 K. It melts at 312.64 K and boils at about 959 K. Its critical temperature has been determined to be 2106 K at a pressure of 408.2 atom and the density at the critical temperature was 0.1818 g cm^{-3}. Naturally-occurring rubidium is composed of one stable isotope, ^{85}Rb (72.15%), and one unstable isotope, ^{87}Rb (27.85%), which is radioactive and has a half-life of 5 × 10^{11} years. Ordinary rubidium is sufficiently radioactive to expose a photographic film in about one to two months. Fifteen other radioactive isotopes of rubidium are known to exist. Rubidium ranks 22nd in the order of abundance of elements in the continental crust of the earth (0.009% by weight).

a. Temperature Dependence

There are 33 sets of experimental data available for the temperature dependence on the electrical resistivity of rubidium. The information on specimen characterization and measurement conditions for each of the data sets is given in table 25. The data are tabulatzd in table 26 and shown in figures 14 and 15. Determination of the electrical resistivity of rubidium for the solid and liquid phase cover the continuous temperature range from 1.13 to 1866 K.

There are 15 sets of experimental data obtained below 100 K. Among these, 4 sets (curves 10, 12, 13, and 14) are at constant volume under various pressures and 2 sets are for thin films (curves 5 and 6). Aleksandrov, Lemonos, and Semenova [85] (curve 32) gave the lowest residual resistivity, ρ_0 = 0.0134 × 10^{-8}Ω m. Four sets of the intrinsic electrical resistivity at zero pressure are obtained by subtraction of the residual resistivity ρ_0 from the measured resistivity. In deriving the smoothed most probable values of intrinsic resistivity from the available data, the following overlapping temperature ranges were considered: below 8 K; 5–20 K; 10–40 K; 20–80 K; 30–150 K; etc. Within each range, a least-mean-square fraction error fit of the semiempirical equation $\rho_i = aT^b$ was made to all available intrinsic resistivity data. The resulting values for adjacent ranges were intercompared and the values were corrected for thermal linear expansion. These preliminary values were then fitted with the equation (7) to generate the final recommended values. The coefficients of equation (7) obtained in the fitted are given in the following table:

Temperature range, K	*a*	*b*	*c*	*d*
1.97– 7.16	−3.322	3.325	1.973	−3.042
7.16– 10.72	−1.375	2.671	−3.140	10.75
10.72– 12.10	−0.945	2.561	2.514	−40.51
12.10– 14.46	−0.810	2.491	−3.851	10.85
14.46– 50.04	−0.635	2.089	−1.327	0.576
50.04–100	0.196	1.161	−0.396	0.562

There are 19 data sets in the temperature region from 100 K to the melting point, 312.64 K. Among these, 4 sets (curves 10, 12, 13, 14) are at constant volume under various pressures and 1 set (curve 1) is a single data point at 273 K. Messiner and Voigt [29] (curve 26) give the highest value, which is about 60% higher than all the other data; therefore, this data set and those sets measured at constant volume are excluded for the computer fitting. A least-mean-square fractional error fit to the totality of experimental data in this range was made with $\rho_i = aT^b$. The resulting values were corrected for thermal linear expansion, and then fitted with the cubic spline function equation (7) to obtain the final recommended values in this temperature range. The coefficients of equation (7) obtained are as follows:

Temperature range, K	*a*	*b*	*c*	*d*
50.04–312.64	0.196	1.161	−0.396	0.562

There are 11 data sets measured in the liquid state. Endo [40] (curve 22) and Lien and Silvertsen [41] (curve 2) have tabulated the electrical resistivity at constant volume up to 470 K. The rest of the data are apparently measured at the saturated vapor pressure. Solov'ev [52] (curve 3) gives the lowest values while Kapelner and Bratton [43] (curve 8) give the highest values. Grosse [5] derived electrical resistivity values (curve 34) from the melting point to his estimated critical temperature, 2106 K, by fitting the data of Kapelner and Bratton [43] (curve 8) to a hyperbola. Below 1000 K, all the experimental data except those measured at constant volume were fitted by a logarithmic third order polynomials. Above 1000 K, the electrical resistivity values are obtained by extrapolating the fitted values and following the experimental trend. The resulting values are fitted with the cubic spline function equation (7) to obtain the final recommended values. The coefficients of equation (7) obtained from fitting are as follows:

Temperature range, K	*a*	*b*	*c*	*d*
312.64– 611.74	1.353	1.051	0.485	−0.498
611.74–1087.7	1.689	1.207	0.049	4.138
1087.7 –2000	2.057	2.007	3.153	−0.531

At the melting point (312.64 K), the electrical resistivity of rubidium in the liquid state is about 63% higher than that of the solid state. Mott's formula (eq 5) gives the electrical resistivity about 75% higher than that of the solid state.

The recommended values for the total and intrinsic electrical resistivity are listed in table 24, and those for the total electrical resistivity are also shown in figures 14 and 15. The recommended values for the liquid state are for the saturated liquid. The recommended values of the total resistivities for the solid state are for a 99.99+% pure rubidium and those at temperatures below 50 K are only applicable for a specimen with residual resistivity ρ_0 = 0.0131 × 10^{-8}Ω m. The recommended values from 1 K to 312.64 K are corrected for thermal linear expansion. The correction amounts to −1.77% at 1 K,

−0.9% at 160 K, and 0.2% at 312.64 K. The uncertainty of the recommended total electrical resistivity is believed to be within ±5% from 1 to 1500 K and within ±10% from 1500 K to 2000 K. Above 20 K the uncertainty of the intrinsic resistivity is about the same as that of the total electrical resistivity; below 20 K this uncertainty is higher than that of the total electrical resistivity.

b. Pressure Dependence

There are 10 sets of experimental data available for the electrical resistivity of rubidium as a function of pressure. The information on specimen characterization and measurement conditions for each of the data sets is given in table 27. The data are tabulated in table 28 and shown in figure 16.

The available data and information for the pressure dependence of electrical resistivity of rubidium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

c. Magnetic Flux Density Dependence

There are three sets of experimental data available for the electrical resistivity of rubidium under the influence of magnetic field. The information on specimen characterization and measurement information for each of the data sets is given in table 29. The data are tabulated in table 30 and shown in figure 17.

The available data and information for the magnetic flux density dependence of electrical resistivity of rubidium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

TABLE 24. RECOMMENDED ELECTRICAL RESISTIVITY OF RUBIDIUM (Temperature Dependence)

[Temperature, T, K; Total Resistivity, ρ, $10^{-8}\ \Omega m$; Intrinsic Resistivity, ρ_i, $10^{-8}\ \Omega m$]

Solid						Liquid	
T	ρ	ρ_i	T	ρ	ρ_i	T	ρ
1	0.0131		35	1.02	1.01	312.64	22.52
2	0.0136	0.00050*	40	1.21	1.20	350	25.42
3	0.0153	0.0022*	45	1.40	1.39	400	29.51
4	0.0194	0.0063*	50	1.58	1.57	500	38.27
5	0.0270	0.0139*	60	1.94	1.93	600	47.61
6	0.0384	0.0253*	70	2.29	2.28	700	57.48
7	0.0528	0.0397*	80	2.65	2.64	800	68.50
8	0.0691	0.0560*	90	3.00	2.99	900	81.50
9	0.0872	0.0741*	100	3.36	3.35	1000	97.26
10	0.109	0.0954*	150	5.27	5.26	1100	116.7
11	0.134	0.121*	200	7.49	7.48	1200	140.8
12	0.165	0.152*	250	10.14	10.13	1300	170.3
13	0.197	0.184*	273.15	11.54	11.53	1400	206.3
14	0.229	0.216*	293	12.84	12.83	1500	249.7
15	0.263	0.250*	300	13.32	13.31	1600	301.8*
16	0.298	0.285*	312.64	14.21	14.20	1700	364.1*
18	0.370	0.357*				1800	438.2*
20	0.444	0.431				1900	525.9*
25	0.636	0.623				2000	629.4*
30	0.830	0.817					

* Provisional values.

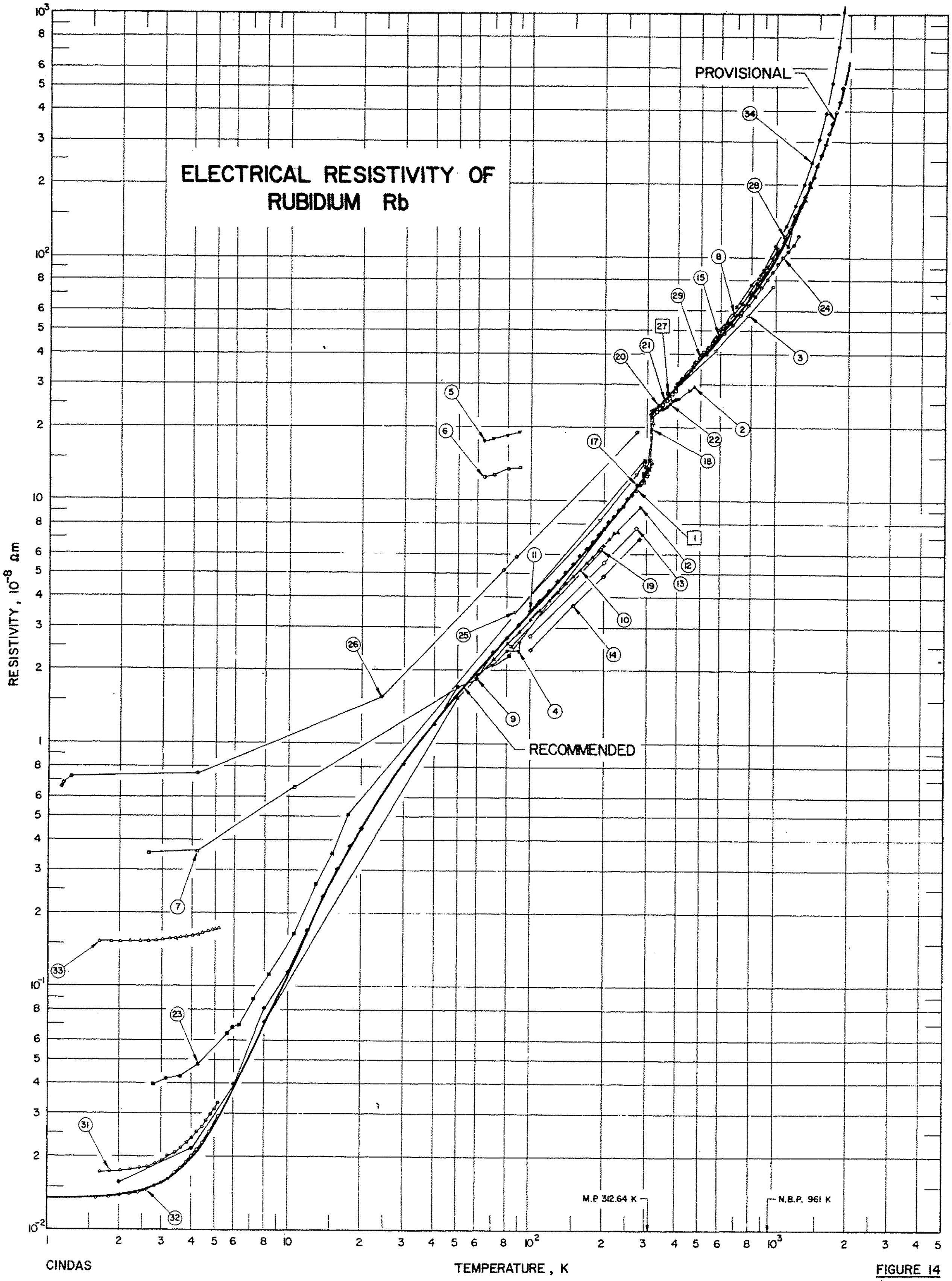

ELECTRICAL RESISTIVITY OF
RUBIDIUM Rb
PROVISIONAL
RECOMMENDED
RESISTIVITY, 10^{-8} Ωm
TEMPERATURE, K
M.P. 312.64 K
N.B.P. 961 K
CINDAS

FIGURE 14

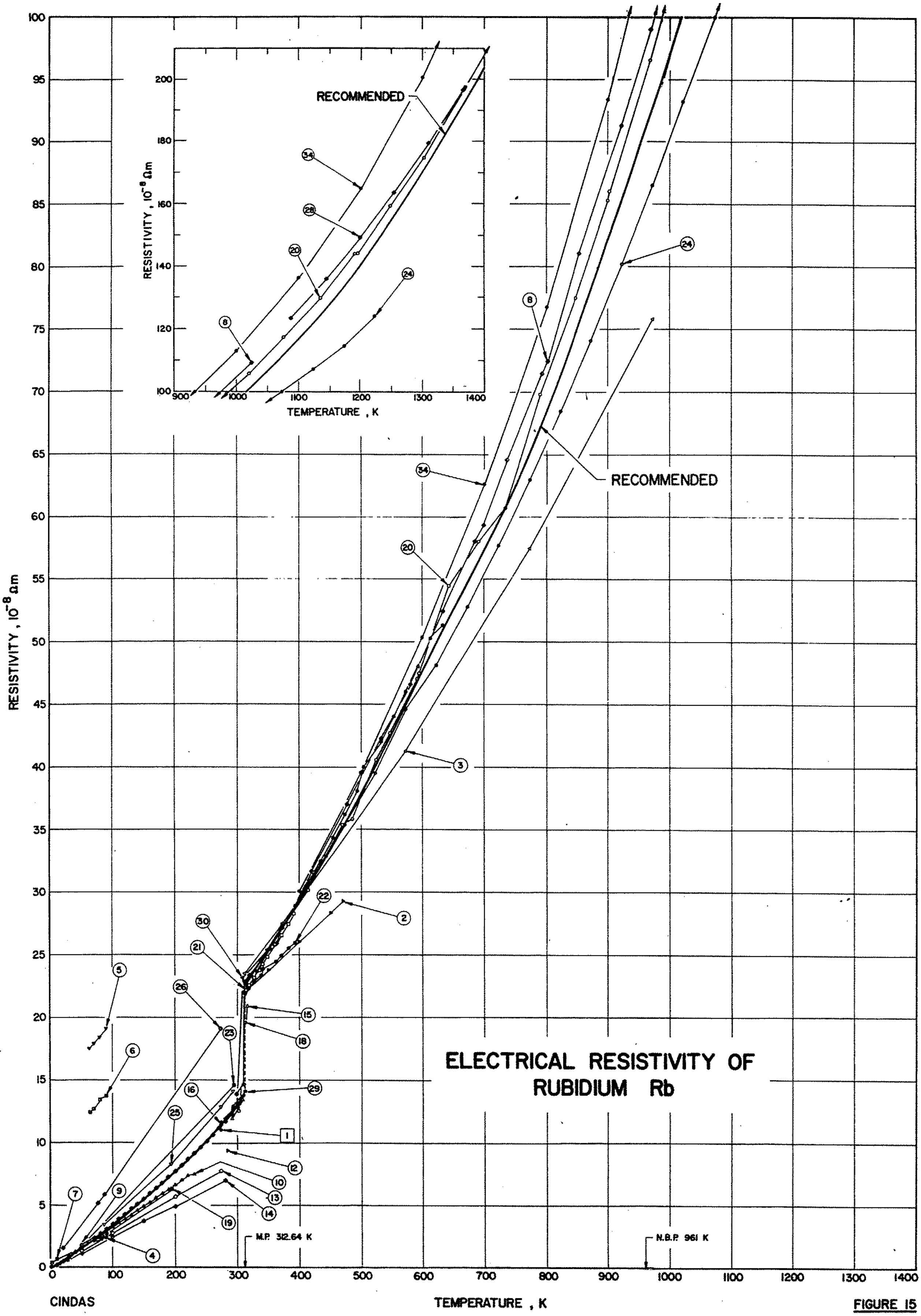

ELECTRICAL RESISTIVITY OF
RUBIDIUM Rb
RESISTIVITY, 10^{-8} Ωm
TEMPERATURE, K
RECOMMENDED
M.P. 312.64 K
N.B.P. 961 K
CINDAS

FIGURE 15

TABLE 25. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF RUBIDIUM Rb (Temperature Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	22	Krautz, E.	1950	A	273		Pure.
2	41	Lien, S.Y. and Silvertsen, J.M.	1969	A	312-470		99.9 pure rubidium was supplied by A. D. Mackay Inc.; the specimen cells were made from precision quartz capillaries open on one end; four tungsten current and potential leads were sealed into the capillary; measurements at constant volume; data represented by $\rho = 22.0 + (\partial\rho/\partial T)\ (T - 312)$, $312 \leq T \leq 470$ K, ρ in units of $10^{-8}\ \Omega m$.
3	52, 88	Solov'ev, A.N.	1963, 1967		312-973		Pure; liquid state specimen; density 1.475 g cm^{-3} at 312 K, 1.179 g cm^{-3} at 973 K.
4	89	Lovell, A.C.B.	1936	A	60-90		0.03 Na, 0.8 K, 0.2 Cs, 0.2 B, trace of Ca, Si; the specimen was prepared by the reduction of rubidium chloride with calcium metal in high vacuum apparatus.
5	89	Lovell, A.C.B.	1936	A	60-90	Rb(Film)	The above specimen was deposited on pyrex glass surface 1.35 cm width, 1.55 cm long; film thickness 43.7 Å.
6	89	Lovell, A.C.B.	1936	A	60-90	Rb(Film)	Similar to the above specimen with film thickness 87.4 Å.
7	54	McLennan, J.C. and Niven, C.D.	1927	B	2.63-293		Pure; specimen was filled in a U-shaped capillary.
8	43	Kapelner, S.M. and Bratton, W.D.	1962	B	299-1025		99.5 pure; 0.32 Cs, 0.05 Na, and 0.06 K; specimen was obtained from American Potash and Chemical Corp.; liquid specimen was loaded into a type 307 stainless steel tube heated at 550 C for 2 hr.
9	90	Dugdale, J.S. and Phillips, D.	1965	A	2-300	6, 7, 8	Pure; specimens were obtained from L. Light and Co. Ltd.; wire specimens about 2 mm in diameter were extruded under distilled paraffin oil; $R_{295}/R_{4.2} = 580$; electrical resistivity was measured under zero pressure.
10	90	Dugdale, J.S. and Phillips, D.	1965	A	2-230	6, 7, 8	Same as above specimen except the electrical resistivity was obtained under constant volume.
11	90	Dugdale, J.S. and Phillips, D.	1965	A	0-240		Similar to the above specimen; ideal resistivity as function of temperature at constant pressure (p = 0); data were extracted from the smooth curve.
12	90	Dugdale, J.S. and Phillips, D.	1965	A	0-284		Similar to the above specimen; ideal resistivity as function of temperature at constant density as at 0 K at zero pressure; data were extracted from the smooth curve.
13	90	Dugdale, J.S. and Phillips, D.	1965	A	0-273		Similar to the above specimen; at constant density as at 0 K at 1000 atm.
14	90	Dugdale, J.S. and Phillips, D.	1965	A	0-280		Similar to the above specimen; at constant density as at 0 K at 4,200 atm; data above 150 K were interpolation between present results and a point based on Bridgman's data at ice point.
15	56	Hackspill, L.	1910	A	291-316	1	Pure; specimen was filled in a U-shaped capillary.
16	56	Hackspill, L.	1910	A	273-293	2	Similar to the above specimen.
17	56	Hackspill, L.	1910	A	273-291	3	Similar to the above specimen.
18	56	Hackspill, L.	1910	A	293-313	4	Similar to the above specimen.
19	56	Hackspill, L.	1910	A	83-313	5	Similar to the above specimen.
20	17, 91, 92	Tepper, F., Murchison, A., Zelenak, J., and Roehlich, F.	1963-1965	A	367-1370		99.5 pure; specimen was placed in a Hayne-25 alloy cylindrical cell 0.5" in O.D., 0.065" wall, and 26" in length.

TABLE 25. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF RUBIDIUM Rb (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
21	40	Eudo, H.	1963	A	313-393		Pure; specimen was supplied by A. D. Mackay Ltd.; specimen was contained in a soft glass capillary tube (I.D. 0.7 mm); electrical resistivity was measured at constant pressure condition.
22	40	Eudo, H.	1963	A	313-393		Same as above specimen; electrical resistivity was obtained at constant volume.
23	23	MacDonald, D.K.C., White, G.K., and Woods, S.B.	1955		2.5-293	Rb 1	Pure; specimen was obtained from Messers A. D. Mackay (New York); specimen was melted in vacuo and run into soft glass tubes with platinum leads sealed in; 1.65 mm in diameter; $\rho_0/\rho_{295} = 2.63 \times 10^{-3}$.
24	18	Semyachkin, B.E. and Solov'ev, A.N.	1964	A	313-1223		Pure; specimen was obtained from RETV 118-59; specimen was placed in a (0.8/0.5 mm) 1 Kh 18 NgT 60 mm long capillary.
25	19	Guntz, A. and Broniewski, W.	1909		86-292		Pure.
26	29	Meissner, W. and Voigt, B.	1930		1.13-273.16	Rb 1	Pure; specimen was distilled in glass tube; specimen diameter was 4.8 mm and 35 mm long.
27	68	Van der Lugt, W., Devlin, J.F., Hennephof, J., and Leenstra, M.R.	1972	B	373.15		Pure; data was extracted from graph.
28	93	Hochman, J.M., Silver, I.L., and Bonilla, C.F.	1964	A	1088-1866		Commercial purity (99.7-99.9 Rb); specimen was provided by Penn Rare Metals; liquid phase specimen was partially filled in a 90 Ta, 8 W, 2 Hf alloy capsule 1 in. O.D., 1/16 in. wall, and 12 in. long; it was surrounded by a molybdenum wire heater on an alumina core and radiation shields, all contained in a vessel pressurized with argon of extreme purity; temperature was obtained by W/W-26Re thermocouple; the electrical resistivity data were corrected for thermal expansion; critical point about 2111 K was determined by comparing the "pseudoreduced" electrical resistivity with mercury and cesium.
29	94	Semyachkin, B.E. and Solov'ev, A.N.	1970	A	293-623		99.97 pure; the specimen was placed in a stainless steel tube in a copper block; the temperature was measured by a Pt-PtRh (10%) thermocouple; the measurements were carried out during both heating and cooling at ~0.01°/min. rate and with current in both directions; $\rho_{liquid}/\rho_{solid} = 1.562$, $(1/\rho\ d\rho/dT)_{solid} = 45.5 \times 10^{-4}$/K and $(1/\rho\ \partial\rho/\partial T)_{liquid} = 37.2 \times 10^{-4}$/K at melting point.
30	84	Kurnakow, N.S. and Nikitinsky, A.J.	1914	B	273-373		Pure; Thomson double bridge was used for measurements; the specimen was filled in a glass tube and immersed in a Vaslin thermostat; mercury was filled in the tube for calibration.
31	85	Aleksandrov, B.N., Lomonos, O.I., and Semenova, E.D.	1973	A	1.6-5.2	Rb 1	99.99 purity specimen was contained in glass capillaries of diameter 0.5 mm and length 22 mm; into which were sealed potential and current leads in the form of platinum or molybdenum wire; $R_0/R_{293} = 1.35 \times 10^{-3}$; relative electrical resistivity data were reported.
32	85	Aleksandrov, B.N., et al.	1973	A	1.6-5.2	Rb 4	Similar to the above specimen except $R_0/R_{290} = 1.085 \times 10^{-3}$.
33	85	Aleksandrov, B.N., et al.	1973	A	1.6-5.2	Rb 5	Similar to the above specimen except $R_0/R_{290} = 1.21 \times 10^{-2}$.
34	5	Grosse, A.V.	1966		312.6-2100		Electrical resistivity data were derived by fitting the data of Kaplener and Bratton to a hyperbolic equation $(\sigma' + b)\ (T' + b) = a$ from 312.64 K to 2106 K; where $\sigma' = \rho_{m.p.}/\rho$ and $T' = (T - T_{m.p.})/(T_{c.p.} - T_{m.p.})$; $b = 0.185$ and $a = 0.141$.

TABLE 26. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF RUBIDIUM Rb (Temperature Dependence)

[Temperature, T, K; Resistivity, ρ, 10^{-8} Ωm]

T	ρ
CURVE 1	
273	11.0
CURVE 2	
312	22.00
350	23.75
400	26.05
450	28.35
470	29.27
CURVE 3	
312	23.5
373	27.5
573	41.3
773	57.5
973	75.8
CURVE 4	
60.0	1.9
69.9	2.1
80.0	2.4
89.8	2.4
CURVE 5	
63.9	17.5
69.8	17.9
79.9	18.4
89.8	19.1
CURVE 6	
64.2	12.4
70.3	12.7
80.3	13.4
90.2	13.7
CURVE 7	
2.63	0.353
4.2	0.357
10.6	0.658
82.0	2.30
293.0	12.6
CURVE 8	
298.7	13.85
310.6	14.67
312.3	22.84
314.8	22.93*
319.5	23.35
364.8	25.96
419.8	31.62
477.3	37.06
583.4	42.30
581.4	46.59
582.5	46.61*
634.8	52.45
685.6	58.01
699.2	59.37
736.2	64.61
793.4	71.48
802.0	72.49
854.8	81.06
923.2	91.29
970.3	99.05
1024.8	109.31
CURVE 9	
2	0.01572
4	0.02172
6	0.03966
8	0.08172
10	0.1155
12	0.1703
14	0.2352
16	0.3045
18	0.3762
20	0.4485
30	0.8219
40	1.2059
50	1.7195
60	1.867
70	2.338
80	2.715
90	3.095
100	3.476
110	3.865
120	4.261
130	4.661
150	5.481
CURVE 9 (cont.)	
160	5.900
170	6.327
180	6.758
190	7.203
200	7.663
210	8.129
220	8.604
230	9.089
240	9.581
250	10.025
260	10.602
270	11.125
280	11.657
290	12.218
300	12.867
CURVE 10	
2	0.01568*
4	0.02188*
6	0.03948*
8	0.07148
10	0.1155*
12	0.1703*
14	0.2353
16	0.3051*
18	0.3755*
20	0.4475*
30	0.8135*
40	1.1835*
50	1.542
60	1.867*
70	2.228
80	2.562
90	2.892
100	3.218
110	3.542
120	3.869
130	4.197
140	4.587
150	4.857
160	5.191
170	5.530
180	5.870
190	6.222
200	6.585
CURVE 10 (cont.)	
210	6.953
220	7.334
230	7.376
CURVE 11	
3	0.00
20	0.43
50	1.57
100	3.49
200	7.63
240	9.50
CURVE 12	
3	0.00
20	0.43
50	1.57
100	3.23
200	6.55
284	9.33
CURVE 13	
6	0.00
20	0.39
50	1.31
100	2.76
200	5.58
273	7.70
CURVE 14	
9	0.00
20	0.28
50	1.13
100	2.42
150	3.70
200	4.89
280	6.96
CURVE 15	
291	11.9
300	12.9
308	13.4
316	20.9
CURVE 16	
273	11.6
290	11.9*
CURVE 17	
273	11.6
291	12.1
CURVE 18	
293	12.3*
303	13.1
313	19.6
CURVE 19	
83	2.5
195	6.3
273	11.6*
290	12.0*
300	12.8*
CURVE 20	
302.59	12.51
366.48	26.55
414.26	30.12
418.70	30.88
442.03	32.82
469.26	35.39
482.59	35.90
524.26	40.56
547.03	42.70
592.03	47.03
595.37	47.48
643.70	54.49
691.48	58.01
734.81	60.70
790.92	69.82
848.70	77.44
901.48	85.30
903.70	86.05
969.26	96.59
1020.92	105.82
1076.48	117.59
1135.37	129.96
CURVE 20 (cont.)	
1190.92	144.17
1195.37	144.27
1249.81	159.55
1303.70	174.96
1367.55	196.97
1369.81	197.36
CURVE 21	
312.65	22.00*
314.95	22.15
319.35	22.54
327.55	23.16
336.35	23.74
341.85	24.22
349.25	24.84
361.65	25.74
372.35	26.58
383.25	27.43
392.95	28.24
CURVE 22	
319.65	22.32
327.95	22.82
339.95	23.35
341.65	23.85
362.05	24.44
372.65	24.94
383.35	25.53
393.25	25.98
CURVE 23	
2.76	0.0394
3.13	0.0409
3.60	0.0427
4.28	0.0474
5.69	0.0641
5.94	0.0678
6.34	0.0695
7.23	0.0887
8.36	0.113
10.52	0.169
13.06	0.261
15.17	0.353

* Not shown in figure.

TABLE 26. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF RUBIDIUM Rb (Temperature Dependence) (continued)

T	ρ
CURVE 23 (cont.)	
18.79	0.5214
293.00	14.6
CURVE 24	
313	22.5
323	23.3
373	27.4*
423	31.4
473	35.4
523	39.5
573	44.6
623	48.1
673	52.8
723	57.7
773	63.0
823	68.5
873	74.1
923	80.2
973	86.5
1023	93.2
1073	100.0
1123	107.2
1173	114.5
1223	124.0
CURVE 25	
86.15	3.45
194.85	8.25
273.15	12.80
292.35	14.08
CURVE 26	
1.13	0.664
1.15	0.6893
1.25	0.7296
4.20	0.7507
20.42	1.569
77.60	5.186
87.81	5.842
273.16	19.2
CURVE 27	
373.15	27.5
CURVE 28	
1088.7	123.5
1144.3	130.0
1199.8	149.2
1255.4	163.6
1310.9	179.4
1366.5	196.6
1422.1	215.8
1477.6	239.1
1533.2	265.0
1588.7	294.0
1644.3	325.6
1699.8	359.6
1755.4	396.6
1810.9	439.8
1866.5	500.6
CURVE 29	
293.2	12.83
312	14.03
312	21.91
313.2	22.06*
333.2	23.72
353.2	25.42
373.2	27.14
393.2	28.89
413.2	30.67
433.2	32.48
453.2	34.32
473.2	36.20
493.2	38.10
513.2	40.04
533.2	42.01
553.2	44.01
573.2	46.05
593.2	48.13
613.2	50.24
633.2	51.32
CURVE 30	
273	11.29*
298	13.16
308	23.15
348	25.32
373	27.47
CURVE 31	
1.66	0.01721
1.84	0.01741
2.03	0.01745
2.24	0.01767
2.43	0.01782
2.63	0.01824
2.82	0.01868
3.01	0.01920
3.20	0.02002
3.42	0.02076
3.62	0.02179
3.82	0.02275
4.00	0.02392
4.21	0.02526
4.34	0.02596
4.44	0.02649
4.52	0.02729*
4.60	0.02802
4.69	0.02863*
4.75	0.02918*
4.81	0.02985
4.90	0.03056*
5.00	0.03126
5.03	0.03187
5.10	0.03248
5.17	0.03311
CURVE 32	
1.6	0.01356
1.8	0.01368
2.0	0.01380
2.2	0.01405
2.4	0.01429
2.6	0.01466
2.8	0.01516
3.0	0.01565
3.2	0.01627
3.4	0.01713
3.6	0.01799
3.8	0.01898
4.0	0.02009
4.22	0.02144
4.41	0.02267
4.59	0.02403*
4.75	0.02526
4.895	0.02662*
5.035	0.02896*
5.16	0.02933
CURVE 33	
1.64	0.1523
1.84	0.1525
2.00	0.1529
2.20	0.1530
2.42	0.1534
2.61	0.1538
2.81	0.1545
3.00	0.1551
3.21	0.1560
3.40	0.1566
3.58	0.1580
3.78	0.1593
4.00	0.1607
4.21	0.1627
4.34	0.1636*
4.40	0.1652
4.50	0.1659*
4.58	0.1663*
4.67	0.1675
4.74	0.1683*
4.81	0.1695*
4.87	0.1704
4.94	0.1710*
5.00	0.1717
5.10	0.1723*
5.14	0.1736
CURVE 34	
400	30.06
500	39.56
600	50.31
700	62.60
800	76.78
900	93.31
1000	112.8
1100	136.2
1200	164.8
1300	200.5
1400	246.4
1500	307.4
1600	392.7
1700	520.2
1800	731.7
1900	1150*
2000	2376*
2100	67800*

* Not shown in figure.

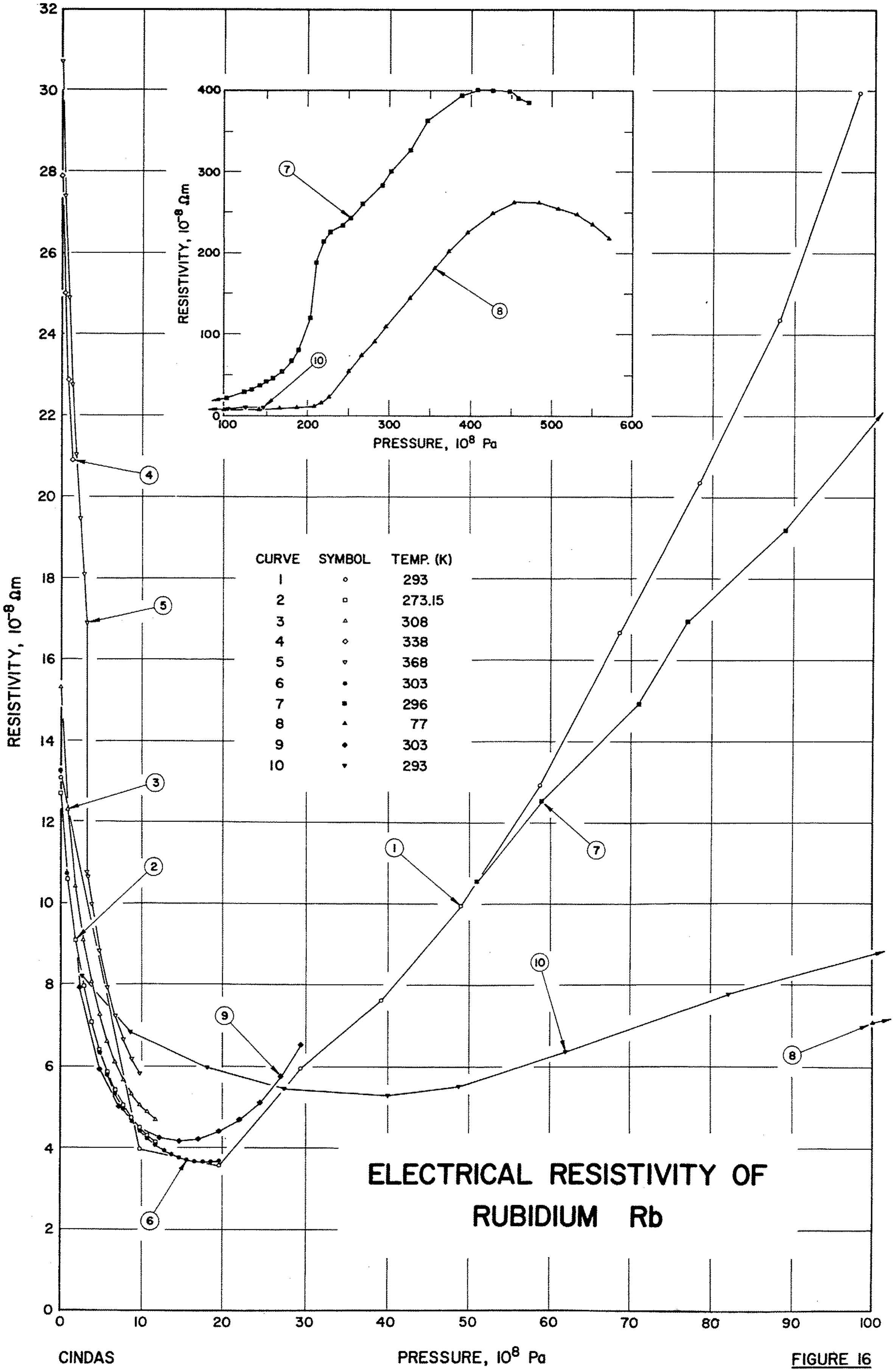

ELECTRICAL RESISTIVITY OF RUBIDIUM Rb
RESISTIVITY, 10^{-8} Ωm
PRESSURE, 10^8 Pa
CURVE SYMBOL TEMP. (K)
1 ○ 293
2 □ 273.15
3 △ 308
4 ◇ 338
5 ▽ 368
6 • 303
7 ■ 296
8 ▲ 77
9 ◆ 303
10 ▼ 293
CINDAS

FIGURE 16

TABLE 27. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF RUBIDIUM Rb (Pressure Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Pressure Range, 10^8 Pa	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	30	Bridgman, P.W.	1952	A	0-98	~293		Pure; 0.013 in. diameter wire specimen was squeezed flat to about 0.004 in. thick; AgCl was used to transmit the pressure; relative electrical resistance were reported; the electrical resistivity data were obtained by using the recommended value of electrical resistivity at 293 K, compressibility data with the relative resistance data.
2	86	Bridgman, P.W.	1925	A	0-11.76	273		Pure; solid, bare wires.
3	86	Bridgman, P.W.	1925	A	0-11.76	308		Pure; solid, bare wires.
4	86	Bridgman, P.W.	1925	A	0-1.47	338		Pure; liquid, in glass capillary, 0.5 mm inside diameter, 4 or 5 cm long.
5	86	Bridgman, P.W.	1925	A	0-9.8	368		Pure; specimen in glass capillary, 0.5 mm inside diameter, 4 or 5 cm long.
6	72	Bridgman, P.W.	1930	A	0-19.6	303		Pure; solid, bare wires; it was extruded to a diameter about 1.6 mm and bent into a haripin 5 or 6 cm on a side.
7	31	Stager, R.A. and Drickamer, H.G.	1963	A	50-472	296		Commercial purity specimen; the resistance as function of pressure data were reported.
8	31	Stager, R.A. and Drickamer, H.G.	1963	A	100-571	77		Same as the above specimen.
9	32	Bridgman, P.W.	1938	A	0-29.4	303		Pure; specimen was enclosed in a U shape glass envelope, the lower part was about 2 mm inside diameter and 2 cm long; the relative electrical resistance data were reported.
10	95	Bundy, F.P.	1959	A	2-150	293		Pure; the specimen was triply vacuum distilled; the specimen was enclosed in a very thin walled glass capillary tube; the silver chloride sleeve around the specimen core served as an approximate hydrostatic medium; resistance data were reported.

TABLE 28. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF RUBIDIUM Rb (Pressure Dependence)

[Temperature, T, K; Pressure, P, 10^8 Pa; Resistivity, ρ, 10^{-8} Ωm]

P	ρ
CURVE 1	**T = 293**
0.0	13.10
9.8	3.97
19.6	3.57
29.4	5.96
39.2	7.62
49.0	9.96
58.8	12.92
68.6	16.68
78.4	20.38
88.2	24.35
98.0	29.95
CURVE 2	**T = 273.15**
0.00	12.71
0.98	10.60
1.96	9.10
2.94	7.97
3.92	7.10
4.90	6.41
5.88	5.87
6.86	5.42
7.84	5.05
8.82	4.75
9.80	4.50
10.78	4.31
11.76	4.15
CURVE 3	**T = 308**
0.00	15.32
0.98	12.32
1.96	10.42
2.94	9.10
3.92	8.07
4.90	7.27
5.88	6.62
6.86	6.11
7.84	5.67
8.82	5.33
9.80	5.05
10.78	4.87
11.76	4.69
CURVE 4	**T = 338**
0.00	27.90
0.49	25.01
0.98	22.88
1.47	20.91
CURVE 5	**T = 368**
0.00	30.72
0.49	27.41
0.98	24.90
1.47	22.76
1.96	21.03
2.45	19.48
2.94	18.10
3.36	16.90
3.36	10.76
3.43	10.65
3.92	9.98
4.90	8.84
5.88	7.94
6.86	7.24
7.84	8.66
8.82	6.19
9.80	5.81
CURVE 6	**T = 303**
0.00	13.28
0.98	10.74
1.96	9.10*
2.94	7.95*
3.92	7.06*
4.90	6.36
5.88	5.80
6.86	5.34
7.84	4.96
8.82	4.66
9.80	4.43
10.78	4.24
11.76	4.08
12.74	3.94
13.72	3.84
14.70	3.77
CURVE 6 (cont.)	**T = 303**
15.68	3.71
16.66	3.67
17.64	3.66
18.62	3.66
19.60	3.68
CURVE 7	**T = 296**
51	10.56
59	12.55
71	14.92
77	16.96
89	19.20
102	21.92
124	29.00
132	32.42
142	37.05
150	42.43
158	47.57
169	54.58
181	67.79
190	81.91
204	120.7
211	189.0
220	215.4
229	226.6
244	235.5
253	244.2
268	260.6
292	284.8
303	301.2
326	327.4
347	363.3
389	393.3
409	401.7
427	400.6
448	399.1
459	390.4
472	385.0
CURVE 8	**T = 77**
100	7.09
CURVE 8 (cont.)	**T = 77**
142	8.51
166	9.20
186	10.92
208	11.95
217	16.84
227	23.89
251	55.57
268	75.08
283	91.57
296	110.0
326	145.6
356	182.1
373	202.9
396	226.5
427	249.7
455	263.1
485	262.5
508	255.0
531	248.5
550	236.6
571	219.5
CURVE 9	**T = 303**
0.00	13.28*
0.45	7.94
4.90	5.94
7.35	5.03
9.80	4.51*
12.25	4.26
14.70	4.17
17.15	4.23
19.60	4.41
22.05	4.69
24.50	5.12
26.95	5.77
29.40	6.55
CURVE 10	**T = 293**
2.74	8.22
8.72	6.84
18.2	5.98
CURVE 10 (cont.)	**T = 293**
27.4	5.45
40.1	5.29
48.8	5.51
62.0	6.36
82.2	7.77
105.4	9.06
105.4	10.03*
126.7	10.21
147.0	10.20

* Not shown in figure.

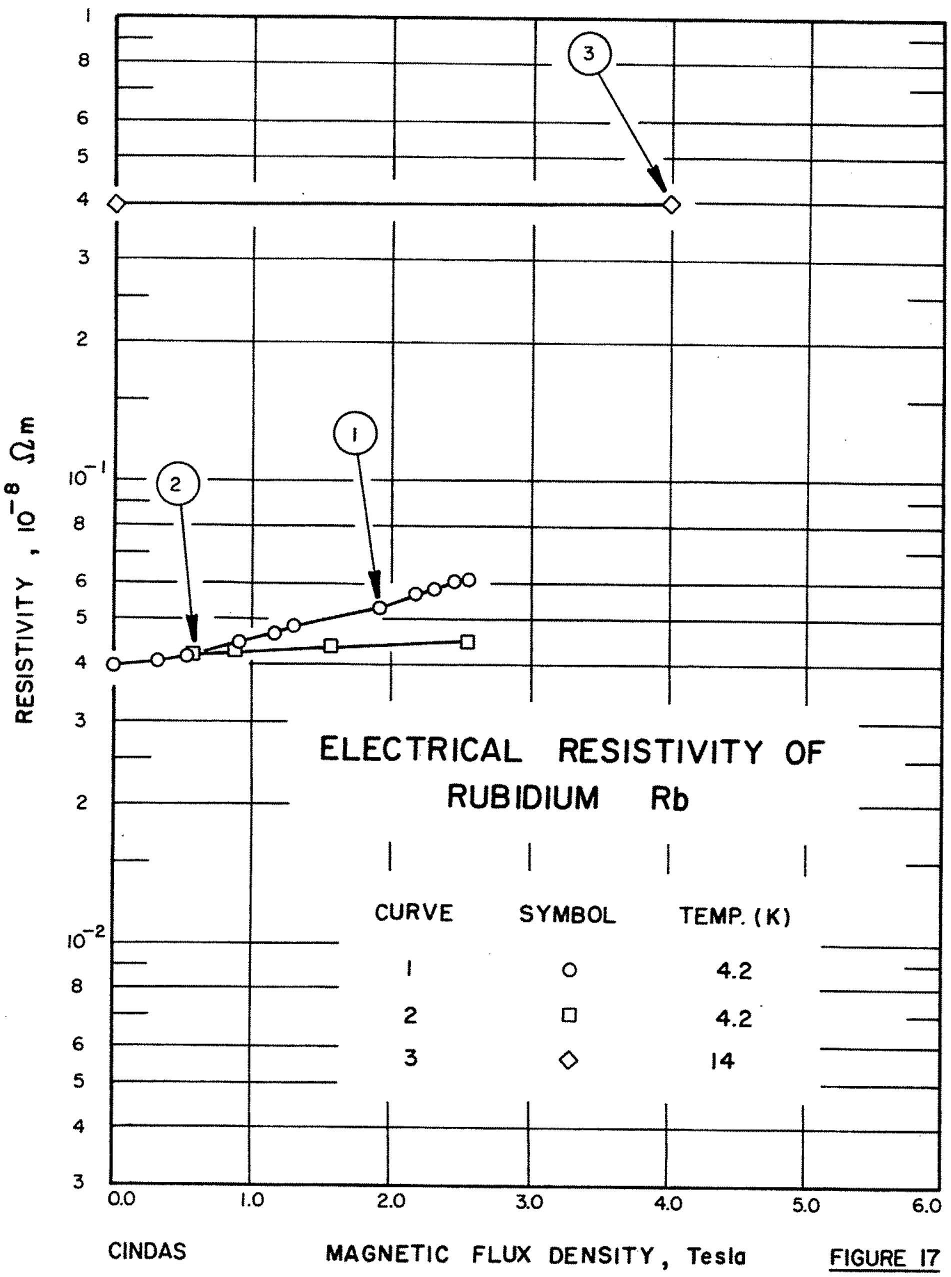

1
8
6
5
4
3
2
10^{-1}
8
6
5
4
3
2
10^{-2}
8
6
5
4
3
RESISTIVITY, 10^{-8} Ω m
0.0
1.0
2.0
3.0
4.0
5.0
6.0
1
2
3
ELECTRICAL RESISTIVITY OF RUBIDIUM Rb
CURVE SYMBOL TEMP. (K)
1 ○ 4.2
2 □ 4.2
3 ◇ 14
CINDAS
MAGNETIC FLUX DENSITY, Tesla

FIGURE 17

TABLE 29. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF RUBIDIUM Rb (Magnetic Flux Density Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Magnetic Flux Density Range, Tesla	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	73	MacDonald, D.K.C.	1957		0-2.55	~4.2		Pure, plate specimen; 0.5-0.6 mm thickness, 7 mm width, and 4.2 cm in length; $R_{4.2\,K}/R_{294\,K} = 3.10^{-3}$; resistance was measured with the plane of specimen perpendicular to the magnetic field.
2	73	MacDonald, D.K.C.	1957		0-2.55	~4.2		Same as the above specimen; the resistance was measured with the plane of specimen parallel to the magnetic field.
3	36	Justi, E.	1948		0,4.0	14	Rb 4	Pure; $R_{14.0\,K}/R_{273.15\,K} = 0.0339$; it was measured in a transverse magnetic field.

TABLE 30. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF RUBIDIUM Rb (Magnetic Flux Density Dependence)

[Temperature, T, K; Magnetic Flux Density, B, Tesla; Resistivity, ρ, 10^{-8} Ωm]

B	ρ	B	ρ
CURVE 1 T = 4.2		CURVE 2 (cont.) T = 4.2	
0.00	0.0393	0.58	0.0418
0.31	0.0407	0.88	0.0426
0.54	0.0417	1.56	0.0433
0.91	0.0446	2.55	0.0445
1.17	0.0464	CURVE 3 T = 14	
1.30	0.0487	0.0	0.3922
1.91	0.0530	4.0	0.3938
2.18	0.0566		
2.31	0.0581		
2.45	0.0601		
2.48	0.0605*		
2.55	0.0615		
CURVE 2 T = 4.2			
0.00	0.0393*		
0.34	0.0405*		

* Not shown in figure.

4.5. Cesium

Cesium, with atomic number 55, is a silvery-white, soft, ductile, alkali metal. It has a body-centered cubic crystalline structure with a density of 1.873 g cm^{-3} at 293 K. It melts at 301.55 K and boils at about 944 K. Its critical temperature has been measured to be 2051 ± 4 K. Cesium has only one stable isotope, ^{133}Cs, though twenty other radioactive isotopes are known to exist. It ranks 45th in the order of abundance of elements in the continental crust of the earth (0.003% by weight).

a. Temperature Dependence

There are 56 sets of experimental data available for the temperature dependence on the electrical resistivity of cesium. The information on specimen characterization and measurement conditions for each of the data sets is given in table 32. The data are tabulated in table 33 and shown in figures 17 and 18. Determinations of the electrical resistivity of cesium for the solid, liquid, and gas phases cover the temperature region from 1.5 to 8800 K.

There are 18 data sets obtained below 100 K. Among these, Aleksandrov, Lomonos, Ignatév, and Gromov [96] (curve 49) gave the lowest residual resistivity ρ_0 = 0.00236 × $10^{-8}\Omega$ m for 99.995 pure specimen. Dugdale and Phillips [90] reported the electrical resistivities for several constant volumes (curves 10, 12, 13, and 14). Appleyard [97] tabulated the electrical resistivity of Cs thin film (495 Å) on pyrex glass (curve 24). McWhan and Stevens [98] tabulated the electrical resistivity data for several constant pressures (curves 50–52). Eight sets of intrinsic electrical resistivity are obtained by subtraction of residual resistivity ρ_0 from the measured resistivity. In deriving the smoothed most probable values of the intrinsic resistivity from the available data, the following overlapping temperatures were considered: below 10 K, 5–20 K, 10–40 K, 20–80 K, 30–150 K, etc. Within each range, a least-mean-square fraction error fit with the semiempirical equation $\rho_i = aT^b$ was made to all available intrinsic resistivity data. The resulting values for adjacent ranges were intercompared and the values were corrected for thermal linear expansion. The preliminary values were then fitted with the cubic spline function equation (7) to generate the final recommended values. The coefficients of equation (7) obtained in the fitting are given in the following table:

Temperature range, K	a	b	c	d
1 - 9.11	−3.551	2.829	1.293	−1.192
9.11– 11.10	−0.698	2.019	−2.137	20.63
11.10– 12.55	−0.529	2.105	3.149	−36.25
12.55– 22.14	−0.413	2.131	−2.670	2.793
22.14–100	−0.00765	1.323	−0.603	0.436

There are 17 data sets in the temperature region from 100 K to the melting point 301.55 K. Among these, four sets (curves 10, 12, 13, and 14) are for constant volume and three sets (curves 50–52) are for constant pressure. For the rest of the data, excluding curve 30, after subtracting the residual resistivity, they agree with one another within 5%. A least-mean-square fraction error fit of the totality of experimental data except those measured at constant volume in this range was made with $\rho_i = aT^b$. The resulting values were corrected for thermal linear expansion, and then fitted with the cubic spline function equation (7) to obtain the final recommended values in this temperature range. The coefficients of equation (7) obtained are as follows:

Temperature range, K	a	b	c	d
22.14–202.68	−0.00765	1.323	−0.603	0.436
202.68–301.55	1.095	1.373	0.655	−5.028

There are 32 data sets available for the liquid state. Endo [40] also tabulated the electrical resistivities at constant volume (curve 27). Pfeifer, Freyland, and Hensel [99] (curves 32–39), Renkert, Hensel, and Franck [100] (curves 40–45), Tamski, Ross, Cusak, and Endo [69] (curves 46 and 47), and Barol'skii, Ermokhin, Kulik, and Mel'mikov [101] (curve 53) have investigated the electrical resistivities at various constant pressure. The rest of the data are apparently measured at the saturated vapor pressure. Below 1000 K they agree with one another within 10% and somewhat higher above 1000 K. Below 1000 K, all the experimental data except those measured at constant volume and at constant pressure were fitted by a logarithm third order polynomial. Above 1000 K, the electrical resistivity values are obtained by extrapolating the fitted values and following the experimental trend. The resulting values are fitted with the cubic spline function equation (7) to obtain the final recommended values. The coefficients of equation (7) obtained from fitting are as follows:

Temperature range, K	a	b	c	d
301.55– 532.3	1.567	0.880	−0.030	0.739
532.3 – 652.4	1.794	1.000	0.516	−0.652
652.4 –2000	1.886	1.076	0.343	4.426

At the melting point (301.55 K), the electrical resistivity of cesium in the liquid is about 73% higher than that of solid state. Using Mott's formula (eq 5), it gives $(\rho_s/\rho_l)_{T_m}$ = 75%.

Borol'skii, Ermoklin, Kulik, and Mel'nikov [101] (curves 53–56) have investigated the electrical resistivity of dense nonideal plasma at various pressures up to 8800 K.

The recommended values for the total and intrinsic electrical resistivity are listed in table 31, and those for the total electrical resistivity are also shown in figures 17 and 18. The recommended values for the liquid state are for the saturated liquid. The recommended values of the total electrical resistivities for the solid state are for a 99.99$^+$% pure cesium and those at temperatures below 50 K are applicable only to a specimen with residual resistivity ρ_0 = 0.00232 × 10^{-8} ω m. The recommended values are corrected for thermal linear expansion from 1 K to 301.55 K. The correction amounts to −1.8% at 1 K,

−1.1% at 140 K, and 0.06% at 301.55 K. The uncertainty of the recommended values for the total electrical resistivity is believed to be within ±5% from 1 K to 1500 K and ± 10% from within 1500 K to 2000 K. Above 20 K the uncertainty of the intrinsic resistivity is about the same as that of the total electrical resistivity; below 20 K this uncertainty is higher than that of the total electrical resistivity.

b. Pressure Dependence

There are 17 sets of experimental data available for the electrical resistivity of cesium as a function of pressure. The information on specimen characterization and measurement conditions for each of the data sets is given in table 34. The data are tabulated in table 35 and shown in figure 20.

The available data and information for the pressure dependence of electrical resistivity of cesium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

c. Magnetic Flux Density Dependence

There is only one set of experimental data available for the electrical resistivity of cesium under the influence of magnetic field. The information on specimen characterization and measurement information for each of the data sets is given in table 36. The data are tabulated in table 37 and shown in figure 21.

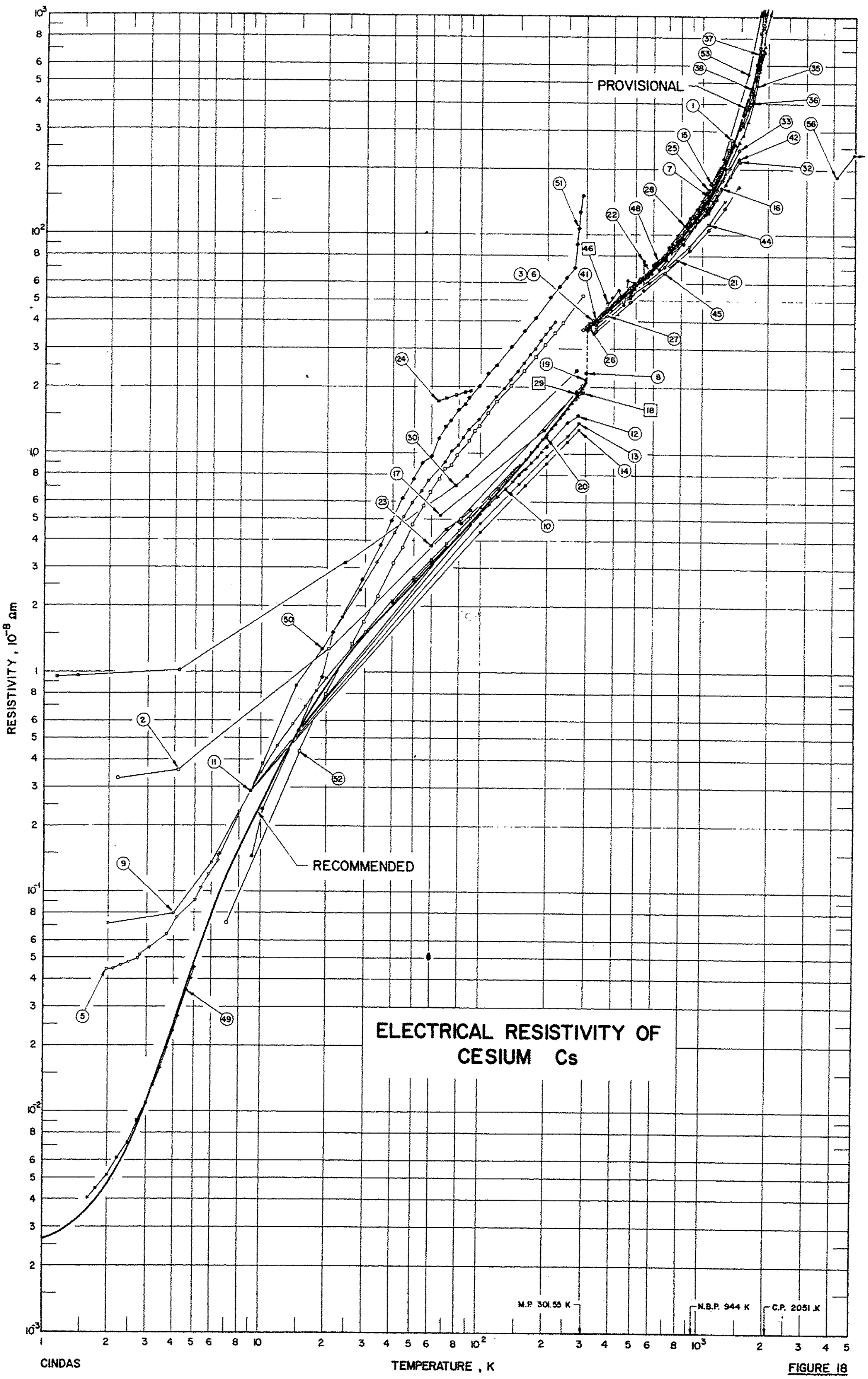
The available data and information for the magnetic flux density dependence of electrical resistivity of cesium are inadequate for performing detailed analysis and synthesis at this time. Consequently, no recommendations are made and only experimental data are presented here.

TABLE 31. RECOMMENDED ELECTRICAL RESISTIVITY OF CESIUM (Temperature Dependence)

[Temperature, T, K; Total Resistivity, ρ, 10^{-8} Ωm; Intrinsic Resistivity, ρ_i, 10^{-8} Ωm]

Solid						Liquid	
T	ρ	ρ_i	T	ρ	ρ_i	T	ρ
1	0.0026		35	1.72	1.72	301.55	36.93
2	0.0048	0.0024*	40	1.99	1.99	350	42.11
3	0.0118	0.0092*	45	2.27	2.27	400	47.45
4	0.0255	0.0229*	50	2.54	2.54	500	58.46
5	0.0474	0.0448*	60	3.07	3.07	600	70.30
6	0.0771	0.0745*	70	3.61	3.61	700	82.97
7	0.114	0.111*	80	4.16	4.16	800	96.97
8	0.155	0.152*	90	4.71	4.71	900	113.4
9	0.198	0.195*	100	5.28	5.28	1000	133.4
10	0.243	0.240*	150	8.43	8.43	1100	158.1
11	0.294	0.291*	200	12.22	12.22	1200	189.0
12	0.354	0.351*	250	16.66	16.66	1300	227.6
13	0.419	0.416*	273.15	18.75	18.75	1400	276.3
14	0.485	0.482*	293	20.46	20.46	1500	337.8
15	0.550	0.547*	300	21.04	21.04	1600	415.5*
16	0.614	0.611*	301.55	21.16	21.16	1700	513.9*
18	0.738	0.735*				1800	638.8*
20	0.859	0.856*				1900	797.6*
25	1.15	1.15				2000	1000.0*
30	1.44	1.44					

* Provisional values.


ELECTRICAL RESISTIVITY OF
CESIUM Cs
PROVISIONAL
RECOMMENDED
RESISTIVITY, 10^{-8} Ωm
TEMPERATURE, K
M.P. 301.55 K
N.B.P. 944 K
C.P. 2051 K
CINDAS
FIGURE 18

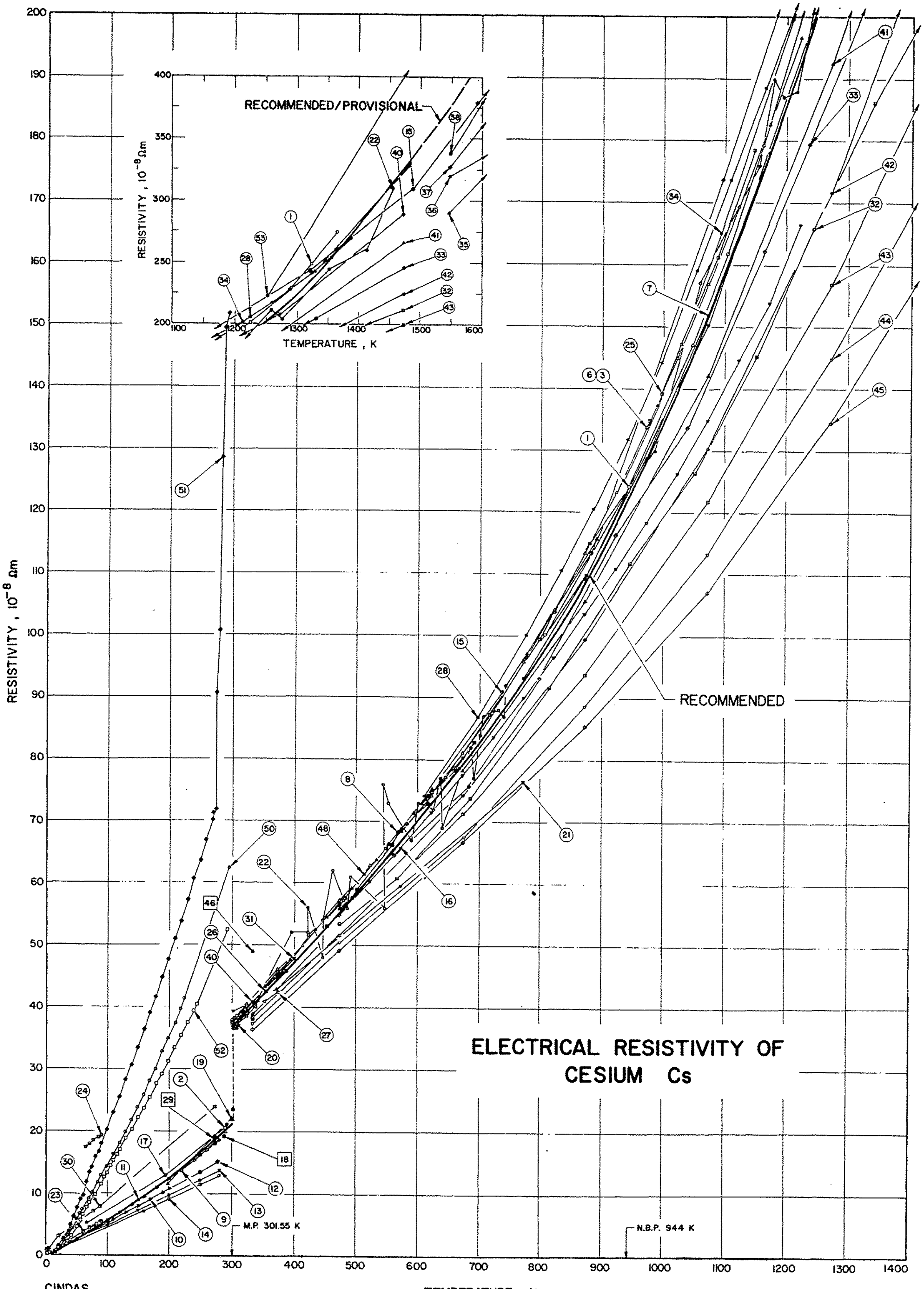

RECOMMENDED/PROVISIONAL
RESISTIVITY , 10^{-8} Ωm
TEMPERATURE , K
RECOMMENDED
ELECTRICAL RESISTIVITY OF
CESIUM Cs
M.P. 301.55 K
N.B.P. 944 K
RESISTIVITY , 10^{-8} Ωm
CINDAS
TEMPERATURE , K

FIGURE 19

TABLE 32. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Temperature Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	17, 91, 92	Tepper, F., Murchison, A., Zelenak, J., and Roehlich, F.	1963-1965	A	302-1360		Pure; specimen was placed in a Haynes-25 alloy cylindrical cell, 0.5 in. O.D. with wall thickness 0.065 in., and 2.6 in. long.
2	102	McLennan, J.C., Niven, C.D., and Wilhelm, J.O.	1928		2.2-290		Pure; specimen was run into a fine capillary tube.
3	12	Shpil'rain, E'.E'., Soldatenko, Yu.A., Yakimovich, K.A., Fomin, V.A., Savchenko V.A., Belova, A.M., Kagan, D.N., and Krainova, J.F.	1965	A	300-1223	Cs (I)	Pure; 0.4 Rb, 0.05 K, and 0.04 Na; specimen in liquid state; measured in insert gas atmosphere; the liquid metal was enclosed in a stainless steel tube; density = 1.853 - 5.71 x 10^{-4} (T-273.15) g cm^{-3}; melting point = 300.45 K; boiling point = 963.15 K; data were presented by ρ = 34.88 + 11.233 x 10^{-2} (T-273.15) 10^{-8} Ωm (from M.P. to 623 K), ρ = 49.66 + 2.318 x 10^{-2} (T-273.15) + 1.386 x 10^{-4} $(T-273.15)^2$ (from 623-1223 K), T in K units.
4*	12	Shpil'rain, E'.E'., et al.	1965	A	300-1223	Cs (II)	Pure; 0.003 Rb, 0.005 Na, and 0.00013 K; melting point = 301.25 K; other specifications similar to the above specimen; data were presented by ρ = 34.089 + 9.816 x 10^{-2} (T-273.15) + 0.383 x 10^{-4} $(T-273.15)^2$ (from M.P. to 723 K), ρ = 63.98 + 2.724 x 10^{-2} (T-273.15) + 1.712 x 10^{-4} $(T-273.15)^2$ (723-1223 K), where ρ in 10^{-8} Ωm, T in K units.
5	23, 103	MacDonald, D.K.C., White, G.K., and Woods, S.B.	1955, 1956	A	2-6.5	Cs 3	Pure; specimen was obtained from Messers A. D. Mackay (New York); specimen was melted in vacuo and run into soft glass tube with platinum leads sealed in; sample diameter 1.6 mm; ρ_0/ρ_{295} = 2.08 x 10^{-3}.
6	14	Shpil'rain, E'.E'. and Savchenko, V.A.	1968	A	303-1173	Cs 1	Pure; 0.4 Na, 0.05 K, and 0.03 Rb; specimen was obtained by reduction of CsCl and distillation of the cesium at pressure of 1 x 10^{-3} ton and at temperature about 700 C; specimen was filled in a 1 Kh 18 NgT stainless steel test tube, 15 mm in diameter and 50 cm long with a wall thickness 0.75 mm.
7	14	White, G.K., et al.	1968	A	303-1173	Cs 2	Pure; 0.005 Na, 0.00013 K, and 0.003 Rb; other specifications similar to the above specimen.
8	104	Hyman, J. Jr.	1961	A	302-692		Pure; specimen was placed in a type 321 stainless steel tube 0.125 in. in diameter, 0.012 in. wall, 3 in. long; fitted with two copper current electrodes; two 30 guage electrodes were spot welded along the tube with 1 in. separation.
9	90	Dugdale, J.S. and Phillips, D.	1965	A	1.5-300	Cs 4,5,6	Pure; specimens were obtained from L. Light and Co. Ltd., Colnbrook, England; wire specimens were extruded under distilled paraffin; 3 mm diameter; $R_{295}/R_{4.2}$ = 250; the electrical resistivity was measured under zero pressure.
10	90	Dugdale, J.S. and Phillips, D.	1965	A	2-200	Cs 4,5,6	Same as above specimen; electrical resistivity was measured at constant volume condition.
11	90	Dugdale, J.S. and Phillips, D.	1965	A	0-274		Similar to the above specimen; ideal electrical resistivity were reported as function of temperature at constant pressure (p = 0); data were extracted from smooth curve.
12	90	Dugdale, J.S. and Phillips, D.	1965	A	0-277		Similar to the above specimen; ideal electrical resistivity were reported as function of temperature at constant density as at 0 K at zero pressure; data were extracted from smooth curve.
13	90	Dugdale, J.S. and Phillips, D.	1965	A	0-281		Similar to the above specimen; at constant density as at 0 K at 1000 atm.
14	90	Dugdale, J.S. and Phillips, D.	1965	A	0-280		Similar to the above specimen; at constant density as at 0 K at 42,000 atm; data above 150 K were interpolated between present results and a point based on Bridgman's data at ice point.

* Not shown in figure.

TABLE 32. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
15	105, 106	Hochman, J.M. and Bonilla, C.F.	1965	A	589-1922		99.97 pure; 0.0154 O_2, 0.0145 Rb, 0.004 Na, 0.0023 Ca, 0.0018 Fe, 0.0013 S, 0.0016 B, 0.0006 K, 0.0003 each Mg, Cr, and Ni; specimen was obtained from Dow Chemical Co.; liquid specimen was placed in a 90 Ta/10 W alloy capsule, 1 in. O.D., 1/10 in. wall, and 12 in. long; thermal expansion corrected.
16	18	Semyachkin, B.E. and Solov'ev, A.N.	1964		303-1223		Pure; specimen was placed in a Haynes-25 alloy cylindrical cell, 0.5 in. O.D., with wall thickness 0.065 in., and 26 in. in length.
17	19	Guntz, A. and Broniewski, W.	1909		86-293		Pure.
18	56	Hackspill, L.	1910	A	289	1	Pure.
19	56	Hackspill, L.	1910	A	198-307	2	Pure.
20	56	Hackspill, L.	1910	A	83-310	3	Pure.
21	52, 88	Solov'ev, A.N.	1963, 1967		302-773		Pure; liquid state specimen; density 1.83, 1.80, 1.69, 1.58 g cm^{-3} at 302, 373, 573, and 793 K.
22	107	Lemmon, A.W. Jr., Deem, H.W., Eldridge, E.A., Hall, E.H., Matolich, J., and Walling, J.F.	1964		333-1456		Pure; 0.0002 each Al, Fe, 0.0001 each Ag, Mo, 0.0003 Ca, 0.001 each Ca, Si, 0.0005 Ni, 0.002 Na, Rb, and 0.0015 K.
23	97	Appleyard, E.T.S.	1937		60-90		Pure; bulk material.
24	97	Appleyard, E.T.S.	1937		64.8-90	Cs (Film)	Pure; Cs film was deposited on Pyrex glass at 64 K; film thickness 49.5 Å.
25	43	Kapelner, S.M. and Bratton, W.D.	1962	B	301.5-1150		99.9 pure; 0.0001 each O_2, N_2, 0.00045 C, and 0.0004 Rb; specimen was obtained from MSA Research Corp.; liquid specimen was loaded into a type 347 stainless steel tube welded and sealed and it was heated at 823 K for 2 hr prior to measurements.
26	40	Endo, H.	1963	A	302-374		Pure; specimen was supplied by A. D. Mackey Ltd.; specimen was placed in an 0.7 mm I.D. soft glass capillary tube; electrical resistivity was measured at constant pressure condition.
27	40	Endo, H.	1963	A	302-374		Same as above specimen; electrical resistivity was obtained at constant volume.
28	108	Hoffman, H.W. and Robin, T.T. Jr.	1967		600-1388		Pure.
29	22	Krautz, E.	1950		273		Pure.
30	29	Meissner, W. and Voigt, B.	1930		1.15-273	Cs 1	Pure; specimen was distilled in a glass tube; sample diameter was 3 mm and about 33 mm in length.
31	68	Van der Lugt, W., Devlin, J.F., Hennephof, J., and Leenstra, M.R.	1973	B	373.15-398.15		Pure; $d\rho/dT = 0.1005 \times 10^{-8}$ Ω m/K.
32	99	Pfeifer, H.P., Freyland, W.F., and Hensel, F.	1973		473-1473		Pure; fluid cesium was placed in a metallic tungsten-26% rhenium tube as container, at the ends of the tube two thermocouples (97% W, 3% Re-74% W, 26% Re) were fixed; electrical resistivity was measured at pressure equal to 500 bar; data were extracted from smooth curve.
33	99	Pfeifer, H.P., et al.	1973		473-1473		Similar to the above specimen; electrical resistivity was measured at pressure equal to 300 bar.
34	99	Pfeifer, H.P., et al.	1973		473-1482		Similar to the above specimen; electrical resistivity was measured at pressure equal to 100 bar.

TABLE 32. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
35	99	Pfeifer, H.P., Freyland, W.F., and Hensel, F.	1973		1546-2103		Similar to the above specimen; electrical resistivity was measured at pressure equal to 200 bar.
36	99	Pfeifer, H.P., et al.	1973		1547-2104		Similar to the above specimen; electrical resistivity was measured at pressure equal to 175 bar.
37	99	Pfeifer, H.P., et al.	1973		1547-2100		Similar to the above specimen; electrical resistivity was measured at pressure equal to 150 bar.
38	99	Pfeifer, H.P., et al.	1973		1548-2093		Similar to the above specimen; electrical resistivity was measured at pressure equal to 130 bar.
39*	99	Pfeifer, H.P., et al.	1973		1548-2007		Similar to the above specimen; electrical resistivity was measured at pressure equal to 115 bar.
40	100	Renkert, H., Hensel, F., and Franck, E.U.	1971		333-1473		Pure; liquid cesium was placed in the cell of pure molybdenum, the vessel was filled with purified argon and the argon pressure balanced the cesium pressure inside the cell; critical point T_c = 2023 K and p_c = 110 bar; electrical resistivity was measured at p = 100 bar.
41	100	Renkert, H., et al.	1971		333-1473		Similar to the above specimen; electrical resistivity was measured at p = 200 bar.
42	100	Renkert, H., et al.	1971		333-1473		Similar to the above specimen; electrical resistivity was measured at p = 400 bar.
43	100	Renkert, H., et al.	1971		333-1473		Similar to the above specimen; electrical resistivity was measured at p = 600 bar.
44	100	Renkert, H., et al.	1971		333-1473		Similar to the above specimen; electrical resistivity was measured at p = 800 bar.
45	100	Renkert, H., et al.	1971		333-1473		Similar to the above specimen; electrical resistivity was measured at p = 1000 bar.
46	69	Tamaki, S., Ross, R.G., Cusack, N.E., and Endo, H.	1973	A	373.15		Pure; liquid state; electrical resistivity was measured at presrure 1 bar.
47*	69	Tamaki, S., et al.	1973	A	373.15		Pure; liquid state; electrical resistivity was measured at pressure 4 kbar.
48	94	Semyachkin, B.E. and Solov'ev, A.N.	1970	A	293-623		99.97 pure; the specimen was placed in a stainless steel tube in a copper block; temperature was measured by a Pt-PtRh(10%) thermocouple; the measurements were carried out during both heating and cooling at 0.01 C/min. rate and with current in both directions; $\rho_{liquid}/\rho_{solid}$ = 1.704, $(1/\rho\ d\rho/dT)_{solid}$ = 49.2 x 10^{-4}/K, $(1/\rho\ d\rho/dT)_{liquid}$ = 31.4 x 10^{-4}/K.
49	96	Aleksandrov, B.N., Lomonos, O.I., Ignat'ev, O.S., and Gromov, O.G.	1969	A	1.6-5		99.995 pure; 0.004 Rb, 0.002 Na, 0.0004 K, and traces of Si, Ca, Mg, Fe, and Al; the resistance of cesium was measured in thick walled cylindrical glass capillaries; platinum wires were used as potential and current leads; relative resistivity ρ_0/ρ_{293} = 1.13 x 10^{-4}; relative resistance data were reported.
50	98	McWhan, D.B. and Stevens, A.L.	1969		3-300		99.97 pure, $\rho_{298}/\rho_{4.2}$ = 450; electrical resistivity were measured at P = 30 Kbar.
51	98	McWhan, D.B. and Stevens, A.L.	1969		3-300		Same as the above specimen except P = 43 Kbar.
52	98	McWhan, D.B. and Stevens, A.L.	1969		3-300		Same as the above specimen except P = 60 Kbar.

* Not shown in figure.

TABLE 32. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Temperature Dependence) (continued)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
53	101	Barol'skii, S.G., Ermokhin, N.V., Kulik, P.P., and Mel'nikov, V.M.	1972	A	1253-2473		Dense strong nonideal plasma; a stationary set up of the "ohmic oven" type at pressure p = 150 atm.
54*	101	Barol'skii, S.G., et al.	1972	A	7050-7750		Dense strong nonideal plasma; a pulse set up with the plasma stabilized by a solid transparent wall; measured at p = 130 atm.
55*	101	Barol'skii, S.G., et al.	1972	A	7150-8800		Same as the above specimen except measured at p = 170 atm.
56*	101	Barol'skii, S.G., et al.	1972	A	4150-5780		Same as the above specimen except measured at p = 350 atm.

* Not shown in figure.

TABLE 33. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Temperature Dependence)

[Temperature, T, K; Resistivity, ρ, 10^{-8} Ω m]

T	ρ
CURVE 1	
308.6	38.6
480.2	57.4
643.5	76.96
808.0	100.33
944.6	124.2
1048.5	147.06
1104.1	161.8
1162.4	174.32
1225.7	201.16
1290.2	229.1
1323.0	248.92
1365.8	274.57
CURVE 2	
2.2	0.324
4.2	0.359
20.6	1.28
82.0	5.04
290.0	20.5
CURVE 3	
300.3	37.94
323	40.49
373	46.11
423	51.72
473	57.34
523	62.96
573	68.57
623	74.19
623	74.75
673	81.11
723	88.15
773	95.90
823	104.33
873	113.46
923	133.28
973	133.80
1023	145.00
1073	156.90
1123	169.50
1173	182.78
1223	196.76
CURVE 4*	
291.1	32.8
323	39.09
373	44.29
423	49.67
473	55.25
523	61.02
573	66.98
623	73.13
673	79.48
723	86.02
723	86.39
773	93.16
823	100.7
873	109.3
923	118.7
973	128.8
1023	139.8
1073	151.8
1123	164.6
1173	178.1
1223	192.6
CURVE 5	
1.9635	0.0445
2.000	0.0448
2.070	0.0450
2.1088	0.0448
2.275	0.0462
2.478	0.0477
2.530	0.0467
2.716	0.0493
2.774	0.0506
3.076	0.0555
3.141	0.0550
3.707	0.0639
3.707	0.0661
4.12	0.0760
4.188	0.0747
5.105	0.0966
5.383	0.1093
5.875	0.1209
6.457	0.1388
6.457	0.1463
CURVE 6	
303	38.25
323	40.50
373	46.12
473	57.35
573	68.58
673	81.12
773	95.92
873	113.5
973	133.8
1073	156.9
1173	182.8
CURVE 7	
303	37.07
323	39.09*
373	44.29*
473	55.25*
573	66.98*
673	79.48*
773	93.16
873	109.3
973	128.8
1073	151.8
1173	178.1
CURVE 8	
302	23.5
323	39.05*
387	45.8
452	53.1
494	57.6
503	59.0
560	66.3
568	68.4
617	73.0
617	74.2
661	78.3
692	82.9
CURVE 9	
2	0.0719
4	0.0796
6	0.1365
CURVE 9 (cont.)	
8	0.2335
10	0.350
12	0.465
14	0.578
16	0.693
18	0.812
20	0.937
30	1.535
40	2.121
50	2.709
60	3.298
70	3.883
80	4.478
90	5.082
100	5.691
110	6.308
120	6.928
130	7.555
140	8.190
150	8.834*
160	9.491
170	10.166
180	10.858
190	11.557
200	12.274
210	13.005
220	13.751
230	14.519
240	15.306
250	16.114*
260	16.939
270	17.774
280	18.650
290	19.551
CURVE 10	
2	0.0559
4	0.0797*
6	0.137*
8	0.233*
10	0.349
12	0.464*
14	0.578*
16	0.693*
18	0.812*
CURVE 10 (cont.)	
20	0.933*
30	1.520
40	2.083
50	2.635
60	3.180
70	3.713
80	4.247
90	4.784
100	5.321*
110	5.862
120	6.399
130	6.927
140	7.460
150	7.989
160	8.534
170	9.078
180	9.628
190	10.189
200	10.748
CURVE 11	
9	0.29
100	5.70
150	8.87
200	12.35
250	16.14
274	18.25
CURVE 12	
9	0.29*
100	5.38
150	8.06
200	10.77
249	13.48
277	15.08
CURVE 13	
9	0.29*
100	4.79
150	7.28
200	9.71
250	12.08
281	13.75
CURVE 14	
9	0.29*
100	4.42
159	7.18
200	9.07
250	11.41
280	12.85
CURVE 15	
582	69.77
737	90.97
883	113.5
1097	173.8
1321	243.5
1488	309.1
1592	379.1
1706	445.6
1818	567.4
1911	690.7
1959	1000± 8000*
CURVE 16	
303	37.9
323	39.9
373	44.9
423	49.8*
473	55.0*
523	60.3
573	65.8
623	71.5
673	77.5
723	83.7
773	90.0
823	96.6
873	103.6
923	110.9
973	118.5
1023	126.2
1073	134.9
1123	144.6
1173	153.8
1223	166.4

* Not shown in figure.

TABLE 33. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Temperature Dependence) (continued)

T	ρ
CURVE 17	
66	5.25
194.7	12.81
273	19.3
292.4	21.1
CURVE 18	
289	19.2
CURVE 19	
198	11.5
273	18.0
290	19.9
300	22.1
307	36.6
CURVE 20	
83	4.8
198	12.0
273	18.2*
290	20.1*
300	22.3*
303	36.6
310	37.0
CURVE 21	
302	39.3
373	42.9
573	59.6
773	76.5
CURVE 22	
333	38
341	41
373	44*
395	52
421	52
421	56
446	48
446	54
462	62
486	56
492	61
544	76
547	56
CURVE 22 (cont.)	
553	73
590	67
601	73
626	72
637	77
640	69
686	82
691	77
701	84
706	87
731	88
740	87
743	92
824	104
880	115
987	130
1059	157
1156	176
1180	190
1195	187
1217	188
1259	211
1277	204
1353	244
1414	260
1456	310
CURVE 23	
60.0	3.8
70.1	4.5
80.0	4.9
90.0	5.5
CURVE 24	
64.8	17.4
70.1	17.9
77.9	18.5
85.2	19.1
90.0	19.3
CURVE 25	
301.3	37.42
308.8	38.32*
321.6	39.80*
374.4	45.77
483.8	57.71
CURVE 25 (cont.)	
549.9	65.74
643.6	77.28
717.2	87.35
800.2	99.68
923.0	123.63*
979.4	134.84
998.8	139.29
1029.9	147.20
1088.3	161.26
1149.7	178.63
CURVE 26	
302.1	36.74*
311.1	37.95
325.7	39.44
337.8	40.62
354.7	42.68
374.3	44.76*
CURVE 27	
306.2	37.22
323.1	38.52
338.6	40.04
351.6	40.95
373.2	42.42
CURVE 28	
611.1	74.2
698.4	86.9
777.3	100.2
835.0	110.7
886.1	120.6
942.8	131.9
997.8	144.3
1055.6	159.1
1110.0	173.8
1166.7	188.7
1222.3	205.9
1260.0	217.1
1288.9	227.9
1325.0	241.4
1357.8	254.4
1388.9	267.4
CURVE 29	
273	19.0
CURVE 30	
1.15	0.950
1.43	0.960
4.21	1.027
20.42	3.170
77.60	7.172
87.81	7.96
273.16	24.05
CURVE 31	
373.15	45.3
398.15	47.8
CURVE 32	
473	53.45
567	60.81
685	73.79
815	91.65
946	111.7
1052	125.3
1152	145.2
1244	165.9
1343	186.2
1473	211.8
CURVE 33	
473	54.95
561	64.56
683	75.64
799	93.32
822	116.4
1039	133.6
1164	162.2
1237	179.5
1331	204.1
1473	245.4
CURVE 34	
473	55.97
559	64.86
666	78.71
778	97.27
891	115.8
990	137.4
1094	165.2
1213	201.4
1327	242.1
1482	328.0
CURVE 35	
1546	289.7
1622	331.1
1704	414.9
1773	489.7
1836	583.4
1913	737.9
1994	937.5
2036	1056*
2064	1253*
2103	1458*
CURVE 36	
1547	319.1
1610	337.3*
1682	403.6
1763	492.0*
1833	602.5
1890	701.4
1939	851.1
1997	1081*
2034	1294*
2069	1520*
2104	2511*
CURVE 37	
1547	326.6
1626	378.4*
1701	459.1
1753	517.6
1802	588.8*
1839	688.6
1896	893.5
1927	1066*
1962	1318*
2006	1729*
2053	2454*
2100	3855*
CURVE 38	
1548	337.2
1613	392.6
1696	476.4
1769	616.6
1813	737.9
1847	847.2
1881	1047*
CURVE 38 (cont.)	
1919	1458*
1958	2032*
1976	2666*
2002	3908*
2021	6426*
2042	9772*
2056	12820*
2068	17140*
2080	23330*
2093	34670*
CURVE 39*	
1548	337.2
1619	392.6
1678	474.2
1748	619.4
1794	731.1
1820	851.1
1852	1037
1886	1282
1915	1828
1935	2410
1950	3311
1968	4385
1980	6982
1990	11160
1997	21280
2006	35310
2007	47640
CURVE 40	
333	40.82
473	56.56
673	80.26
873	109.9
1073	150.15
1273	208.33
1473	289.85
CURVE 41	
333	40.16
473	55.31*
673	78.13
873	105.71
1073	142.04
1273	192.68
1473	265.96

* Not shown in figure.

TABLE 33. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Temperature Dependence) (continued)

T	ρ
CURVE 42	
333	38.91
473	53.22
673	74.18
873	99.50
1073	130.04
1273	171.82
1473	224.20
CURVE 43	
333	38.17
473	51.60
673	71.12
873	93.72
1073	121.80
1273	156.98
1473	199.20
CURVE 44	
333	37.17
473	50.40
673	67.75
873	88.73
1073	113.38
1273	144.93
1473	183.48
CURVE 45	
333	36.23
473	49.09
673	65.79
873	85.40
1073	107.07
1273	134.59
1473	168.92
CURVE 46	
373.15	49.0
CURVE 47*	
373.15	37.3
CURVE 48	
293.2	20.96
301.5	21.86
CURVE 48 (cont.)	
301.5	37.24*
313.2	38.57
333.2	40.88
353.2	43.17
373.2	45.45*
393.2	47.72
413.2	49.99
433.2	52.26
453.2	54.55
473.2	56.86
493.2	59.20
513.2	61.58
533.2	63.99
553.2	66.46
573.2	68.90
593.2	71.46
613.2	73.98
623.2	75.25
CURVE 49	
1.64	0.00406
1.78	0.00449
2.01	0.00516
2.24	0.00617
2.48	0.00718
2.75	0.00906
3.00	0.01091
3.23	0.01318
3.49	0.01597
3.74	0.01955
4.00	0.02342
4.22	0.02748
4.29	0.02934*
4.46	0.03317
4.64	0.03599
4.87	0.04037
5.04	0.04565
CURVE 50	
6.6	0.149
10.3	0.383
14.7	0.867
19.1	1.285
23.8	1.781
28.5	2.380
34.0	3.205
41.0	4.348
45.0	5.173
CURVE 50 (cont.)	
49.7	5.958
54.8	6.784
58.8	7.511
69.3	9.191
74.7	10.13
80.6	10.92
84.6	11.80
89.2	12.89
99.1	14.31
109.1	16.30
119.2	18.16
128.6	19.98
138.6	21.80
148.9	23.87
159.2	25.83
168.8	28.06
178.3	30.00
188.5	32.84
198.7	35.02
209.2	37.49
218.1	39.74
223.6	41.41
295.9	62.48
CURVE 51	
9.2	0.145
10.3	0.239
15.1	0.542
19.3	0.950
21.5	1.527
29.1	2.662
35.2	3.845
39.9	4.911
44.7	6.257
50.0	7.693
55.4	9.018
60.1	9.780
65.5	11.83
70.2	13.38
74.4	14.18
80.9	15.98
86.1	16.75
89.8	18.00
99.5	20.24
109.9	23.12
119.1	25.41
129.8	28.34
139.0	30.62
149.0	33.57
CURVE 51 (cont.)	
159.2	36.34
169.1	39.11
178.9	41.73
188.9	44.81
198.5	47.68
209.2	51.09
219.1	53.94
229.3	57.37
238.6	60.65
248.7	63.71
257.4	66.97
268.1	70.29
269.8	76.40
273.2	71.90
275.5	90.68
280.8	108.99
284.1	128.7
287.8	149.4
292.2	151.7
CURVE 52	
7.1	0.072
15.2	0.439
20.3	0.794
26.3	1.358
29.6	1.701
34.3	2.239
40.4	3.154
44.8	3.717
49.8	4.725
55.3	5.795
59.3	6.685
65.4	7.695
69.9	8.501
74.3	8.885
79.6	9.834
89.5	11.41
94.5	12.71
99.6	13.39
104.8	14.51
109.6	15.31
115.1	16.27
119.7	17.16
129.3	18.79
139.1	20.35
149.1	22.26
159.0	23.73
169.3	25.44
179.0	27.61
CURVE 52 (cont.)	
188.6	29.28
198.5	31.21
208.8	33.45
218.5	35.44
228.9	37.58
238.9	39.46
243.6	40.48
292.7	52.44
CURVE 53	
1253	223
1623	549
1953	1348*
2353	1736*
2473	6896*
CURVE 54*	
7050	512.8
7300	370.3
7750	308.6
CURVE 55*	
7150	289.8
8050	250.0
8800	217.4
CURVE 56*	
4150	185.2
4960	222.5
5780	232.5

* Not shown in figure.

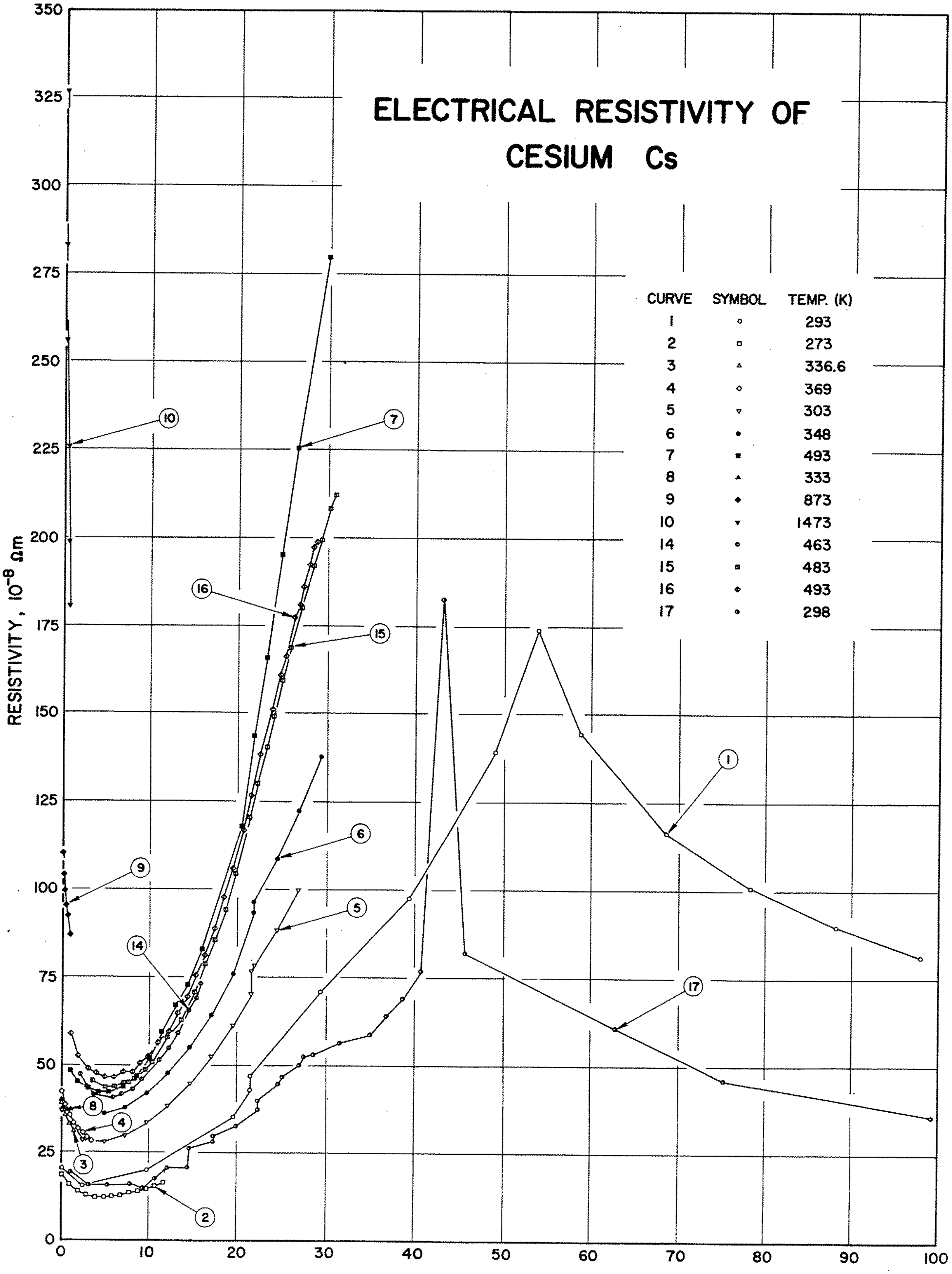

ELECTRICAL RESISTIVITY OF CESIUM Cs
CURVE SYMBOL TEMP. (K)
1 293
2 273
3 336.6
4 369
5 303
6 348
7 493
8 333
9 873
10 1473
14 463
15 483
16 493
17 298
RESISTIVITY, 10^{-8} Ωm
PRESSURE, 10^8 Pa
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350
0 10 20 30 40 50 60 70 80 90 100
1 2 3 4 5 6 7 8 9 10 14 15 16 17
CINDAS

FIGURE 20

TABLE 34. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Pressure Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Pressure Range, 10^8 Pa	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	30	Bridgman, P.W.	1952		0-98	~298		Pure; extruded wire specimen; AgCl was used as the material for transmitting pressure; relative resistance data were reported; combine this with the recommended value of electrical resistivity at 293 K and compressibility data, the electrical resistivity data were obtained.
2	86	Bridgman, P.W.	1925	A	0-11.76	273		Pure; solid, bare wires.
3	86	Bridgman, P.W.	1925	A	0-1.47	336.6		Pure; liquid; in glass capillary.
4	86	Bridgman, P.W.	1925	A	0-3.43	369		Pure; liquid; in glass capillary; $R_{liquid}/R_{solid} = 1.695$ at p = 3780 kg/cm^2.
5	32	Bridgman, P.W.	1938		0-29.4	303		Pure; specimen was obtained from Mackay; provided sealed in glass; relative electrical resistance as a function of pressure data were reported.
6	32	Bridgman, P.W.	1938		0-29.4	348		Same as the above specimen.
7	109	Oshima, R., Endo, H., Shimomura, O., and Minomura, S.	1974		0-30	493		99.9 pure; liquid state specimen was filled in a glass capillary with inner diameter of 1.5 mm and length of 12 mm; silicon oil was used as a pressure transmitted medium.
8	100	Renkert, H., Hensel, F., and Franck, E.U.	1971		0.025-1.0	333		Pure; liquid specimen was placed in the cell of pure molybdenum; the vessel was filled with purified argon and the argon pressure balanced the cesium pressure inside the cell; critical point $T_c = 2023$ K and $P_c = 110$ bar.
9	100	Renkert, H., et al.	1971		0.025-1.0	873		Same as the above specimen.
10	100	Renkert, H., et al.	1971		0.025-0.79	1473		Same as the above specimen.
11*	100	Renkert, H., et al.	1971		0.02-0.145	2073		Same as the above specimen.
12*	100	Renkert, H., et al.	1971		0.03-0.133	2173		Same as the above specimen.
13*	100	Renkert, H., et al.	1971		0.02-0.175	2273		Same as the above specimen.
14	110	Stishov, S.M. and Makarenko, I.N.	1968		2-16	463		Pure; liquid state; data were extracted from the figure.
15	110	Stishov, S.M. and Makarenko, I.N.	1968		3.6-30	483		Same as the above specimen.
16	110	Stishov, S.M. and Makarenko, I.N.	1968		1-29	493		Same as the above specimen.
17	98	McWhan, D.B. and Stevens, A.L.	1969		0-100	298		99.97 pure; $\rho_{298\,K}/\rho_{4.2\,K} = 45°$.

* Not shown in figure.

TABLE 35. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Pressure Dependence)

[Temperature, T, K; Pressure, P, 10^8 Pa; Resistivity, ρ, 10^{-8} Ωm]

P	ρ
CURVE 1 T = 293	
0.00	20.52
2.45	15.69
9.80	20.13
19.60	35.42
21.56	42.96
21.56	46.93
29.40	70.93
39.20	97.59
49.00	139.3
53.85	174.0
58.80	144.4
68.60	116.3
78.40	100.7
88.20	89.89
98.00	81.15
CURVE 2 T = 273	
0.00	18.68
0.98	15.80
1.96	14.01
2.94	12.94
3.92	12.42
4.90	12.40
5.88	12.58
6.86	12.96
7.84	13.51
8.82	14.08
9.80	14.78
10.78	15.57
11.76	16.53
CURVE 3 T = 336.6	
0.00	39.21
0.49	35.77
0.98	33.23
1.47	31.18
CURVE 4 T = 369	
0.00	42.59
CURVE 4 (cont.) T = 369	
0.49	38.72
0.98	35.79
1.47	33.54
1.96	31.84
2.45	30.73
2.94	29.48
3.43	28.59
CURVE 5 T = 303	
0.00	37.10
2.45	28.62
4.90	28.05
7.35	29.94
9.80	33.56
12.25	38.51
14.70	44.92
17.15	52.48
19.60	61.38
21.63	70.13
21.63	76.64
22.05	78.12
24.50	88.17
26.95	99.74
CURVE 6 T = 348	
4.90	36.13
7.35	37.84
9.80	42.07
12.25	47.77
14.70	55.01
17.15	64.11
19.60	75.85
21.95	93.33
21.95	96.03
22.05	96.18*
24.50	108.53
26.95	122.31
29.40	137.67
CURVE 7 T = 493	
1.0	48.4
1.8	45.1
3.1	43.3
4.2	42.4
5.4	42.4
7.1	43.8
8.6	47.0
10.1	52.1
11.5	59.5
13.1	67.0
14.4	72.9
16.0	82.6
20.5	117.8
21.9	143.6
23.3	165.8
24.9	195.1
26.6	225.3
30.0	279.6
CURVE 8 T = 333	
0.025	40.0
0.100	39.8*
0.200	38.0
0.410	38.0*
0.600	38.0*
0.775	37.32
1.007	37.32
CURVE 9 T = 873	
0.025	110.2
0.100	104.2
0.200	99.5
0.400	95.5
0.600	92.5*
0.800	92.5
0.986	87.1
CURVE 10 T = 1473	
0.025	326.6
CURVE 10 (cont.) T = 1473	
0.100	283.1
0.200	255.8
0.400	225.9
0.600	198.6
0.790	180.3
CURVE 11* T = 2073	
0.020	6.95 x 10^5
0.030	8.79 "
0.040	6.67 "
0.040	5.65 "
0.050	5.78 "
0.050	3.10 "
0.060	5.12 "
0.070	4.87 "
0.070	2.15 "
0.080	4.83 "
0.080	1.80 "
0.090	4.26 "
0.090	1.51 "
0.096	1.00 "
0.100	3.80 "
0.100	1.46 "
0.100	8.28 x 10^4
0.105	5.52 "
0.110	1.06 x 10^5
0.110	6.89 x 10^4
0.111	3.12 "
0.115	1.31 "
0.120	3.83 "
0.125	5.73 x 10^3
0.145	3.46 "
CURVE 12* T = 2173	
0.030	7.65 x 10^5
0.030	4.49 "
0.040	3.32 "
0.050	3.02 "
0.060	1.77 "
0.070	1.26 "
0.080	9.2 x 10^4
CURVE 12 (cont.)* T = 2173	
0.088	8.39 x 10^4
0.095	8.39 "
0.100	1.44 x 10^5
0.100	7.31 x 10^4
0.100	6.57 "
0.105	6.33 "
0.110	4.81 "
0.110	1.106 x 10^5
0.110	4.09 x 10^4
0.114	3.23 "
0.115	7.17 "
0.118	3.63 "
0.120	1.67 "
0.124	9.5 x 10^3
0.126	3.47 x 10^4
0.130	1.67 "
0.130	5.83 x 10^3
0.133	1.13 x 10^4
CURVE 13* T = 2273	
0.020	9.08 x 10^5
0.030	7.14 "
0.030	6.48 "
0.040	6.60 "
0.040	4.24 "
0.050	5.91 "
0.050	3.61 "
0.060	4.96 "
0.060	3.45 "
0.070	4.26 "
0.070	2.95 "
0.080	2.30 "
0.090	2.50 "
0.090	1.77 "
0.098	1.37 "
0.099	1.21 "
0.100	1.98 "
0.105	1.18 "
0.111	1.12 "
0.116	9.04 x 10^4
0.120	5.83 "
0.120	6.63 "
0.130	3.93 "
CURVE 13 (cont.)* T = 2273	
0.135	3.36 x 10^4
0.140	2.51 "
0.155	2.69 "
0.175	1.26 "
CURVE 14 T = 463	
2.1	47.5
2.8	44.0
3.6	41.7
5.8	40.9
6.9	41.7
8.1	43.1
9.2	46.0
11.2	51.5
12.3	54.9
13.3	59.1
14.5	65.6
15.4	69.0
15.9	73.1
CURVE 15 T = 483	
3.6	45.6
5.0	43.9
6.1	44.0
7.1	45.1
7.7	45.1
8.4	46.3
9.6	48.7
10.4	50.8
12.1	58.0
13.7	62.8
15.2	70.9
16.4	78.7
17.5	85.6
18.7	94.1
19.8	104.4
21.4	120.4
22.2	130.0
23.3	140.5
24.1	149.3
25.0	159.5

* Not shown in figure.

TABLE 35. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Pressure Dependence) (continued)

P	ρ	P	ρ
CURVE 15 (cont.)		CURVE 17	
T = 483		T = 298	
25.9	168.8	1.00	19.50
27.1	180.2	3.18	15.80
28.4	191.8	5.25	15.80
29.3	199.4	7.93	16.10
30.2	208.2	9.35	15.1
30.9	212.4	10.70	17.6
		12.20	20.9
CURVE 16		14.45	20.9
T = 493		14.67	26.4
		17.32	28.1
1.0	59.0	17.35	29.9
1.9	52.7	19.99	32.6
3.0	49.0	22.43	37.4
3.9	48.0	22.43	40.0
4.9	46.7	24.74	44.6
6.0	46.7	25.17	46.6
7.1	48.1	27.05	50.0
8.1	48.1	27.52	52.5
9.0	50.8	28.65	53.0
9.9	52.2	31.68	56.3
11.1	56.5	35.14	58.6
12.3	59.7	36.90	63.9
13.3	64.7	38.75	68.9
14.4	69.5	40.70	76.9
15.3	75.4	43.00	182.7
16.3	81.1	45.69	81.9
17.4	88.8	62.85	60.9
18.4	97.5	75.26	46.0
19.5	105.9	99.31	35.8
20.7	116.8		
21.6	126.7		
22.6	138.3		
23.9	151.0		
24.8	160.9		
25.3	166.1		
26.3	177.1		
26.9	181.0		
27.3	185.8		
28.0	192.1		
28.4	197.2		
28.8	198.6		

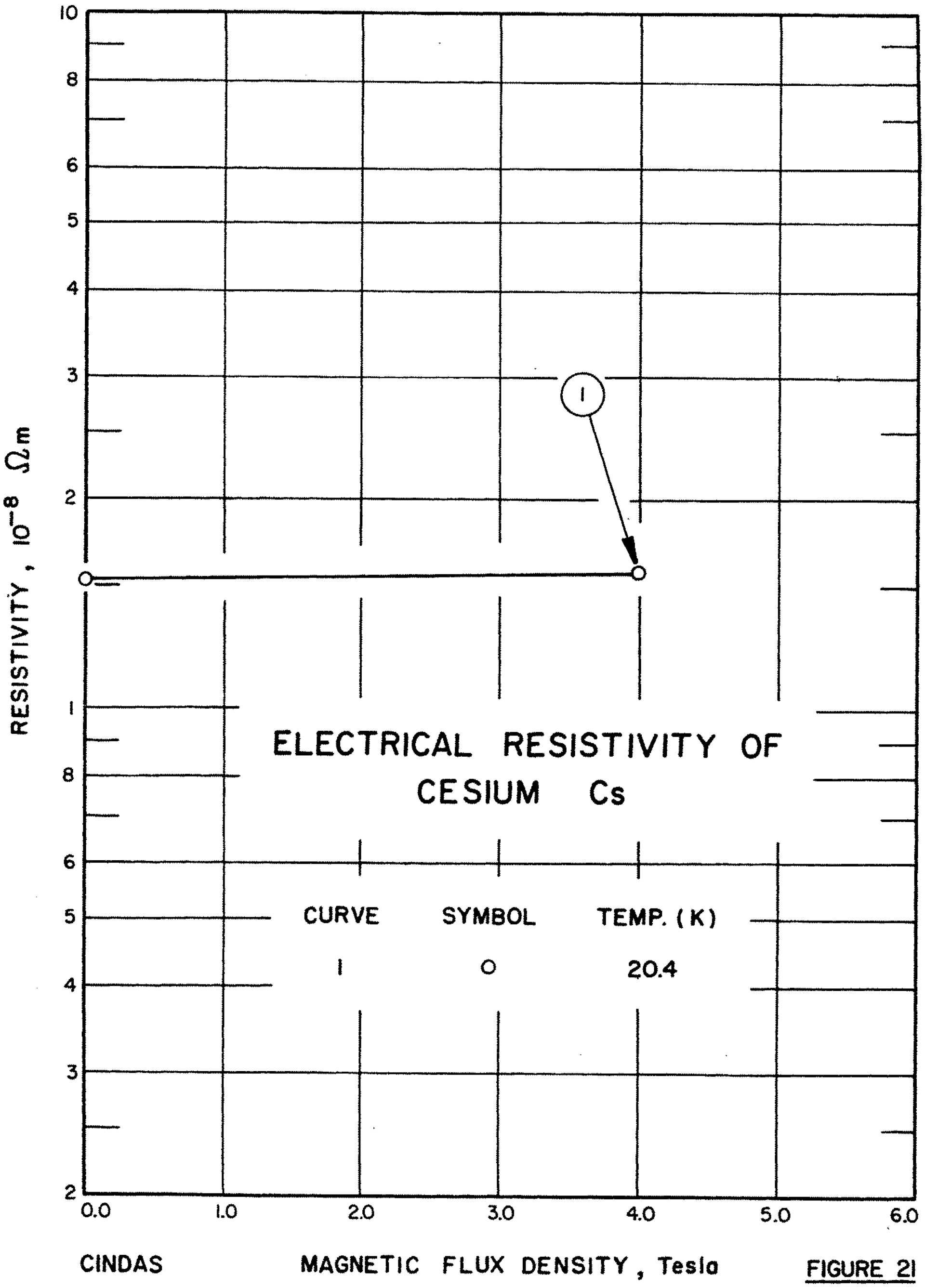

10
8
6
5
4
3
2
1
8
6
5
4
3
2
RESISTIVITY, 10^{-8} Ωm
1
ELECTRICAL RESISTIVITY OF
CESIUM Cs
CURVE SYMBOL TEMP. (K)
1 O 20.4
0.0 1.0 2.0 3.0 4.0 5.0 6.0
CINDAS
MAGNETIC FLUX DENSITY, Tesla

FIGURE 21

TABLE 36. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Magnetic Flux Density Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Magnetic Flux Density Range, Tesla	Temperature Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	36	Justi, E.	1948	A	0,4.0	20.4	Cs 2	Pure; $R_{20.4\ K}/R_{273.15\ K} = 0.0746$; it was measured in a transverse magnetic field.

TABLE 37. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CESIUM Cs (Magnetic Flux Density Dependence)

[Temperature, T, K; Magnetic Flux Density, B, Tesla; Resistivity, ρ, 10^{-8} Ωm]

B	ρ
CURVE 1 T = 20.4	
0.0	1.531
4.0	1.575

4.6. Francium

Francium, with atomic number 87, is the last member of the alkali metal series and is unstable and radioactive. Its chemical properties closely resemble those of cesium. It is a solid at room temperature having a melting point of 300.2 K and a boiling point of 950 K. Francium has no stable isotope, but twenty short-lived radioactive isotopes are known to exist, with half-lives ranging from far less than 1 millisecond (^{215}Fr) to 22 min. (^{223}Fr). The longest-lived isotope (^{233}Fr) exists in nature in uranium minerals, but the total amount of it in the crust of the earth at any time is probably less than an ounce.

a. Temperature Dependence

There is no experimental determination of electrical resistivity on francium. Solov'ev [52] calculated the electrical resistivity from 293.15 to 1273.15 K by assuming that the atomic electrical resistances of alkali metals are all the same.

On the basis of the expected similarities between francium and the other alkali metals, we have roughly estimated the electrical resistivity values from 100 K to 1500 K by extrapolation to the atomic number 87 of a curve drawn through the values for sodium, potassium, rubidium, and cesium in a graph of electrical resistivity versus atomic number with temperature as a parameter. The change of resistivity at the melting point was obtained by using Mott's formula, eq (5), with a latent heat of 0.4 K cal/mol, which was also obtained by extrapolating the data of latent heat versus atomic number of lithium, sodium, potassium, rubidium, and cesium to 87 (Fr).

The provisional values for the intrinsic electrical resistivity are smoothed by the cubic spline function eq (7). The four term coefficients for the function eq (7) are given in the following:

Temperature range, K	a	b	c	d
100–300.2	0.934	0.952	0.0137	1.286
300.2–881	1.74	0.907	−0.276	0.820
881–1500	2.19	1.186	0.874	1.522

These values are listed in table 38 and shown in figure 22 with the data of Solov'ev. The uncertainty of the provisional values is believed to be within ±50%.

TABLE 38. PROVISIONAL ELECTRICAL RESISTIVITY OF FRANCIUM (Temperature Dependence)

[Temperature, T, K; Intrinsic Resistivity, ρ_i, 10^{-8} Ω m]

Solid		Liquid	
T	ρ_i	T	ρ_i
100	8.6	300.2	55
150	12.9	400	71
200	18.0	500	86
250	25.0	600	102
273.15	28.9	700	119
293	32.6	800	138
300.2	34.0	900	158
		1000	181
		1100	211
		1200	251
		1300	307
		1400	385
		1500	497

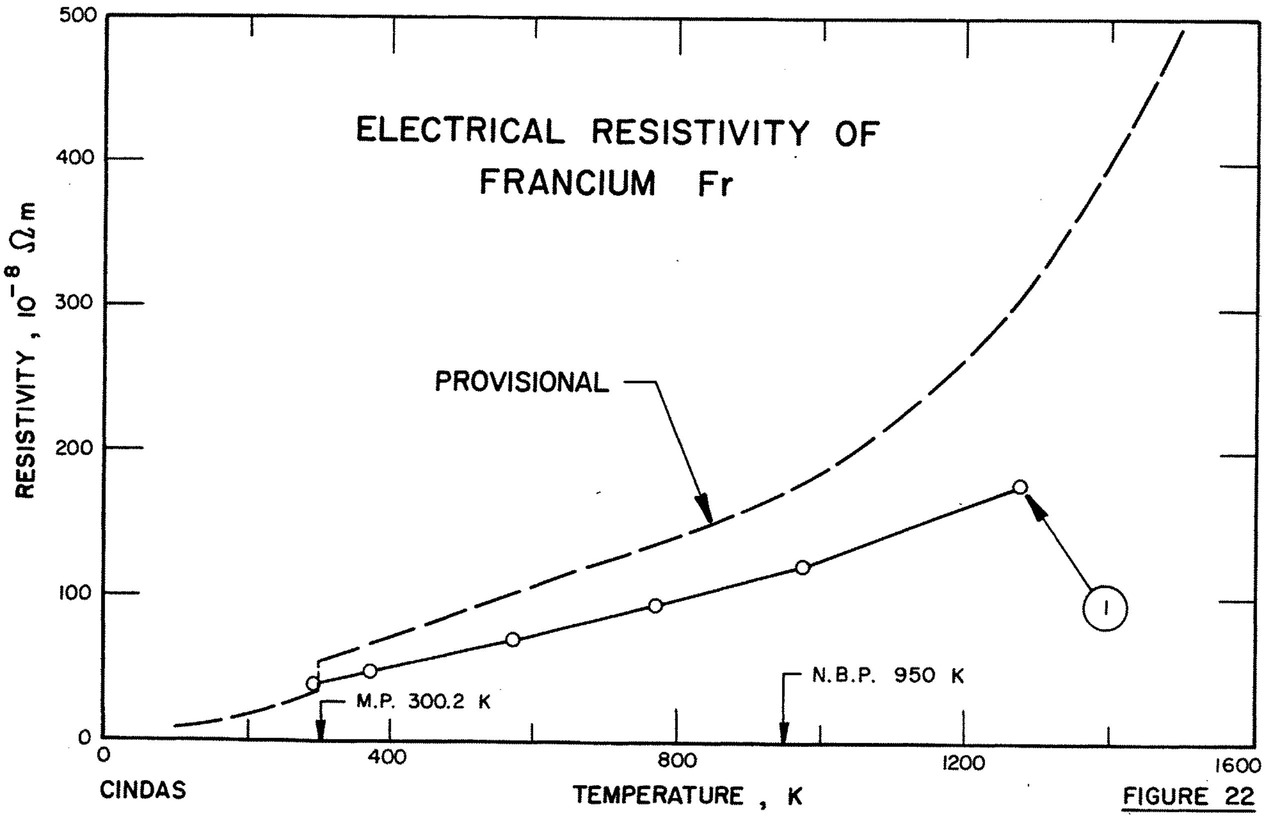

ELECTRICAL RESISTIVITY OF
FRANCIUM Fr
RESISTIVITY, 10^{-8} Ω m
500
400
300
200
100
0
PROVISIONAL
1
M.P. 300.2 K
N.B.P. 950 K
0
400
800
1200
1600
CINDAS
TEMPERATURE, K

FIGURE 22

TABLE 39. CALCULATED INFORMATION ON THE ELECTRICAL RESISTIVITY OF FRANCIUM Fr (Temperature Dependence)

Cur. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	52	Solov'ev, A.N.	1963		293-1273		Electrical resistivity data were calculated by assuming the atomic electrical resistances of alkali metals are all the same; the data necessary for the calculation, i.e., the melting point and the density at T = 0 K and $T = T_{melt}$, were found by extrapolation of the straight lines for alkali metals in coordinates of properties vs atomic number.

TABLE 40. CALCULATED DATA ON THE ELECTRICAL RESISTIVITY OF FRANCIUM Fr (Temperature Dependence)

[Temperature, T, K; Resistivity, ρ, 10^{-8} Ωm]

T	ρ
CURVE 1	
293.15	39.0
373.15	47.5
573.15	70.2
773.15	95.5
973.15	122.0
1273.15	178.0

5. Summary and Conclusion

The electrical resistivities of the alkali elements have been surveyed and studied from time to time by a number of investigators, including Meaden [111], Kaye & Laby [112], Grosse [5], and Shpil'rain, et al. [113], to name just a few. Electrical resistivity data are compiled in a number of handbooks such as those sponsored by Landolt-Börnstein [114], AIP [115], CRC [116], and Liquid-Metals Handbook [117], etc. However, their main concern is to provide a general picture through only one or a few particular sets of data, and only a limited temperature range is covered. The purpose of the present work is quite different from that of the above mentioned works. There are two major aims: (1) to exhaustively search the open literature so that all the available experimental data are comprehensively compiled, and (2) to generate recommended reference values by critical evaluation, analysis, and synthesis of the existing experimental data.

The above aims are now achieved. The recommended values were obtained by least squares fitting of the selected experimental data, or by correlating the related properties, and by smoothing with a cubic spline function. The comparison of electrical resistivity data from the literature with the present recommended values are shown in table 41. The values from AIP [115] are taken from the book by Meaden [111] so that they are identical.

With a view to bring out any similarities or differences between the recommended values for the alkali elements, the recommended values of the intrinsic resistivities are plotted together from 2 to 2000 K and shown in figure 23.

6. Acknowledgements

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The author is grateful to H. M. James and C. Y. Ho of CINDAS's senior staff for their valuable guidance and suggestions.

TABLE 41. COMPARISON OF ELECTRICAL RESISTIVITY DATA FROM THE LITERATURE WITH THE PRESENT RECOMMENDED VALUES

Element	Temperature K	Total Resistivity, ρ, 10^{-8} Ω m								
		Present work (1976)	CRC (1974)	AIP (1972)	Shpil'rain, et al. (1970)	Grosse (1966)	Kaye & Laby (1966)	Meaden (1965)	Landolt & Börnstein (1960)	L. M. H. (1954)
Li	20	0.0129	-	-	-	-	-	0.035	-	-
	273.15	8.53	8.55	8.51	8.12	-	8.55	8.51	8.55, 8.9	-
	1000	39.69	-	-	39.00	41.83	-	-	-	45.25 (503K)
	2000	73.73	-	-	-	98.34	-	-	-	-
Na	20	0.0156	-	-	-	-	-	0.0175	-	-
	273.15	4.33	4.20	4.29	4.29	-	4.2	4.29	4.28-5.09	-
	1000	40.73	-	-	39.80	41.79	-	-	-	18.44 (623K)
	2000	184.4	-	-	-	207.4	-	-	-	-
K	20	0.117	-	-	-	-	-	0.112	-	-
	273.15	6.49	6.15	6.45	6.23	-	6.1	6.45	6.1-7.03	-
	1000	67.94	-	-	67.91	78.8	-	-	-	31.4 (623K)
	2000	575.3	-	-	-	746	-	-	-	-
Rb	20	0.431	-	-	-	-	-	0.443	-	-
	273.15	11.54	11.28	11.26	11.25	-	11.0	11.26	11.29-12.8	-
	1000	97.26	-	-	102.6	112.8	-	-	-	27.47 (373K)
	2000	629.4	-	-	-	2376	-	-	-	-
Cs	20	0.859	-	-	-	-	-	0.922	-	-
	273.15	18.75	20 (293K)	18.04	18.30	-	18.8	18.04	18.1-19.3	-
	1000	133.4	-	-	-	153.0	-	-	-	37.0 (310K)
	2000	1000	-	-	-	5731	-	-	-	-
Fr	100	8.6*	-	-	-	-	-	-	-	-
	273.15	28.9*	-	-	-	-	-	-	-	-
	1500	497*	-	-	-	-	-	-	-	-

* Intrinsic Resistivity, ρ_i.

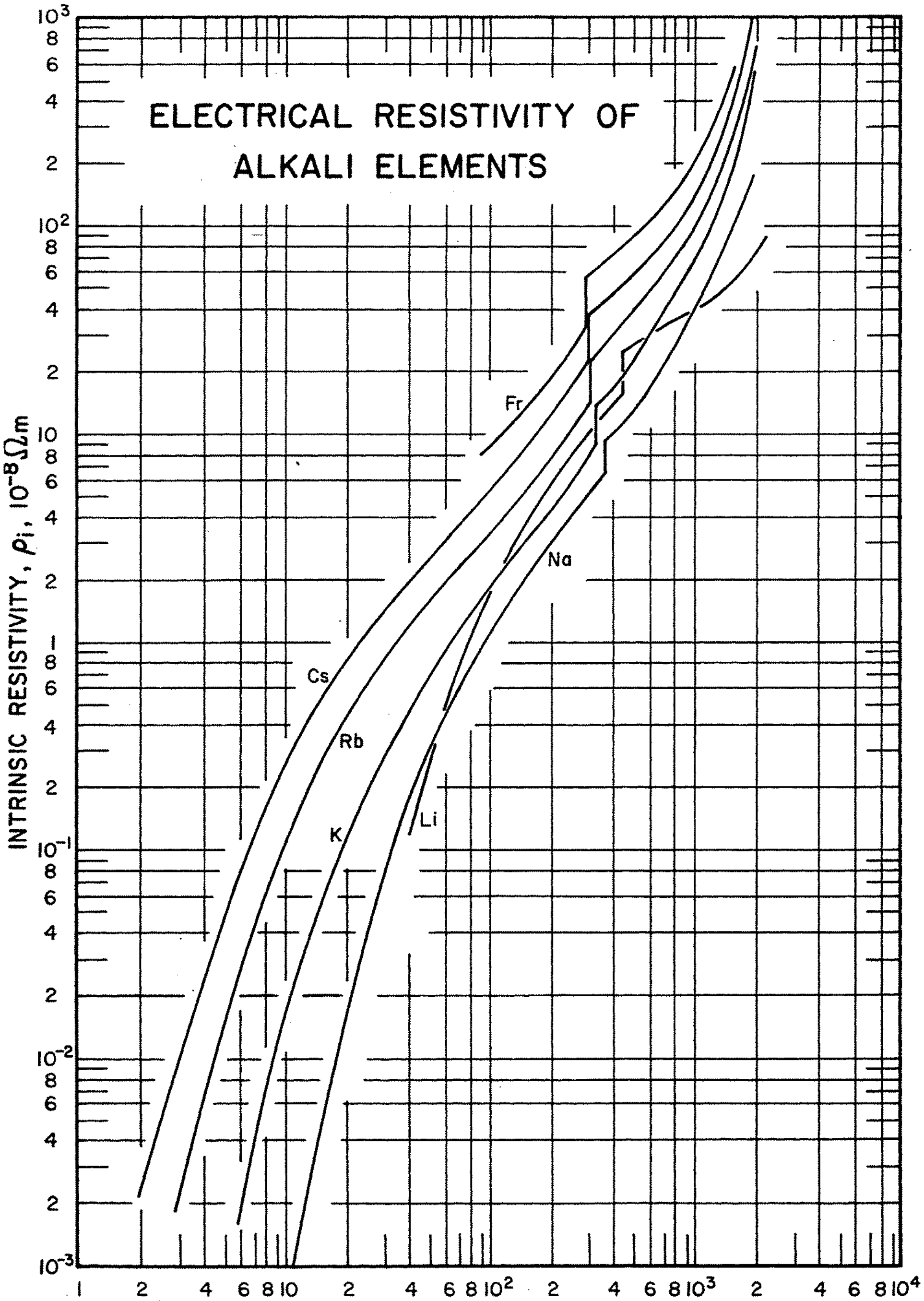

FIGURE 23

7. References

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8. Appendix

8.1. Methods of Measuring Electrical Resistivity

A. Steady State Methods
  1. Voltmeter and ammeter direct reading (V) [118, p. 159; 119, pp. 244–5]
  2. dc Potentiometric Method (A) [111, pp. 151–8]
     a. 4-probe potentiometric method
  3. dc Bridge Method (B) [111, pp. 144–51]
     a. Kelvin Double Bridge
     b. Mueller Bridge
     c. Wheatstone Bridge
  4. van der Pauw Method (P), [120]
  5. Galvanometer Amplifier Method (G), [121, pp. 159–62]

B. Non-steady State Methods
  1. Periodic currents involved
     a. Direct connection to sample
        (1) ac Potentiometric Method (C) [111, pp. 161–2]
        (2) ac Bridge Method (D) [111, p. 162]
        (3) Q-Meter Method (Q)
     b. No connection to sample
        (1) Mutual Inductance Method (M) [122]
        (2) Self-inductance Method (S) [123]
        (3) Rotating Field Method (R) [124]
  2. Non-periodic currents involved
     a. Direct connection to sample
        (1) Transient (subsecond) technique (T) [125]
     b. No connection to sample
        (1) Eddy current decay method (E) [126; 111, p. 103]

C. General Comments
  1. Code "I" means Induction Method
     This is a combination of Items B.1.b. and B.2.b. above. Subsumed under I is M, R, S, or E. Used only if author indicates induction method used and does not report which specific one.
  2. The symbol "→" used if method described by the author is not sufficient to assign a specific code presently used. Example:
     a. If the author says an "ac Method" was used, the

following wording would be used under the item "Measuring conditions" in the column Composition, Specifications, and Remarks: "Experimental Method described as an ac Method." Note this "Method" corresponds to the heading B.1. above. In the column for Method Used on the Specification Table the following symbol would appear: →.

8.2. Conversion Tables for Units of Temperature, Pressure, and Magnetic Flux Density

TABLE 42. CONVERSION TABLES BETWEEN THE KELVIN, CELSIUS, FAHRENHEIT, AND RANKINE TEMPERATURE SCALES*

K	°C	°F	°R
0	-273.15	-459.67	0
50	-223.15	-369.67	90
100	-173.15	-279.67	180
150	-123.15	-189.67	270
200	-73.15	-99.67	360
250	-23.15	-9.67	450
273.15	0	32	491.67
293	19.85	67.73	527.4
300	26.85	80.33	540
350	76.85	170.33	630
400	126.85	260.33	720
450	176.85	350.33	810
500	226.85	440.33	900
1000	726.85	1340.33	1800
1500	1226.85	2240.33	2700
2000	1726.85	3140.33	3600
3000	2726.85	4940.33	5400
4000	3726.85	6740.33	7200

TABLE 43. CONVERSION FACTORS ON UNITS OF PRESSURE*

	atm	dyne/cm^2	inch of water	cm Hg	PASCAL	lb/in.^{2}	lb/ft^2
1 atmosphere =	1	1.013×10^6	406.8	76	1.013×10^5	14.70	2116
1 dyne per cm^2 =	9.869×10^{-7}	1	4.015×10^{-4}	7.501×10^{-5}	0.1	1.450×10^{-5}	2.089×10^{-3}
1 inch of water at 4° C^a =	2.458×10^{-3}	2491	1	0.1868	249.1	3.613×10^{-2}	5.202
1 centimeter of mercury at 0° C^a =	1.316×10^{-2}	1.333×10^4	5.353	1	1333	0.1934	27.85
1 NEWTON per METER^2=1 PASCAL=	9.869×10^{-6}	10	4.015×10^{-3}	7.501×10^{-4}	1	1.450×10^{-4}	2.089×10^{-2}
1 pound per in.^{2} =	6.805×10^{-2}	6.895×10^4	27.68	5.171	6.895×10^3	1	144
1 pound per ft^2 =	4.725×10^{-4}	478.8	0.1922	3.591×10^{-2}	47.88	6.944×10^{-3}	1

[a] Where the accleration of gravity has the standard value 9.80665 meters/sec^2.

1 bar = 10^5 Pa 1 Kbar = 10^8 Pa

TABLE 44. CONVERSION FACTORS ON UNITS OF MAGNETIC FLUX DENSITY*

	gauss	kiloline/in^2	TESLA	milli-gauss	gamma
1 gauss (line per cm^2) =	1	6.452×10^{-3}	10^{-4}	1000	10^5
1 kiloline per in.^{2} =	155.0	1	1.550×10^{-2}	1.550×10^5	1.550×10^7
1 WEBER per METER^2 = 1 TESLA =	10^4	64.52	1	10^7	10^9
1 milligauss =	0.001	6.452×10^{-6}	10^{-7}	1	100
1 gamma =	10^{-5}	6.452×10^{-8}	10^{-9}	0.01	1

* This table is based on the universal constants from "The International System of Units (SI)," NBS Special Publication 330, National Bureau of Standards, U.S. Department of Commerce.