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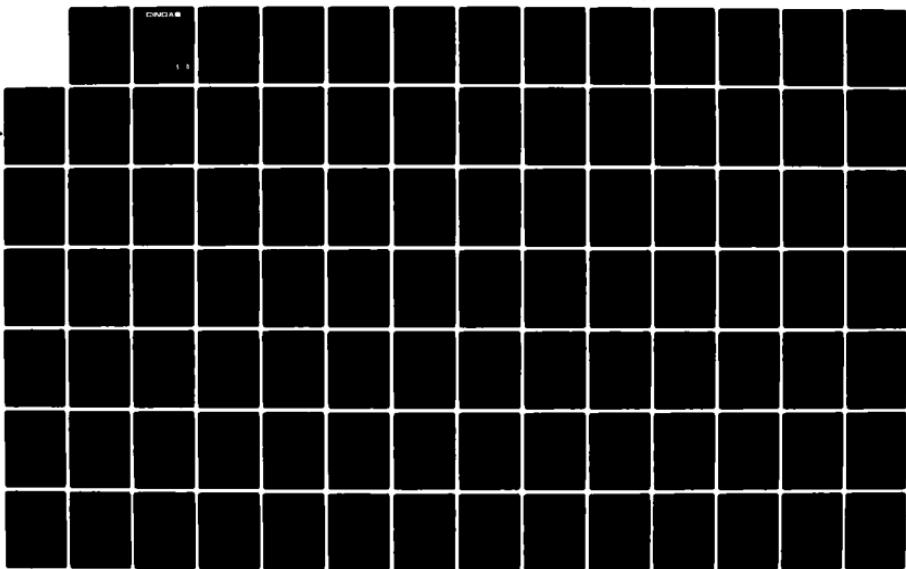
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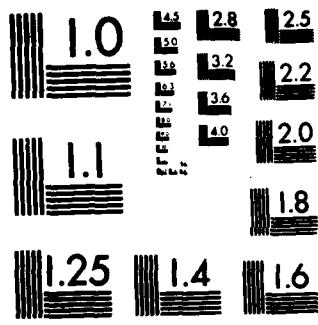
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ELECTRICAL RESISTIVITY OF CHROMIUM, COBALT, IRON, AND NICKEL

By

T. K. Chu and C. Y. Ho

CINDAS Report 60

June 1982

Prepared for

OFFICE OF STANDARD REFERENCE DATA
National Bureau of Standards
U. S. Department of Commerce
Washington, D.C. 20234

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CENTER FOR INFORMATION AND NUMERICAL DATA ANALYSIS AND SYNTHESIS
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PREFACE

This technical report was prepared by the Center for Information and Numerical Data Analysis and Synthesis (CINDAS), Purdue University, West Lafayette, Indiana, under the auspices of the Office of Standard Reference Data of the National Bureau of Standards (NBS), Department of Commerce, Washington, D.C.

This report represents the most exhaustive compilation and critical evaluation of the recorded world knowledge on the electrical resistivity of chromium, cobalt, iron, and nickel, and is one of a series of technical reports on the electrical resistivity of selected elements. The literature search and data compilation have been done in a most extensive and detailed manner, making it possible for all users of the subject to have access to the original data without having to duplicate the laborious and costly process of literature search and data extraction. Also, for the active researchers in the field, a detailed discussion is presented for each material, reviewing the available data and information, giving details of data analysis and synthesis, and discussing the considerations involved in arriving at the final recommended values.

It is hoped that this work will prove useful not only to the engineers and scientists in the field but also to other engineering research and development programs and for industrial applications, as it provides a wealth of knowledge heretofore unknown or inaccessible to many. In particular, it is thought that the critical evaluation, analysis and synthesis, and reference data generation constitute a unique aspect of this work.

Although this report is primarily the result of financial support and interest of the NBS Office of Standard Reference Data, the extensive documentary activity essential to this work was supported by the Defense Logistics Agency of the Department of Defense. Thanks are due Dr. H. J. White, Jr., of the NBS Office of Standard Reference Data for his guidance, cooperation, and sympathetic understanding during the course of this work.

ABSTRACT

This work compiles, reviews, and discusses the available data and information on the electrical resistivity of chromium, cobalt, iron, and nickel and presents the recommended values resulting from critical evaluation, correlation, analysis, and synthesis of the available data and information. The recommended values presented are uncorrected and also corrected for the thermal expansion of the material and cover the temperature range from 1 K to above the melting point into the molten state. The estimated uncertainties in most of the recommended values are about $\pm 5\%$.

Key words: Chromium; cobalt; conductivity; critical evaluation; data analysis; data compilation; data synthesis; electrical conductivity; electrical resistivity; elements; iron; metals; nickel; recommended values; resistivity.

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NOMENCLATURE

A	Constant in eqs (3b) and (8)
c	Impurity concentration
C	Constant in eq (3a)
e	Base of natural logarithm
\hbar	Planck constant divided by 2π
k	Boltzmann constant
L	Length of specimen at T
L_0	Length of specimen at T_0
ΔL	$\Delta L = L - L_0$
M	Atomic weight
T	Temperature
T_0	Reference temperature
x	$x = \hbar\omega/kT$
α	Constant in eqs (7) and (8)
Δ	Deviation from the Matthiessen's rule
θ_D	Debye temperature
θ_R	Characteristic temperature for intrinsic electrical resistivity
ρ	Electrical resistivity
ρ_0	Residual electrical resistivity
ρ_e	Electrical resistivity due to electron-electron scattering
ρ_i	Intrinsic electrical resistivity
ω	Phonon angular frequency

1. INTRODUCTION

The principal objective of this project was to exhaustively compile, critically evaluate, analyze, and synthesize all the available data and information on the electrical resistivity of a large number of selected elements and to generate recommended values over a full range of temperature from 1 K to the melting point and beyond. The results on the electrical resistivity of chromium, cobalt, iron, and nickel are presented in this work, which is one in a series of similar works on the electrical resistivity of selected elements, some published [1-3]¹. The comprehensive study of the electrical resistivity of the elements at the Center for Information and Numerical Data Analysis and Synthesis (CINDAS) has been a continuation of a similar extensive work on the thermal conductivity of the elements [4].

The general background information on this work is given in Section 2, which includes a brief introduction to the theory of the electrical resistivity of metals and a detailed explanation of the specifics and conventions used in the presentation of the data and information.

The experimental data and information and the recommended values for the electrical resistivity of the four elements are presented in Section 3. In the discussion of the electrical resistivity of each element, individual pieces of available data and information are reviewed, details of data analysis and synthesis are given, the considerations involved in arriving at the final assessment and recommendation are discussed, the recommended values and the experimental data are compared, and the uncertainties in the recommended values are stated. Recommended values uncorrected and corrected for the thermal expansion of the material are both presented in this section. The values cover the temperature range from 1 K to above the melting point.

The last three sections are for acknowledgments, appendices, and references. There are two appendices given. The first appendix presents a logical organization of the methods for the measurement of electrical resistivity. The methods are designated with respective code letters and the same code letters are used in the "Method Used" column of the Table of Measurement Information for indicating

¹Numbers in brackets indicate literature references listed in Section 6.

the experimental methods used by the various authors. The second appendix presents conversion factors for the units of electrical resistivity, which may be used to convert easily the electrical resistivity values in the SI units given in this work to values in any of the several other units listed.

2. GENERAL BACKGROUND

2.1. Theoretical Background

It was found experimentally by Matthiessen [5,6] that the increase in the electrical resistivity of a metal due to the presence of a small amount of another metal in solid solution is independent of the temperature. According to this Matthiessen's rule, the total electrical resistivity of an impure metal may therefore be separated into two additive contributions and written in the form

$$\rho(c,T) = \rho_0(c) + \rho_i(T), \quad (1)$$

where ρ_0 is the residual resistivity caused by the scattering of electrons by impurity atoms and lattice defects and is temperature-independent but dependent on the impurity concentration, c , and ρ_i is the temperature-dependent intrinsic resistivity arising from the scattering of electrons by lattice waves, or phonons.

In reality, however, deviations from Matthiessen's rule do occur. Thus, in general the electrical resistivity of an impure metal is given by

$$\rho(c,T) = \rho_0(c) + \rho_i(T) + \Delta(c,T), \quad (2)$$

where Δ is the deviation from the Matthiessen's rule.

The intrinsic electrical resistivity which is due to scattering of electrons by phonons may be approximated by the Bloch-Grüneisen formula [7,8]:

$$\rho_i = \frac{C}{M\theta_R} \left(\frac{T}{\theta_R} \right)^5 \int_0^{\theta_R/T} \frac{x^5 e^x dx}{(e^x - 1)^2} \quad (3a)$$

$$= A \left[\frac{T}{\theta_R} \right]^5 \int_0^{\theta_R/T} \frac{x^5 e^x dx}{(e^x - 1)^2}, \quad (3b)$$

where C is a constant characteristic of the metal and proportional to the square of the electron-phonon interaction constant, M is the atomic weight, θ_R is a characteristic temperature of the metal which characterizes its intrinsic electrical resistivity in the same way as the Debye temperature,

θ_D , characterizes its lattice specific heat, and $A \equiv C/M\theta_R$. The dimensionless variable of integration $x = \hbar\omega/kT$, where \hbar is the Planck constant divided by 2π , ω is the phonon angular frequency, and k is the Boltzmann constant. The derivation of eq (3) is based on the simplifying assumptions that the Fermi surface is spherical, that the conduction electrons can be treated as free in the first approximation, that the spectrum of lattice vibrations is that of the Debye model, that the phonon distribution is essentially undisturbed by the scattering processes, and that electron-phonon Umklapp processes can be ignored. Consequently, it is perhaps most reasonable to expect the Bloch-Grüneisen formula to agree with experiment in the case of monovalent metals. Nevertheless, the intrinsic resistivity of many metals can be well represented by eq (3) over a wide temperature range by a suitable choice of θ_R and C , though no single values of θ_R can fit the data at all temperatures.

At low temperatures ($T \leq \theta_R/20$), eq (3a) reduced to

$$\rho_i = \frac{124.4C}{M\theta_R} \left(\frac{T}{\theta_R} \right)^5, \quad (4)$$

while at high temperatures ($T > \theta_R$), to a good approximation, it reduces to

$$\rho_i \approx \frac{C}{4M\theta_R} \left(\frac{T}{\theta_R} \right). \quad (5)$$

Thus it agrees with the experimental facts that at very low temperatures the intrinsic electrical resistivity (after subtracting ρ_0 from ρ) of most metallic elements is proportional to T^5 , and at high temperatures the resistivity of most metals increases approximately linearly with temperature.

In separating the electrical resistivity into its components, the temperature dependent part sometimes includes the electrical resistivity due to electron-electron scattering, ρ_e ; indeed, this is thought to be the dominant temperature-dependent term in transition metals at low temperatures. That is,

$$\rho = \rho_0 + \rho_e + \rho_i(T) \quad (6)$$

As in the case of the scattering of electrons by phonons, electron-electron collisions are of two types: normal processes in which the total wave vector is conserved, and Umklapp processes in which the total wave vectors before and after the collision differ by a reciprocal lattice vector. On the other hand, unlike electron-phonon Umklapp processes which are frozen out at low temperatures

if the Fermi surface is everywhere clear of the zone boundary, electron-electron Umklapp processes are not frozen out at low temperatures. Normal processes, involving the collision between two s-band conduction electrons, do not contribute directly to the electrical resistivity because they do not change the total momentum and thus have no effect on the current. Normal processes involving the scattering of an s-band conduction electron by a non-conducting d-band electron do contribute to the electrical resistivity, and are thought to be the dominant temperature-dependent resistive processes in transition elements and their alloys at very low temperatures, since their resistivities show the T^2 temperature dependence expected for electron-electron scattering rather than the T^5 temperature dependence expected for the intrinsic resistivity. This temperature dependence of the electrical resistivity due to electron-electron scattering:

$$\rho_e = \alpha T^2 \quad (7)$$

comes about through the double application of the exclusion principle in the scattering processes; it applies to both the initial states and final states. In eq (7), α is a constant.

Umklapp processes between two conduction electrons do contribute to the electrical resistivity. Because these processes involve a reciprocal lattice vector, the wave functions of the electrons involved cannot be regarded as simple plane waves, but must be treated as true Bloch functions having the periodicity of the lattice. The results of this are to introduce into the expression for the resistivity the square of an interference factor. Apparently this factor is quite small, as the low temperature electrical resistivity of most ordinary metals does not show the T^2 temperature dependence expected for such a resistive mechanism.

Substituting eqs (7) and (3b) into eq (6) yields

$$\rho = \rho_0 + \alpha T^2 + A \left(\frac{T}{\theta_R} \right)^5 \int_0^{\theta_R/T} \frac{x^5 e^x dx}{(e^x - 1)^2}. \quad (8)$$

Equation (8) has been used frequently in analyzing the experimental data and in generating the recommended values for the electrical resistivity of cobalt, iron, and nickel at low temperatures.

2.2. Presentation of Data and Information

In each of the subsections in Section 3, electrical resistivity data and information for each element are presented in the following order:

- (1) A discussion text,
- (2) A table of recommended values,
- (3) A figure presenting recommended values and experimental data as a function of temperature in log-log scale,
- (4) A figure presenting recommended values and experimental data as a function of temperature in linear scale,
- (5) A table giving measurement information on the experimental data presented in the figures, and
- (6) A comparable table tabulating experimental data of all the data sets presented in the figures and/or listed in the tables.

In the discussion text on the electrical resistivity of each alloy system, individual pieces of available data and information are reviewed, details of data analysis and synthesis are given, the considerations involved in arriving at the final assessment and recommendation are discussed, the recommended values and the experimental data are compared, and the uncertainties of the recommended values are stated.

The recommended values are for well-annealed high-purity specimens of the respective elements; however, those values for low temperatures are applicable only to the particular specimens having residual electrical resistivities as given at 1 K in the tables.

Recommended values uncorrected and corrected for the thermal expansion of the element are both given in the table. The uncorrected and corrected values are related by the following equation:

$$\rho_{\text{corrected}}(T) = \left[1 + \frac{\Delta L(T)}{L_0} \right] \rho_{\text{uncorrected}}(T), \quad (9)$$

where $\Delta L = L - L_0$, and L and L_0 are the lengths of the specimen at any temperature T and at a reference temperature T_0 , respectively. The thermal expansion correction amounts roughly to about -0.2% to -0.7% at very low temperatures, zero at room temperature, about 0.3% to 0.7% at 500 K, and about 2% near the melting point of the element.

The recommended values in some cases are given with more significant figures than warranted, which is merely for tabular smoothness or for the convenience of internal comparison. Hence, the number of significant figures given in the table has no bearing on the degree of accuracy or uncertainty in the values; the uncertainty in the values is always explicitly stated.

In the figures, a data set consisting of a single data point is denoted by a number enclosed by a square, and a curve that connects a set of two or more data points is denoted by a ringed number. These data set numbers correspond to those listed in the accompanying tables providing measurement information and tabulating numerical data for each of the data sets. When several sets of data are too close together to be distinguishable, some of the data sets, though listed and tabulated in the tables, are omitted from the figure for the sake of clarity. The data set numbers of those data sets omitted from the figure are asterisked in both tables providing the measurement information and tabulating the experimental data. If only part of the data points of a data set are omitted from the figure, only those data points omitted are asterisked in the table tabulating the experimental data.

The tables providing the measurement information contain for each set of experimental data the following information: data set number, reference number, author(s), year of publication, experimental method used for the measurement, temperature range covered by the data, name and specimen designation, specimen composition, specification and characterization, and information on measurement conditions, which are contained in the original paper. The experimental methods used for the measurement of the electrical resistivity are indicated in the column headed "Method Used" in the table by the following code letters:

- A Direct-current potentiometer method
- B Direct-current bridge method
- C Alternating-current potentiometer method
- D Alternating-current brige method
- G Galvanometer amplifier method
- R Rotating magnetic field method
- V Voltmeter and ammeter direct reading method

- This symbol means either that the method described by the author is not sufficient for assigning a specific code letter or that the use of a code letter would not convey enough of the information reported in the research document, and therefore the method used is described briefly in the last column of the table.

Details of these and other methods for the measurement of electrical resistivity may be found in the literature references given in Appendix 5.1, which presents a complete scheme for the classification and organization of the methods.

In the tables tabulating the experimental data, all the original data reported in different units have been converted to have the same units: the SI units $10^{-8} \Omega \text{ m}$. The recommended values generated are also given in the same units. Conversion factors for the units of electrical resistivity, which may be used to convert the electrical resistivity values in the SI units given in this work to values in other units, are given in Appendix 5.2.

3. ELECTRICAL RESISTIVITY DATA AND INFORMATION

3.1. Chromium

There are 163 sets of experimental data available for the electrical resistivity of chromium. The information on specimen characterization and measurement condition for each of the data sets is given in table 2. The data are tabulated in table 3 and shown partially in figures 1 and 2.

Chromium undergoes an antiferromagnetic-paramagnetic transition at about 312 K; it is not surprising that more than one third of the data sets deal with the behavior of the electrical resistivity at temperatures in the vicinity of the transition. In general, the purities of the chromium specimens studied are not as high as those of other more common elements, such as iron and nickel. Judging from the impurity analyses reported, a purity of 99.99% appears to be the highest available at the present time. It is therefore not unexpected that the reported residual resistivity ratios are not very high. Indeed, the highest for a polycrystalline specimen is 380 given by Laubitz and Matsumura [9] (data sets 53-61). Their specimen was the same as that of Moore et al. [10] (data sets 50-52), who reported a residual resistance ratio of 280. This specimen was prepared by compacting (apparently small) crystals, and by hot extending. The former authors, in addition, carried out extended annealing periods: four days at 1100 K and one day at 1200 K. The reported purity of this specimen was not particularly high; 99.98^+ % with major impurities of 0.0070% C and 0.0030% Fe. For comparison, the cast specimen of Meaden et al. [11-13] (data sets 69-75), had a reported purity of 99.999% with major impurities of 0.0010% C and 0.0080% O. However, the residual resistance ratio of this specimen is only 178. After annealing at >1273 K for 75 hours (of which 50 hours is at 1473 K), the residual resistance ratio increases to 295 (data sets 76, 77). It is apparent that, in order to obtain a true indication of the residual resistivity of a chromium specimen, prolonged annealing at temperatures in excess of 1000 K is quite essential. The present recommendation for the electrical resistivity of chromium at low temperatures is only for chromium having a particular residual resistivity, which is based on the residual resistance ratio reported by Laubitz and Matsumura [9] for data set 53.

There are only a few data sets which give the electrical resistivity of chromium from liquid-helium temperature to room temperature in reasonably small temperature intervals: Harper et al. [14] (data set 17), Goff [15,16] (data sets 79,80), and Arajs et al. [17-20] (data sets 94-102). The data of Harper

et al. had been analyzed by White and Woods [21] who found the temperature dependent part of the resistivity proportional to $T^{3.2}$ for temperatures below 100 K. A similar analysis on the data sets 7, 79-80, and 99-100 substantiated the finding of White and Woods; the exponent was found to be 3.23, with an uncertainty of ± 0.20 . In addition, selected data points from those reported by Chiu et al. [22] (data set 46), and by Moore et al. [10] (data sets 47-50) in the temperature range 80-100 K are also in agreement with this finding. With a coefficient of $5.756 \times 10^{-15} \Omega m K^{-3.23}$, the experimental data of $\rho - \rho_0$ predominantly stay within $0.1 \times 10^{-8} \Omega m$ of the calculated values at the higher end of this temperature range, and within $0.002 \times 10^{-8} \Omega m$ at lower temperatures (<20 K). (It is interesting to note that the specimen of Arajs et al. [17,18] (data sets 94-99) is for a single crystal specimen with residual resistivity of $1.06 \times 10^{-8} \Omega m$.) The electrical resistivity values below 100 K were therefore obtained by the relation

$$\rho(10^{-8} \Omega m) = \rho_0 + 5.756 \times 10^{-7} T^{3.23} \quad (10)$$

At temperatures above 100 K, the rate of increase of the temperature dependent part of the resistivity becomes slower with increasing temperature. The discrepancies between the data sets also become larger with increasing temperature, indicating that the deviation from Mattheissen's Rule becomes important. From studies of the electrical resistivities of chromium alloys (see, e.g., Arajs et al. [20], deVries [23], Cox and Lucke [24], Taylor [25], and Muheim and Müller [26]), it was found that impurities not only affect the values of the resistivity, but also the Néel temperature. Since the electrical resistivities of chromium and dilute chromium alloys generally show a local maximum at temperatures slightly below the Néel temperature, it is not unexpected that the data sets show greater discrepancies as the Néel temperature is approached. Furthermore, depending on the type of impurity, the electrical resistivity of a chromium alloy can be lower than that of the pure chromium at temperatures immediately below the Néel temperature of pure chromium (see, e.g., Taylor [25], Susuki [27] and deVries [23]). The recommended values in the temperature range from 100 K to the Néel temperature are based on the data of Moore et al. [10] (data set 50), and in the vicinity of the Néel temperature they are based on the above data and that of Laubitz and Matsumura [9] (data set 53). As it is mentioned previously, the same specimen was used in both of these two measurements: the latter authors annealed the specimen at a higher temperature for

long periods of time. The difference between the resistivity values of these data sets at ~ 300 K is $\sim 0.4\%$ or $\sim 0.05 \times 10^{-8} \Omega \text{m}$. This difference is higher than the difference of $\sim 0.01 \times 10^{-8} \Omega \text{m}$ in their residual resistivities (calculated from the reported residual resistance ratios); but is still within the limits given by the reported measurement inaccuracies. The data of Meaden et al. [13, 28] (data sets 76-78) for a specimen with a residual resistance ratio of 295 show slightly weaker temperature dependence: the values being $\sim 10\%$ above and $\sim 2\%$ below those of data set 50 at ~ 100 K and ~ 300 K, respectively.

The behavior of the electrical resistivity of chromium in the vicinity of the Néel temperature has been studied quite extensively: it goes through a broad maximum at approximately 4 K below the Néel temperature and decreases rapidly as the Néel temperature is approached. The temperature derivative of the electrical resistivity then goes through a spike-like minimum. The ensuing minimum in electrical resistivity value occurs at a few tenth of a degree above the Néel temperature. The position of the minimum in the temperature derivative has been associated with the Néel temperature. However it has been proposed recently, from theoretical calculations, that the temperature derivative of the electrical resistivity should follow a power law relation: $(T_N - T)^{-1}$ (see, e.g., Suezaki and Mori [29], Alexander et al. [30]). The recent publication by Rapp et al. [31] showed that the power law was only applicable in the temperature range from $T_N - 8.5$ K to $T_N - 0.5$ K, and the temperature derivative of the measured resistance was at a minimum at about 0.18 degree below T_N determined by a fit to the power law relation. The simultaneous measurements of electrical resistivity and sublattice magnetization by neutron diffraction method on a single crystalline iodide chromium specimen by Ishikawa et al. [32] (data set 158), showed that the minimum in the electrical resistivity occurred at about 0.5 degree above the Néel temperature. They also found that there was some residual ordering above the transition. This residual ordering persisted till ~ 315 K, and was attributed by the authors to the strain introduced in spot welding the specimen. However, this interpretation appears to be in conflict with the observation of Stebler [33] (data sets 112-115), who reported considerable hysteresis across the Néel transition. Stebler attributed the hysteresis to (thermal) strain, but failed to observe appreciable residual ordering (again with neutron diffraction method) in his specimen. It is apparent that the critical phenomenon of antiferromagnetic-paramagnetic transition in chromium is

a complex one and is still subject to further investigations. Experimentally, the accurate determination of the electrical resistivity in the close vicinity of the Néel temperature poses considerable difficulties. This is due to the rapid change in the temperature derivative of the electrical resistivity over a narrow temperature range, while the value of the electrical resistivity itself changes only slightly. Thus, even for the same specimen, Laubitz and Matsumura [9] (data set 53) found that the position of the resistivity minimum was at 311.7 K, but from the data of Moore et al. [34] (data set 63), it appeared that the minimum occurred at around 312.3 K. For comparison, Matsumoto and Mitsui [35] stated that the minimum was at 312.0 K for a specimen with residual resistivity ratio comparable to that of the above (350 instead of 380). For these reasons, it is concluded that a recommendation for the detailed variation of the electrical resistivity of chromium at the close vicinity ($\sim \pm 0.5$ degree K) is beyond the scope of the present study. The position of the resistivity minimum is tentative taken at 311.7 K following Laubitz and Matsumura [9], as these authors apparently made their measurements at very small temperature intervals. This temperature is within ± 0.2 degree of those determined from the data of Anderson et al. [36] (data set 87), Stebler [33] (data sets 114, 115) and Trego and Mackintosh [37] (data set 116). The Néel temperature of chromium is tentatively taken as 311.5 K, as determined by specific heat measurements.

Even though hysteresis across the Néel transition is not generally mentioned by most authors, it has been reported by some: Mitsui and Tomizuka [38] (data sets 33, 34), and Stebler [33] (data sets 112, 113). If the hysteresis is caused by strain, as suggested by Stebler [33], it should disappear in specimens that have been annealed for a sufficiently long period of time at high temperatures and are heated up and/or cooled down through the transition at a sufficiently slow rate during the measurements.

For chromium, there is another transition occurring at about 120 K: the spin-flip transition. At this temperature, the polarizations of the spin-density waves, which give rise to the antiferromagnetism in chromium, changes from longitudinal (at lower temperatures) to transverse (at higher temperatures). Arajs [39], upon reanalyzing the earlier data of Arajs and Dunmyre [19] (data set 100), concluded that there is a change in the temperature coefficient of the resistivity, which was first reported by Matsumoto et al. [35]. Meaden et al. [12,13] (data sets 71-77) reported a step-type anomaly, in addition to a change of slope.

However, the slope changes reported are quite different: from $T^{2.8}$ to $T^{2.0}$ according to Arajs [39] and from $T^{2.45}$ to $T^{2.25}$ according to Meaden et al. [12,13]. In addition, the step-type anomaly, also reported by Kostina et al. [40] (data sets 134, 138) for single crystalline specimen, is in the opposite direction (a decrease instead of an increase in value) to that reported by Meaden et al. [12,13]. Most other authors did not report any unusual behavior of the electrical resistivity at this temperature, and Moore et al. [10] stated that the spin-flip transition did not have a noticeable effect on the electrical resistivity. Muir and Ström-Olsen [41] also did not detect any change of the temperature coefficient of the measured resistance of their single domain specimen at the spin-flip temperature. In generating the present recommended values, it is assumed that the electrical resistivity is not affected by this transition, and the values and their temperature derivative are continuous through the transition.

At temperatures above the Néel transition, the electrical resistivity of chromium varies smoothly with temperature. Among the available data sets, there are three from independent sources that agree well with one another: Moore et al. [34] (data set 64), Arajs et al. [20] (data set 102), and Cox and Lucke [24] (data set 103). The agreement between data sets 64 and 102 is within 1% from 400 to 1000 K, and between data sets 64 and 103 is within 2.5% from 400 to 1300 K. The recommended values from the Néel temperature to 1300 K are based on these three data sets, with more weight given to that of Moore et al. [34] (data set 64) since the specimen of this data set is the same as that of data sets 50 and 53 upon which the recommended values at lower temperatures are based. It should be noted here that the resistivity values reported by Moore et al. [34] had been corrected for thermal expansion. However, these authors did not report the method by which the correction was applied. Therefore, the comparison mentioned above was carried out after account had been taken of the effect of thermal expansion, using the recommended thermal expansion values of Touloukian et al. [42, p. 61].

There are a number of data sets for temperatures above 1300 K. The agreement between them is not good: the spread among them is about $20 \times 10^{-8} \Omega m$ at 1500 K and $30 \times 10^{-8} \Omega m$ at 1900 K. Even though there are five data sets (26, 27, 29, 82, 83) from essentially two groups of workers that show agreement within $\pm 4 \times 10^{-8} \Omega m$ at 1700 K, these data are considered not reliable. Those by Anderson et al. [43] (data sets 82, 83) give values that are much too low at lower temperatures, and

those by Baum et al. [44,45] (data sets 26, 27), and by Levin et al. [46] (data set 29) show slopes that are considered too low. In addition, the room temperature value given by data set 26 is much too high (by $\sim 4.5 \times 10^{-8} \Omega \text{m}$ than the recommended value). The recommended values from 1300 to 1700 K were derived by extrapolation of the recommended values for lower temperatures with a temperature dependence that was based roughly on the data by Powell and Tye [47] (data set 106) and by Anderson et al. [43] (data set 84). In this temperature range, both of these data sets show a slight curvature toward the temperature axis, and are more or less parallel to each other, even though data set 106 is for a 99.985% pure electrodeposited specimen and data set 84 is apparently for a single crystalline specimen. The slight curvature also appears to be evident in data sets 26, 27, and 29. The recommended values for temperatures from 1700 K to the melting point are based on numerical extrapolation of the values for 1300 to 1700 K. At 1700 K the recommended value is higher by $\sim 11\%$ (or $\sim 9 \times 10^{-8} \Omega \text{m}$) than the data of Baum et al. [44,45] (data set 26, 27), and at 2100 K it is higher by $\sim 12\%$ (or $\sim 12 \times 10^{-8} \Omega \text{m}$). Anderson et al. [43] (data sets 82, 83) reported sudden increase in electrical resistivity values at ~ 1900 K, which they attributed to the evaporation of sample material. There was no evidence of such behavior from the data of Baum et al. [44,45] (data sets 26, 27) and those of Levin et al. [46] (data set 29). Neither was evident from the data of Grube and Knabe [48] (data sets 6-8) which were apparently for specimens that were either porous and/or less pure.

There are only three data sets on the electrical resistivity of chromium in the molten state: by Baum et al. [44,45] (data sets 26, 27) and by Levin et al. [46] (data set 29). As it is mentioned in the last paragraph, the electrical resistivity values of these data for lower temperatures appeared to be questionable. The recommended value for the electrical resistivity of molten chromium at the melting point was obtained by multiplying the recommended value for solid chromium at the melting point by the ratio of the electrical resistivity values (101.5 and $108.1 \times 10^{-8} \Omega \text{m}$, respectively, for the solid and the molten states) reported explicitly in the text by Baum et al. [45] (data set 27). For temperatures above the melting point, the recommended values were calculated according to a linear dependence based on data sets 26 and 29.

The recommended values both uncorrected and corrected for thermal expansion of the material are presented in table 1, while only the uncorrected values are

shown in figures 1 and 2 along with the experimental data. The values are applicable to chromium of purity 99.98% or higher; however, those values for temperatures below 100 K are applicable only to chromium having a residual resistivity of $0.0306 \times 10^{-8} \Omega\text{m}$. The estimated uncertainty in the recommended values is about $\pm 5\%$ up to 1300 K. The uncertainty increases with temperature at higher temperatures and is estimated to be $\pm 10\%$ immediately below the melting point, and $\pm 15\%$ for the molten state.

From the available data, it appears that the low-temperature resistivity of chromium of lower purity can be obtained by the use of the Mattheissen's rule if the residual resistivity of a specimen does not exceed $\sim 0.2 \times 10^{-8} \Omega\text{m}$. Thus, using the recommended values and the Mattheissen's rule, the data for the specimen CrB of Moore et al. [10] (data set 47) would be reproduced to within $\sim \pm 5\%$. For the data of Chiu et al. [22] (data set 46), it was $\sim \pm 10\%$. Generally, this method underestimates the resistivity values. And even though the derivation from Mattheissen's rule can be negative for some dilute chromium alloys, it is not likely to occur for chromium of reasonable purity.

The recommended values uncorrected for thermal expansion given in table 1 can be represented approximately by the following expressions to within $\pm 0.5\%$.

1-90 K:

$$\rho = 0.0306 + 5.756 \times 10^{-7} T^{3.23} \quad (11)$$

90-293 K:

$$\rho = 0.398 - 2.950 \times 10^{-2} T + 5.112 \times 10^{-4} T^2 - 9.218 \times 10^{-7} T^3 \quad (12)$$

293-305 K:

$$\rho = 250.125 - 2.65115 T + 9.68307 \times 10^{-3} T^2 - 1.16108 \times 10^{-5} T^3 \quad (13)$$

305-311 K:

$$\rho = 1.4614467 \times 10^4 - 1.4360559 \times 10^2 T + 4.7073008 \times 10^{-1} T^2 - 5.142874 \times 10^{-4} T^3 \quad (14)$$

312-400 K:

$$\rho = 27.036 - 1.5301 \times 10^{-1} T + 4.5057 \times 10^{-4} T^2 - 3.4505 \times 10^{-7} T^3 \quad (15)$$

400-1300 K:

$$\rho = 4.457 + 1.3084 \times 10^{-2} T + 4.9046 \times 10^{-5} T^2 - 3.0031 \times 10^{-8} T^3 + 8.653 \times 10^{-12} T^4 \quad (16)$$

1300-2133 K:

$$\rho = -49.515 + 1.11856 \times 10^{-1}T - 2.3954 \times 10^{-5}T^2 + 3.4937 \times 10^{-9}T^3 \quad (17)$$

2133-2300 K:

$$\rho = 14.54 + 0.050 T \quad (18)$$

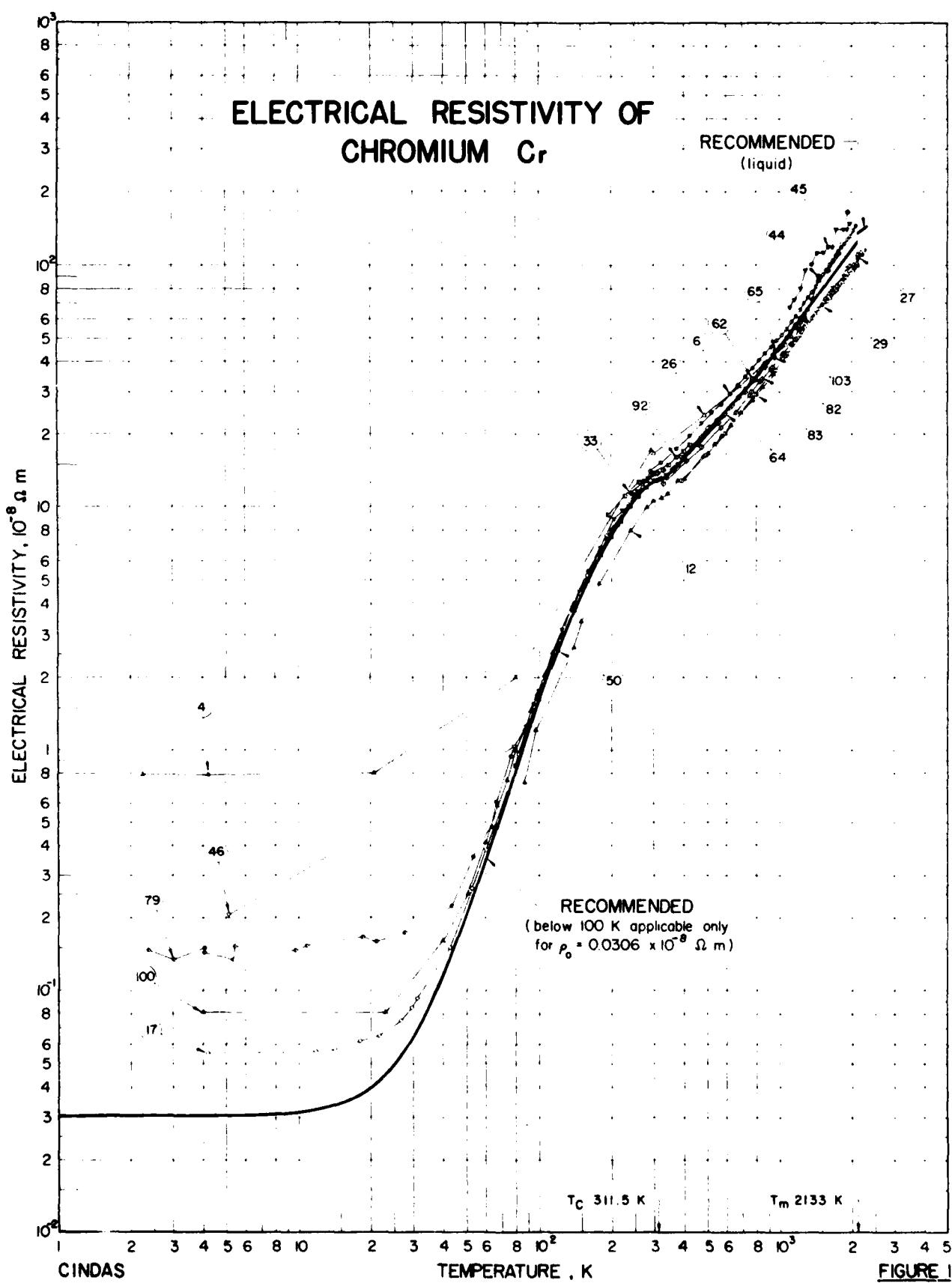
It should be emphasized that these expressions do not necessarily suggest any theoretical justification, and should be treated, most appropriately, as numerical aids only. It should also be understood that giving these expressions does not imply a recommendation for the temperature derivative of the electrical resistivity.

TABLE 1. RECOMMENDED VALUES FOR THE ELECTRICAL RESISTIVITY OF CHROMIUM^a[Temperature, T, K; Electrical Resistivity, ρ , $10^{-8} \Omega \text{m}$]

T	ρ		T	ρ	
	uncorrected	corrected		uncorrected	corrected
1	0.0306	0.0306	316	12.785	12.786
4	0.0307	0.0307	320	12.905	12.907
7	0.0309	0.0309	350	13.888	13.891
10	0.0316	0.0316	400	15.84	15.86
15	0.0342	0.0342	500	20.05	20.08
20	0.0398	0.0398	600	24.60	24.66
25	0.0495	0.0495	700	29.43	29.53
30	0.0646	0.0645	800	34.48	34.64
35	0.0865	0.0864	900	39.75	39.98
40	0.117	0.117	1000	45.21	45.52
50	0.207	0.207	1100	50.89	51.30
60	0.349	0.349	1200	56.84	57.37
70	0.555	0.554	1300	63.09	63.78
80	0.838	0.837	1400	69.72 ^b	70.56 ^b
90	1.212	1.21	1500	76.16 ^b	77.18 ^b
100	1.64	1.64	1600	82.44 ^b	83.68 ^b
150	4.36	4.36	1700	88.58 ^b	90.05 ^b
200	7.57	7.57	1800	94.59 ^b	96.33 ^b
250	10.57	10.57	1900	100.5 ^b	102.5 ^b
273	11.69	11.69	2000	106.3 ^b	108.7 ^b
293	12.45	12.45	2100	112.1 ^b	114.8 ^b
300	12.650	12.650	2133	114.0 ^b (s)	116.8 ^b (s)
306	12.760	12.761	2133	121.4 ^b (l)	124.4 ^b (l)
308	12.779	12.780	2200	124.8 ^b	127.8 ^b
309	12.779	12.780	2300	129.8 ^b	132.8 ^b
310	12.769	12.770			
311	12.739	12.740			
311.7	12.670	12.671			
312	12.673	12.674			
314	12.728	12.729			

^a The values are for chromium of purity 99.98% or higher, but those below 100 K are applicable only to chromium having a residual resistivity of $0.0306 \times 10^{-8} \Omega \text{m}$. The columns headed uncorrected and corrected refer to values uncorrected and corrected for thermal expansion, respectively. Solid line separating tabular values indicates solid to liquid state transformation.

^b Provisional value.



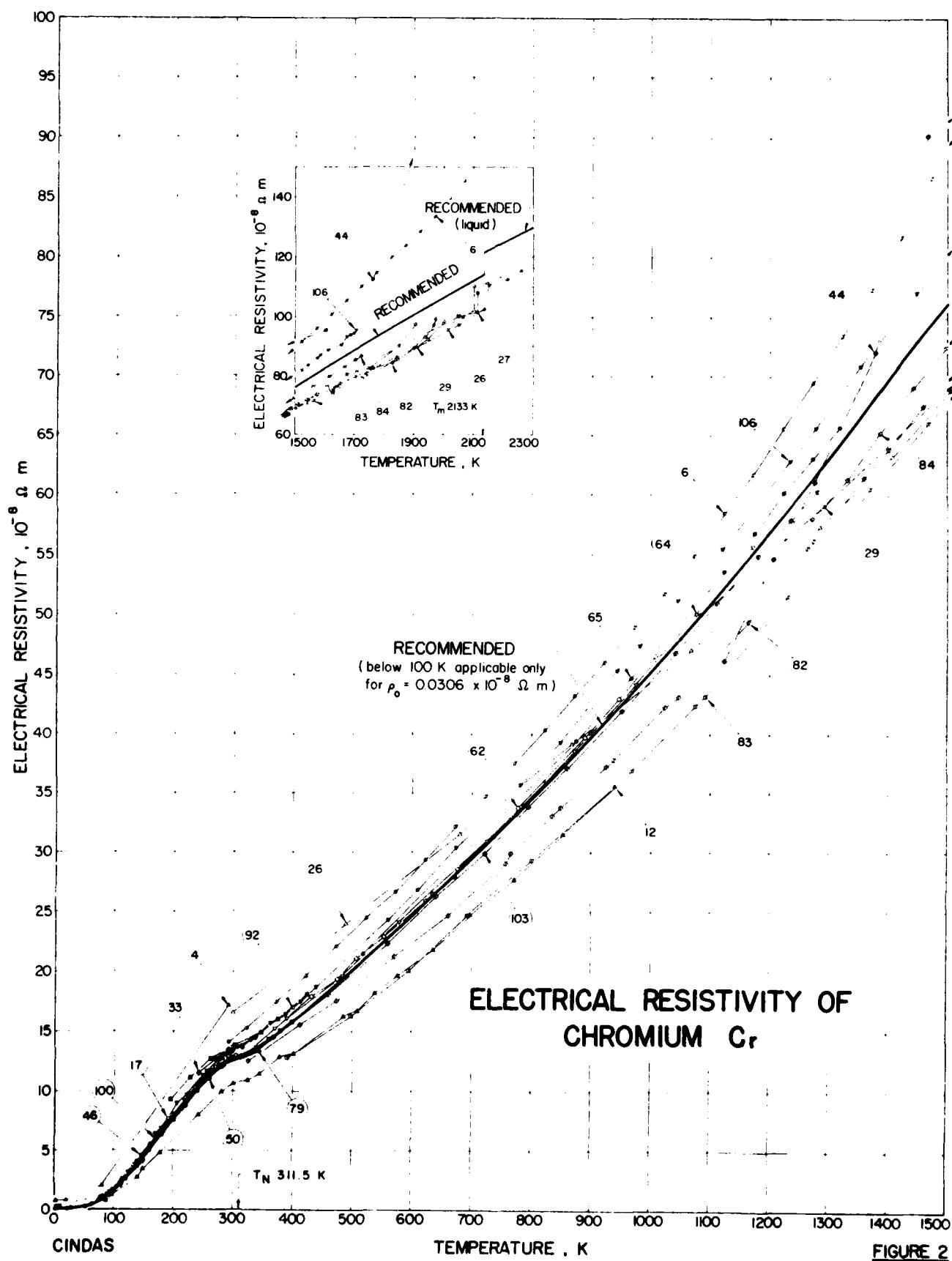


TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
1*	49	McLennan, J.C. and Niven, C.D.	1927	B	2.4-290	Unaged-I	Trace of Cu; strip sample obtained from General Electric Co. of England; electrolytically deposited sheet ground down to 3.81 cm (1.5 in.) long and 0.475 cm (0.187 in.) thick; unannealed; data uncorrected for thermal expansion.
2*	49	McLennan, J.C. and Niven, C.D.	1927	B	2.2-290	Unaged-II	Trace of Cu; strip sample; material obtained from General Electric Co. of England; electrolytically deposited sheet dissolved in acid with aid of electrical potential; unannealed; data uncorrected for thermal expansion.
3*	49	McLennan, J.C. and Niven, C.D.	1927	B	20.6-292	Aged-I	Similar to the above specimen; annealed for 1 h at comparatively low temperature, cooled to room temperature, annealed for 2 h at much higher temperature; data uncorrected for thermal expansion.
4	50	McLennan, J.C., Niven, C.D., and Wilhelm, J.O.	1928	B	2.3-293		The above specimen with measurements extended to lower temperatures (there is an apparent discrepancy between values at 80 K between data set and the above).
5*	48	Grube, G. and Knabe, R.	1936	A	373-1673	"Pure Cr."	
6	48	Grube, G. and Knabe, R.	1936	A	293-2073	Electrolytic Cr, sintered in H ₂ atmosphere at 1673 K; density 6.95 × 10 ³ kg cm ⁻³ .	
7*	48	Grube, G. and Knabe, R.	1936	A	1643-1973	B	Electrolytic Cr, remelted and measured in an Ar atmosphere.
8*	48	Grube, G. and Knabe, R.	1936	A	1643-1933	B	The above specimen measured with decreasing temperature.
9*	48	Grube, G. and Knabe, R.	1936	A	1553-1973	C	Electrolytical Cr, remelted and measured in an Ar atmosphere.
10*	48	Grube, G. and Knabe, R.	1936	A	1563-1953	C	The above specimen measured with decreasing temperature.
11*	51	Potter, H.H.	1941	V	87-1064		"99.99" pure; 1 cm long; annealed at 873 K.
12	51	Potter, H.H.	1941	V	87-941		Similar to the above; outgassed just below the melting point by electron bombardment.
13*	14	Harper, A.F.A., Kemp, W.R.G., Klemens, P.G., Tainsch, R.J., and White, G.K.	1957	G	4.2	Sample 1	99.998 pure; supplied by Dr. H.L. Main of the Aeronautical Res. Lab., Commonwealth Dept. of Supply; 3 mm in diam and 8 cm long; cold worked; temperature 4.2 K assumed.
14*	14	Harper, A.F.A., et al.	1957	G	4.2	Sample 2	The above specimen annealed in vacuum at 1323 K for 4 h.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
15*	14 Harper, A.F.A., Keep, W.R.G., Klemens, P.C., Tainsh, R.J., and White, G.K.	1957	C	4.2	Sample 3	Similar to the above; partially recrystallized after cold worked.
16*	14 Harper, A.F.A., et al.	1957	C	4.2	Sample 4	The above specimen; annealed.
17	14 Harper, A.F.A., et al.	1957	C	4.2-320	Sample 5	Similar to the above; cold worked and fully recrystallized.
18*	52 De Morton, M.E.	1958		200-344		0.013 O ₂ , 0.0015 C, 0.0005 Al, Fe, N ₂ and Si each, 0.00027 H ₂ (3N1/100 gm), 0.0002 Cu, Mg, and Pb each, and 0.00001 Ag; metallic impurities spectrographically determined; 0.073 cm diam and 20.7 cm long; arc-melted electrolytic Cr ingot 1.5 in. diam; extruded to 0.5 in. diam; swaged to 0.2 in. diam; drawn at 573 K to 0.027 in. diam; given a 32 reduction at 423 K; total reduction 98%.
19*	52 De Morton, M.E.	1958		200-346		The above specimen annealed at 973 K for 15 min. under a vacuum of 2 x 10 ⁻⁶ mmHg; "completely recrystallized".
20*	53 Neumann, H.M. and Stevens, K.W.H.	1959	A	94-390		Spectrographically standardized chromium supplied by Johnson and Matthey Co.; contains dissolved oxygen; 2 cm long; machined; sealed in evacuated quartz tube and annealed at 1200 K for 1 month.
21*	54 Sabine, T.M. and Svenson, A.C.	1968	D	301-328		0.024 O ₂ and 0.015 N ₂ ; supplied by Aeronautic Res. Lab., Melbourne; hot extruded (1373 K); 0.5 in. in diam and 3 in. long; measured with an AC bridge at 50 Hz; error of measurement 1%.
22*	54 Sabine, T.M. and Svenson, A.C.	1968	D	291-328		Similar to the above, annealed at 1373 K.
23*	54 Sabine, T.M. and Svenson, A.C.	1968	D	289-328		Similar to the above, annealed at 1673 K; fine grained.
24*	54 Sabine, T.M. and Svenson, A.C.	1968	D	289-328		Similar to the above, annealed at 1673 K; course grained; grain diam 0.25 in. approximately.
25*	55 Hamaguchi, Y. and Kunitomi, N.	1964		295-810		99.9 pure; cut by diamond saw; measured in vacuum.
26	44 Baum, B.A., Gel'd, P.V., and Sachil'nikov, S.I.	1964	R	300-2194		99.98 pure.
27	45 Baum, B.A., Gel'd, P.V., and Sachil'nikov, S.I.	1963	R	1673-2113		>99.98 pure (specimen appears to be the same as the above); resistivity values at melting point (reported at 2113 K approximately) from text.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
28*	56	Pavars, I.A., Baum, B.A., and Gel'd, P.V.	1969	R	2013		99.98 pure, doubly refined electrolytic chromium; melted in a fusion induction furnace in an argon atmosphere of 500 mm Hg.
29	46	Levin, E.S., Gel'd, P.V., and Ayushina, G.D.	1973	R	1084-2261		99.98 pure, doubly refined electrolytic.
30*	57	Levin, E.S.	1971	R	1973		99.98 pure, doubly refined.
31*	58	Fine, M.E., Greiner, E.S., and Ellis, W.C.	1951	A	78-401		99.8 pure; prepared by cold pressing sintered electrolytic powder compact; annealed at 1673 K in purified helium.
32*	58	Fine, M.E., et al.	1951	A	275-377		99.98 pure, from electrochemical analysis by F.K. Jaycox, no Fe or Ni detected; electroformed from an aqueous solution by R.A. Ehrhardt and G. Brittrich, using the method of Brennar, Burhead and Jennings, NBS J. of Res., 40, 31, (1948); vacuum annealed at 1273 K with specimen packed in chromium powder.
33	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-331		0.08 N and 0.03 O, others not detectable spectrophotographically; supplied by Prof. R. Street of Monash Univ., Melbourne; 0.5 mm wide, 0.5 mm thick and 58 mm long approximately; manufactured from ARL chromium ingot; ground and formed; annealed and recrystallized at 1523 K for 2 h; resistivity values calculated from reported $\rho(1)/\rho(273 \text{ K})$ and reported $\rho(273 \text{ K}) = 12.7 \times 10^{-8} \Omega \text{m}$.
34*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-322		The above measured with decreasing temperature.
35*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-330		The above measured under a pressure of 0.98 kbar.
36*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-326		The above with decreasing temperature.
37*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-331		The above measured under a pressure of 1.96 kbar.
38*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-329		The above with decreasing temperature.
39*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-331		The above measured under a pressure of 2.94 kbar.
40*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-326		The above measured under a pressure of 5.30 kbar.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Ref. Set No.	Ref. No.	Author(s)	Year	Method Used	Temp Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
41*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-326		The above with decreasing temperature.
42*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-325		The above measured under a pressure of 7.16 kbar.
43*	38	Mitsui, T. and Tomizuka, C.T.	1965	A	243-326		The above measured under a pressure of 7.85 kbar.
44	59	Barykin, B.M., Gordon, V.G., Levinov, B.M., Rekov, A.I., and Spiridonov, E.C.	1974	V	1124-1938		99.9 ⁺ pure chromium powder; average particle size 5-10 μm ; pressed and sintered at 1973 K; density 7.0 g cm^{-3} ; porosity 1.5%.
45*	59	Barykin, B.M., et al.		V	1120-1976		Similar to the above.
46	22	Chiu, C.H., Jericho, N.M., and March, R.H.	1971	V	5.1-313		0.0012 O ₂ and Fe each, 0.0010 Si, 0.00009 N ₂ , 0.00003 Al, Ca and Ni each, 0.00002 H ₂ and 0.00001 Cu, Mg, and Mn each (at.-%); "10 ⁻² cm diameter," and 5 cm long; spark machined; measurement error 2%.
47*	10	Moore, J.P., William, R.K., and McEroy, D.L.	1968	A	80-400	CrB	99.98 ⁺ pure; 0.0060 C, 0.0028 N, <0.0020 Ga, 0.0009 H, 0.0008 Mo, 0.0006 O, 0.0005 Cu, S, and Si each, 0.0004 K, 0.0003 Co, Fe, and U each, <0.0003 Pt, <0.0002 Sr and Zn each, 0.0001 B, <0.0001 Hg, Pd, Rn, Ru, Sb, Te, Ti, U, W, and Zr each, <0.00008 Cu and Pb each, 0.00006 Ca, <0.00005 Ag and Ba each, <0.00004 Bi, 0.00003 Mn, 0.00002 Nb, <0.00002 Ge, In, Mg and Na each, 0.00001 Ti and <0.00001 Ag, Li, and P each (at.-%); content of C by combustion analysis, H, N, and O by vacuum fusion analysis, and of others by semi-quantitative spectrographic analysis; material supplied by Girosealloy Corp.; consolidated into a disc-shaped ingot and drop-cast into a rod of 1.6 cm diam and 15 cm long; machined to 0.96 cm in diam and 7.7 cm in length; density 7.15 g cm^{-3} ; grain diam 440 to 840 μm ; $\rho(273 \text{ K})/\rho(4.2 \text{ K}) = 58$; measurement error $\pm 0.38\%$; smoothed values from cable.
48*	10	Moore, J.P., et al.	1968	A	310-315	CrB	The above in the vicinity of the Néel temperature.
49*	10	Moore, J.P., et al.	1968	A	307-320	CrB	The above measured with a temperature gradient of 0.014 K m^{-1} .

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
50*	10	Moore, J.P., William, R.K., and McElroy, D.L.	1968	A	80-400	CrA	99.98 ⁺ pure; 0.0070 C, 0.0030 Fe, <0.0020 Au and Mg each, 0.0015 S, 0.0014 O, 0.0010 Mn, <0.0010 Pt, 0.0006 Ca, 0.0005 H and Si each, 0.0003 B, N and U each, 0.0002 Ba, Cu, and Pb each, <0.0002 Ta, 0.0001 Ag and As each, <0.0001 Hg, P, Pd, Ru, Sb, Sn, Te, Ti, U, W, and Zr each, <0.00008 Cd, 0.00005 Tl, <0.00005 Mo, Ni, and Sr each, 0.00004 K and Nb each, <0.00004 Bi, <0.00003 Co, <0.00002 Ge, In, and Na each, and <0.00001 Li and Rn each (at.-%); same methods of analysis as above; crystals supplied by Chromalloy Corp.; sealed in vacuum jacket after cleaned and compacted; hot extruded to a rod of 1.6 cm diam and 60 cm long (by BMI); machined to a rod of 0.96 cm diam and 7.7 cm long; density 7.19 g/cm ³ ; average grain diam 63 μm; ρ(273 K) / ρ(4.2 K) = 280; measurement error ±0.38%; smoothed values from table.
51*	10	Moore, J.P., et al.	1968	A	308-320	CrA	The above in the vicinity of the Néel temperature.
52*	10	Moore, J.P., et al.	1968	A	307-320	CrA	The above measured with a temperature gradient of 0.014 K m ⁻¹ .
53*	9	Laubitz, M.J. and Matsumura, T.	1970	D	300-319		The above specimen on loan from Oak Ridge National Lab.; annealed at 1100 K for 4 days and 1200 K for 1 day; ρ(273 K) / ρ(4.2 K) = 380; specimen immersed in oil bath maintained to within 1 x 10 ⁻³ K of desired temperature; measured with an ac (7 Hz) bridge with an absolute accuracy of 0.2%, and a precision of 0.03%; smoothed values from curve, which is reported to be based on 68 data points and to deviate from the measured values by amounts less than the precision of the measurements.
54*	9	Laubitz, M.J. and Matsumura, T.	1970	D	301-318		The above measured in a thermal conductivity apparatus, with temperature difference along specimen less than 0.01 K.
55*	9	Laubitz, M.J. and Matsumura, T.	1970	D	301		The above after being cooled from 320 K.
56*	9	Laubitz, M.J. and Matsumura, T.	1970	D	301-318		The above specimen measured during a thermal conductivity experiment with temperature difference along specimen less than 0.25 K.
57*	9	Laubitz, M.J. and Matsumura, T.	1970	D	301		The above after being cooled from 320 K.
58*	9	Laubitz, M.J. and Matsumura, T.	1970	D	301-315		The above specimen measured during a thermal conductivity experiment with temperature difference along specimen less than 0.5 K.
59*	9	Laubitz, M.J. and Matsumura, T.	1970	D	318		The above after being cooled from 320 K.
60*	9	Laubitz, M.J. and Matsumura, T.	1970	D	302-319		The above specimen measured during a thermal conductivity experiment with temperature difference along specimen less than 1.0 K.
61*	9	Laubitz, M.J. and Matsumura, T.	1970	D	302		The above after being cooled from 320 K.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent). Specifications and Remarks
62	34	Moore, J.P., Williams, R.K., and Graves, R.S.	1977	A	293-1008	CrA'	Same sample material as the above; average grain diam 60 μm ; $\rho(273 \text{ K})/\rho(4.2 \text{ K}) = 280 - 380$, depending on thermal cycling; measurement error $\pm 0.38\%$; corrected for thermal expansion.
63*	34	Moore, J.P., et al.	1977	A	300-320	CrA'	The above in the vicinity of the Néel temperature; corrected for thermal expansion.
64	34	Moore, J.P., et al.	1977	A	371-1172	CrA	From the same stock as the above; thermally cycled during brazing of specimen to heater and nickel heat sink; $\rho(273 \text{ K})/\rho(4.2 \text{ K}) = 380$; corrected for thermal expansion.
65	34	Moore, J.P., et al.	1977	A	518-1319	CrB	Same specimen material as for Data Set 47; density 7.19 g cm^{-3} ; grain size 400 to 800 μm ; arc-cast; $\rho(273 \text{ K})/\rho(4.2 \text{ K}) = 58$; specimen found to have a hairline casting void along its axis, causing approximately 1% change in the measured values; corrected for thermal expansion.
66*	60	Söchtig, H.	1940		79-319	CrI	From Dr. Kroll of Luxemburg; cut from a rolled plate; approximate dimensions: 0.12 cm thick, 0.21 cm wide and 1.37 cm long; resistivity values calculated from reported resistances and reported $\rho(273 \text{ K}) = 19.7 \times 10^{-8} \Omega\text{m}$.
67*	60	Söchtig, H.	1940		20.8-373	CrII	Electrolytic chromium; approximate dimensions: 0.21 cm wide, 0.23 cm thick, and 0.58 cm long; resistivity values calculated from reported resistances and reported $\rho(273 \text{ K}) = 21.1 \times 10^{-8} \Omega\text{m}$.
68*	61	Meaden, G.T., Rao, K.V., and Loo, H.Y.	1969		278-323		99.999 pure; 0.0010 C, 0.0009 O ₂ , 0.0003 Ca, 0.0001 Al, Cu, and Mg each, and 0.0008 H ₂ ; residual resistance ratio 1/78.
69*	11	Meaden, G.T. and Sze, N.H.	1969		301-317		99.999 pure; 0.0010 C, 0.0008 O, 0.0003 Ca and N ₂ each, 0.0002 Fe, 0.0001 Al, Cu, and Mg each, and 0.00008 H ₂ ; cast iodide chromalum machined to 3.8 mm in diam and 65 mm in length; unannealed; $\rho(295 \text{ K})/\rho(4.2 \text{ K}) = 178$; measured with increasing temperature (specimen is apparently the same as the above).
70*	11	Meaden, G.T. and Sze, N.H.	1969		300-318		The above specimen measured with decreasing temperature.
71*	12	Meaden, G.T., Rao, K.V., and Loo, H.Y.	1969		100-145		99.999 pure; 0.0010 C, 0.0008 O ₂ , 0.0003 Ca, 0.0001 Al, Cu, and Mg each; residual resistivity ratio 1/78 (specimen is apparently the same as the above).
72*	13	Meaden, G.T. and Sze, N.H.	1969		101-140	Cr-O	99.999 pure; unannealed; grain diam 0.25 mm; residual resistivity ratio 1/78 (specimen is apparently the same as the above).
73*	13	Meaden, G.T. and Sze, N.H.	1969		116-124	Cr-O	The above in the vicinity of the spin-flip transition.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
74*	13 Meaden, G.T. and Sze, N.H.	1969		101-140	Cr-1	Similar to the above except annealed at 1473 K for 1 h.
75*	13 Meaden, G.T. and Sze, N.H.	1969		116-125	Cr-1	The above in the vicinity of the spin-flip transition.
76*	13 Meaden, G.T. and Sze, N.H.	1969		101-140	Cr-50	Similar to the above except annealed for 75 h at temperatures above 1273 K, 50 h of which is at 1473 K; grain diam 2 to 4 mm; grain orientation is random as determined by x-ray Laue photography; residual resistivity ratio 295.
77*	13 Meaden, G.T. and Sze, N.H.	1969	.	117-125	Cr-50	The above in the vicinity of the spin-flip transition (discrepancies between these two data sets are due to graph-reading errors).
78*	28 Meaden, G.T., Rao, K.V., and Tee, K.T.	1970		202-329		Pure chromium sample; annealed in vacuum (10^{-6} Torr) for 75 h above 1273 K of which 50 h is at 1473 K; grain diam 2 to 4 mm; residual resistivity ratio 295 (specimen is apparently the same as the above).
79	15 Goff, J.F.	1970	A	2.4-343	CrII	99.92 pure; 0.005 Fe, 0.004 Mn, 0.003 Cu, 0.002 Mg, and balance mostly S, P, Ni and Mn; electrolytic; melted with argon arc, cast in oxygen-free copper boat; annealed twice at 1173 K for 24 h; ground to approximate dimensions of 4 mm wide, 4 mm thick and 50 mm long; polycrystalline; $\rho(297 K)/\rho(4 K) = 88$; average residual resistivity $0.145 \times 10^{-8} \Omega m$; measurement error $\pm 1\%$.
80*	15, Goff, J.F.	1970	A	1.2-286	CrI	Similar to the above except $\rho(297 K)/\rho(4 K) = 72$ and average residual resistivity (1.2 K to 12.9 K) $= 0.1834 \times 10^{-8} \Omega m$.
81*	62 Moore, J.P., Williams, R.K., and McElroy, D.L.	1968	A	90-360		The above specimen; $\rho(296 K)/\rho(4.2 K) = 70.5$; smoothed values from table.
82	43 Anderson, J.M., Stewart, A.D., and Ramsay, I.	1970	A	330-1973		Single crystal produced by the iodide process; supplied by Material Research Corp.; 0.0025 interstitial impurities and 0.0015 substitutional impurities, quoted by manufacturers; 1 mm thick, 1 mm wide and 5 mm long; cut by a combination of diamond saw, spark planning and electropolishing techniques; measurement done in a high purity hydrogen atmosphere; reported errors in resistivity value 0.002%, and in temperature 0.2%; values corrected for thermal expansion using expansion data of B.N. Vasyutinskii, G.N. Katurazov and G.N. Finkel, Soviet Phys.-Phys. Met. Metallog., 12, 141 (1961); rapid increase of resistivity above 1750 K was reported to be due to evaporation of material.
83	43 Anderson, J.M., et al.	1970	A	391-1905		Similar to the above, except supplied by Koch-Light Lab. and containing "Crystal 3"; no specimen detail reported; measured with decreasing temperature.
84	43 Anderson, J.M., et al.	1970	A	1272-1724		"Crystal 3"; no specimen detail reported; measured with decreasing temperature.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp Range, K	Name and Specimen Designation	Composition (Weight percent). Specifications and Remarks
85*	43 Stewart, A.D., and Ramsay, I.	1970	A	1482-1740	The above specimen; measured with increasing temperature.	
86*	43 Anderson, J.M., et al.	1970	A	1469-1693	The above specimen; measured with decreasing temperature again.	
87	36 Anderson, J.M., Stewart, A.D., and Ramsay, I.	1972	A	285-324	0.0012 O ₂ and Fe each, 0.0010 Si, 0.0009 N ₂ , 0.00002 H ₂ , <0.000001 C and 0.0002 others (at.%) ; single crystal prepared from Koch-Light crystalline, cut with diamond saw, spark planed and electropolished; 1 mm thick, 1 mm wide and 7 mm long; specimen axis parallel to the [100] direction; annealed at 1970 K for 3 h in hydrogen; TN 311.5 K.	
88*	36 Anderson, J.M., et al.	1972	A	282-324	The above specimen deformed at a strain rate of $5 \times 10^{-5} \text{ s}^{-1}$; TN 309 K.	
89*	36 Anderson, J.M., et al.	1972	A	77	0.03 O ₂ , 0.02 H ₂ , 0.0030 C and 0.0010 N ₂ (at.%) ; polycrystal from vacuum melted ingot; average grain size 1 mm.	
90*	63 Marcinkowski, M.J. and Lipsitt, H.A.	1961		199-414	Pure; plastically deformed: 96% reduction in area at 623 K.	
91*	63 Marcinkowski, M.J. and Lipsitt, H.A.	1961		283-323	The above specimen in the vicinity of the Néel temperature.	
92	63 Marcinkowski, M.J. and Lipsitt, H.A.	1961		196-425	The above specimen recrystallized by annealing at 1323 K for 1/2 h.	
93*	63 Marcinkowski, M.J. and Lipsitt, H.A.	1961		284-323	The above specimen in the vicinity of the Néel temperature.	
94*	17 Arajs, R.V., Colvin, R.V., and Marcinkowski, M.J.	1962	A	298-315	0.055 O ₂ and <0.001 N ₂ ; single crystal; 0.235 cm thick, 0.254 cm wide and 0.900 cm long; long axis of specimen aligned to within 1 degree of the [100] direction; measured at temperatures in the order: 297.4, 305.3, 306.1, 307.2, 313.5, 314.5, 312.4, 311.4, 310.3, 308.8, 309.5, and 309.6 K.	
95*	17, 18 Arajs, S., et al.	1962	A	310-328	The above specimen measured after being left overnight at 309.6 K; measurements between 309.6 K and 312.7 K were done over a period of 8 h, changing temperature slowly; the rest of the data points were obtained the following day.	
96*	17, 18 Arajs, S., et al.	1962	A	312	The above specimen, cooled; "leaving the crystal at this temperature overnight did not change the value of the resistivity".	
97*	17, 18 Arajs, S., et al.	1962	A	78	The above specimen; heated to 373 K and cooled rapidly to 78 K, and kept at 78 K for two days.	
98*	17, 18 Arajs, S., et al.	1962	A	78-140	The above specimen.	
99*	17, 18 Arajs, S., et al.	1962	A	4.2-330	The above specimen, cooled to 78 K, left overnight and cooled to 4.2 K; measurements in the temperature ranges, 4 to 115 K, 130 to 155 K, 155 to 215 K, and 215 to 295 K were done in successive days.	

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Set No.	r.f. Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
100 19	Arajs, S. and Dunmyre, G.R.	1965	A	4-297		0.0013 O, 0.0010 C and Si each, 0.0001 Ca, Mg, N, and Ni each, and 0.00005 H, others not detected; contents of O, H, and N determined by vacuum fusion, of C by combustion, and the rest by spectroscopic methods; arc-melted polycrystalline ingot 0.7 x 1.6 x 8.0 cm supplied by Chromalloy Corp.; cut by surface grinding machine to 0.478 ± 0.001 cm thick, 0.476 ± 0.001 cm wide and ~5 cm long; $\rho(273\text{ K})/\rho(4.2\text{ K}) = 160$; $T_N = 313.0 \pm 0.2$ K; duration of measurement 8 h; specimen was left at 290.5 K for 15 h without detectable change in resistivity (due to small size of graph, data points below 80 K are selected values; hence this curve does not represent all the measurements reported by the authors).
101*	19	Arajs, S. and Dunmyre, G.R.	1965	A	300-318	The above specimen in the vicinity of the Néel temperature; duration of measurement 8 h.
102*	20	Arajs, S., DeYoung, T.F., and Anderson, E.E.	1970	A	9-1035	From the same stock as the above.
103	24	Gor, J.E. and Lucke, W.H.	1967	+	299-1281	99.999 iodide chromium; melted 15 to 18 times in 2/3 atmosphere of ionization grade; 99.999 pure argon; spark eroded to cylindrical form; centerless-ground to 1/8 in. diam and 2 1/2 in. long; wrapped in molybdenum foil and annealed at 1523 K in 1/2 atmosphere of ionization Grade helium; water quenched and etched; measured by a method by Dauphinee, T.M. and Hooser, E., Rev. Sci. Instr., 26, 660, 1955.
104*	25	Taylor, M.A.	1962		77-359	99.99 pure; 0.01 O, ~0.0001 N, C, S and Sn each, and <0.0001 others; electrolytic; supplied by the Aeronautical Res. Lab., Melbourne; smoothed values from curve.
105*	64	Taylor, M.A. and Smith, C.H.L.	1962	A	20-273	99.99 pure; supplied by the Aeronautical Res. Lab., Melbourne; 1 mm wide, 1 mm thick, and 10 mm long; cut with carbondum slitting wheel; annealed at 1073 K for 50 h in vacuum; measurement error 1%.
106*	47	Powell, R.W. and Tye, R.P.	1956	A	94-1707	99.985 pure; <0.01 N and <0.005 O (as Cr ₂ O ₃); electrodeposited chromium 1.28 cm O.D., 0.63 cm I.D. and 18.05 cm long; prepared from chromium flakes supplied by Johnson Matthey Co.; enclosed in alumina tube and heat-treated at 443, 486, 678, 818, 1133, 1327, and 1683 K, with the five last treatments done in vacuum; reductions of 0.010 cm in O.D. and I.D. are observed after final treatment; initial density 6.975 x 10 ³ kg/m ³ , after final treatment 7.15 x 10 ³ kg/m ³ .
107*	47	Powell, R.W. and Tye, R.P.	1956	A	273-333	The above in the vicinity of the Néel temperature.
108*	26	Masheim, J. and Müller, J.	1964	+	100-339	Cylindrical specimen 1 mm in diam and 50 cm long; measured by a compensation method.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
109* 23	DeVries, G.	1959		165-356		Prepared by Prof. Fast, Eindhoven.
110* 65	Zinov'ev, V.E., Krentsis, R.P., and Gel'd, P.V.	1969		300-1800		0.05 total impurity; residual resistance ratio = 65; values calculated from reported equations: $\rho = 4.8 \times 10^{-2} T$, $T < 800$ K and $\rho = 4.8 \times 10^{-2} T + 3.1 \times 10^{-6} (T-800)^2$, $T > 800$ K.
111* 66	Maystrenko, L.G. and Polovov, V.M.	1977	A	89-400		Polycrystalline; appropriate dimensions 1 mm thick, 1 mm wide, and 10-15 cm long; annealed at 1273 K for 24 h in helium; furnace cooled; measurement error $\pm 5\%$.
112 3;	Stebler, B.	1970	A	296-344		99.996 pure, 0.0002 N ₂ ; single crystal; 7 mm thick, 8 mm wide and 25 mm long; specimen axis ~8 degrees of arc from the [100] direction; measured with increasing temperature; resistivity values calculated from reported $\Delta\rho/\rho_0$, where ρ_0 is the resistivity at 273.2 K, taken to be $11.667 \times 10^{-8} \Omega \cdot \text{m}$.
113 33	Stebler, B.	1970	A	287-350		The above specimen measured with decreasing temperature.
114 33	Stebler, B.	1970	A	305-316		The above specimen in the vicinity of the Néel temperature; measured with increasing temperature.
115 33	Stebler, B.	1970	A	305-316		The above specimen in the vicinity of the Néel temperature; measured with decreasing temperature.
116 37	Trego, A.L. and Mackintosh, A.R.	1968		277-320		0.0072 C, 0.0030 N, 0.0016 O and 0.0001 H (at. %); Iodide Cr supplied by Chromalloy Corp.; arc melted and arc zone melted; single crystal 2 mm square cross section and 1.5 cm long, cut by spark erosion technique from 0.5 in. diam and 6 in. long ingot; electropolished in orthophosphoric acid; annealed in vacuum at 1273 K for 50 h; sample length parallel to crystal [001] axis; resistivity values calculated from reported resistance R(T) and R(320 K), with $\rho(320 \text{ K})$ taken to be $12.906 \times 10^{-8} \Omega \cdot \text{m}$.
117 37	Trego, A.L. and Mackintosh, A.R.	1968		272-310		The above specimen measured after cooled through the Néel temperature in a longitudinal magnetic field of 55 kG.
118 37	Trego, A.L. and Mackintosh, A.R.	1968		275-311		The above specimen but measured after cooled through the Néel temperature in a transverse magnetic field (either in [010] or [100] direction) of 55 kG.
119 37	Trego, A.L. and Mackintosh, A.R.	1968		270-310		The above specimen, but measured after cooled through the Néel temperature in a longitudinal magnetic field of 40.5 kG; resistivity value calculated from reported $\Delta\rho/\rho(T_N)$, with $\rho(T_N)$ taken to be $12.70 \times 10^{-8} \Omega \cdot \text{m}$.
120 37	Trego, A.L. and Mackintosh, A.R.	1968		270-313		The above specimen except strength of magnetic field is 28 kG.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
121	37	Trego, A.L. and Mackintosh, A.R.	1968		275-307		The above specimen except strength of magnetic field is 15.6 kG.
122	37	Trego, A.L. and Mackintosh, A.R.	1968		285-310		The above specimen but cooled through the Néel temperature in a transverse magnetic field of 47 kG.
123	37	Trego, A.L. and Mackintosh, A.R.	1968		274-308		The above specimen except strength of magnetic field is 40.5 kG.
1-4	37	Trego, A.L. and Mackintosh, A.R.	1968		274-310		The above specimen except strength of magnetic field is 28 kG.
125	37	Trego, A.L. and Mackintosh, A.R.	1968		275-307		The above specimen except strength of magnetic field is 15.6 kG.
126	67	Akiba, C. and Mitsui, T.	1972	A	294-320		99.997 pure; iodide chromium supplied by A.D. Mackay Inc.; 0.77 mm thick, 0.7 mm wide and 10 mm long; single crystal, spark cut and chemically polished; specimen axis within ± 3 degrees from the crystalline <100> direction; $R(293 \text{ K})/R(4.2 \text{ K}) = 630$ without magnetic field cooling; specimen in single magnetic domain state (single Q) prepared by heating to 329 K, applying a longitudinal magnetic field of 74 kG, then cooled to 273 K, and magnetic field reduced to zero; resistivity values calculated from reported resistance, and with $\rho(320 \text{ K})$ taken to be $12.906 \times 10^{-8} \Omega \text{m}$.
127	67	Akiba, C. and Mitsui, T.	1972	A	301-320		The above specimen except magnetically cooled with a transverse field of 74 kG.
128	73	Semenenko, E.E. and Tutov, V.I.	1969		1.5-6.8		Monocrystalline whisker specimen, 0.10-0.12 mm in diam and ~8 mm long; $R(4.2 \text{ K})/R(300 \text{ K}) = 8 \times 10^{-3}$; resistivity values calculated from reported resistance and $\rho(300 \text{ K})$, taken to be $12.650 \times 10^{-8} \Omega \text{m}$.
129	68	Semenenko, E.E. and Tutov, V.I.	1972		4.7-329		Primary impurity is iron; only resistance as a function of temperature reported; resistivity calculated by assuming $\rho(328.6 \text{ K}) = 13.177 \times 10^{-8} \Omega \text{m}$.
130	68	Semenenko, E.E. and Tutov, V.I.	1972		280-330		The above specimen in the vicinity of the Néel temperature.
131	68,	Semenenko, E.E. and Tutov, V.I.	1972		4.4-16.1		Similar to the above; $R(1.5 \text{ K})/R(300 \text{ K}) = 8 \times 10^{-3}$; resistivity values calculated from reported $R/R(300 \text{ K})$ with $\rho(300 \text{ K})$ taken to be $12.650 \times 10^{-8} \Omega \text{m}$.
74		Semenenko, E.E.	1966				Similar to the above; $R(1.5 \text{ K})/R(300 \text{ K}) = 7.6 \times 10^{-3}$.
132	68	Semenenko, E.E. and Tutov, V.I.	1972		1.7-14.8		Similar to the above; $R(1.5 \text{ K})/R(300 \text{ K}) = 6.8 \times 10^{-3}$.
133	68	Semenenko, E.E. and Tutov, V.I.	1972		2.0-7.1		

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent). Specifications and Remarks
134	40	Kostina, T.I., Ekonova, L.N., and Kondorskii, E.I.	1970		103-130		Single crystal cut by electric spark method; 0.1 mm thick, 0.15 mm wide and 4 mm long; $R(293 \text{ K})/R(4.2 \text{ K}) = 500$; TN 311 ± 2 K; longitudinal axis of sample parallel to the [110] direction; resistivity values calculated from reported $R(R(77 \text{ K}))$, with $\rho(77 \text{ K})$ taken to be $0.737 \times 10^{-8} \Omega \cdot \text{m}$.
135	40	Kostina, T.I., et al.	1970		285-326	The above specimen.	
136	40	Kostina, T.I., et al.	1970		106-131	The above specimen after magnetically annealed by an external field in the [100] direction of magnitude 34 kOe.	
137	40	Kostina, T.I., et al.	1970		103-119	Similar to the above except external field is in the [110] direction.	
138	40	Kostina, T.I., et al.	1970		121-153	Similar to the specimen of data set 134, except longitudinal axis of sample is parallel to the [100] direction.	
139	40	Kostina, T.I., et al.	1970		287-329	The above specimen.	
140	40	Kostina, T.I., et al.	1970		101-125	The above specimen after magnetically annealed by an external field in the [100] direction of magnitude 34 kOe.	
141	40	Kostina, T.I., et al.	1970		111-133	Similar to the above except magnetic field is in the [110] direction.	
142	41	Muir, W.B. and Ström-Olsen, J.O.	1971		76-326	Single crystal, 1 mm thick, 1 mm wide and 7 mm long; cut by spark erosion technique from vapor transport grown polycrystal ingot containing many large single crystals, supplied by Battelle Memorial Institute; annealed at 14/0 K in argon for 50 h; strain free (found by x-ray technique; specimen axis parallel to the <100> direction; $R(300 \text{ K})/R(4.2 \text{ K}) = 350$; in single magnetic domain state by cooling from 343 to 273 K in a longitudinal magnetic field of 60 kOe; measuring current parallel to the spin density wave vector Q ; resistivity values calculated from reported $R(R(320 \text{ K}))$ with $\rho(320 \text{ K})$ taken to be $12.906 \times 10^{-8} \Omega \cdot \text{m}$.	
143	41	Muir, W.B. and Ström-Olsen, J.O.	1971		76-328	The above specimen in the multidomain state.	
144	41	Muir, W.B. and Ström-Olsen, J.O.	1971		296-320	The above specimen, single domain state, in the vicinity of the Néel temperature; measuring current parallel to Q .	
145	41	Muir, W.B. and Ström-Olsen, J.O.	1971		298-318	The above specimen, in the multidomain state after the above measurement.	
146	41	Muir, W.B. and Ström-Olsen, J.O.	1971		300-319	The above specimen, magnetically cooled to the single domain state again after the above measurement; measuring current again parallel to Q .	

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
147 41	Muir, W.B. and Strom-Olsen, J.O.	1971		295-312		The above specimen, in the multidomain state after the above measurement.
148 41	Muir, W.B. and Strom-Olsen, J.O.	1971		299-320		The above specimen, in single domain state after cooling from 343 to 273 K in a transverse magnetic field of 60 koe; measuring current perpendicular to Q.
149 41	Muir, W.B. and Strom-Olsen, J.O.	1971		299-310		The above in the multidomain state.
150 69	Borovik, E.S. and Volotskaya, V.G.	1959		2.4-78		Vacuum distilled chromium; needle shaped; "0.35 mm across" and 8 mm long; appear to be single crystal; resistivity value calculated from reported R/R(273 K), with $\rho(273 \text{ K})$ taken to be $11.667 \times 10^{-8} \Omega \text{m}$.
151 70	McWhan, D.B. and Rice, T.M.	1967		4.3-232	Sample 2	Battelle Lochrone; single crystal; $R(298 \text{ K})/R(4.2 \text{ K}) = 140$; measured under a pressure of 26.5 kbar; AgCl used as pressure transmitting medium; resistivity values calculated from reported R/R(1 atm, 298 K), with $\rho(1 \text{ atm.}, 298 \text{ K})$ taken to be $12.319 \times 10^{-8} \Omega \text{m}$.
152 70	McWhan, D.B. and Rice, T.M.	1967		60-223	Sample 2	The above measured under a pressure of 45.7 kbar.
153 70	McWhan, D.B. and Rice, T.M.	1967		32.5-223	Sample 2	The above measured under a pressure of 64.9 kbar; data points below 30 K cannot be resolved from graph, and are not reported here.
154 70	McWhan, D.B. and Rice, T.M.	1967		188-216	Sample 2	From the same ingot as the above specimen; $R(298 \text{ K})/R(4.2 \text{ K}) = 275$ and 165 before and after pressure experiment respectively; measured under a pressure of 26.3 kbar; AgCl used as pressure transmitting medium; resistivity values calculated by the same method as for the above specimen.
155 70	McWhan, D.B. and Rice, T.M.	1967		59-262	Sample 2	The above measured under a pressure of 45.9 kbar.
156 70	McWhan, D.B. and Rice, T.M.	1967		70-262	Sample 2	The above measured under a pressure of 65.9 kbar.
157 27	Suzuki, T.	1966		216-331		
158 32	Ishikawa, Y., Ikeda, S., and Akiba, C.	1975		299-320		99.997 pure; Iodide chromium from A.D. Mackay Inc.; single crystal, 0.7 mm thick, 0.7 mm wide and 10 mm long; specimen axis along [100] direction; resistivity value calculated from reported resistance values and $\rho(370 \text{ K})$, taken to be $12.906 \times 10^{-8} \Omega \text{m}$.

* Not shown in figure.

TABLE 2. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
159 71	Bridgeman, P.W.	1933		193-347		Swaged rod supplied by P.H. Brace, Westinghouse Electric and Manufacturing Co.; spectroscopic examination by Martin Grahm show only a "doubtful trace of magnesium"; resistivity values calculated from reported $R(T)/R(273 K)$ with $\rho(273 K) = 11.687 \times 10^{-6} \Omega \cdot m$.
160 31	Rapp, Ö., Benediktsson, G., Aström, H.U., Arajs, S., and Rao, K.V.	1978	A	300.2-315.0	Cr(1)	Specimen material same as for Data Set 100; approximate dimensions 0.1 mm thick, 1 mm wide and 20 mm long; spark cut from arc-melted ingot, etched in HCl, placed in silica tube, flushed with helium, evacuated to about 0.1 Torr and encapsulated; annealed at 1250 K for 100 h, and water quenched; etched again in HCl to the suitable dimensions; data reported as ratio of ρ to the ρ at the Néel temperature, value at Néel temperature not reported; measured with increasing temperature at $\sim 1 K \cdot hr^{-1}$; resistivity values calculated from reported resistance ratios and an assumed $\rho(300.23 K) = 12.655 \times 10^{-6} \Omega \cdot m$; because of graph reading difficulties, not all data points are included.
161 31	Rapp, Ö., et al.	1978	A	300.1-313.5	Cr(2)	Similar to the above except approximate dimensions 1 mm thick, 1 mm wide and 20 mm long, and annealed at 1250 K for 24 h and furnace-cooled in 12 h; T_N determined from a power law fit to $\rho^{-1} \propto d\rho/dT$ 310.79 K; resistivity value calculated from reported resistance ratio and an assumed $\rho(300.07 K) = 12.651 \times 10^{-6} \Omega \cdot m$.
162 31	Rapp, Ö., et al.	1978	A	304.2-313.4	Cr(3)	Similar to the above except approximate dimensions 1 mm thick, 1 mm wide and 15 mm long, and annealed at 1250 K for 100 h and furnace-cooled in 24 h; "thermally cycled before measurement;" T_N determined by same method as above 310.77 K; resistivity values calculated from reported resistance ratio and an assumed $\rho(304.15 K) = 12.733 \times 10^{-6} \Omega \cdot m$.
163* 72	Clinard, F.W. and Kemper, C.P.	1968	A	4-300		0.3 O, <0.002 N and H each by chemical analysis; <0.03 Zn and <0.01 K by spectrographic analysis; polycrystalline specimen; 0.25 in. in diameter and 1 in. long; annealed; resistivity values calculated from reported equations: $\rho = 0.1 + 1.58 \times 10^{-6} T^3$; $\rho_2 = 0.1 + 1.58 \times 10^{-6} T^3$ for $T < 109.5$ K, and $\rho = -1.08 + \left(\frac{C}{M\theta}\right) \times \left(\frac{1}{\theta}\right)^5 \int_{\theta}^{T_f} \frac{dx}{(e^x - 1)(1 - e^{-x})} \quad \text{with } \theta = 357 \text{ K and } C = 1.43 \times 10^{-6} \quad (M = \text{atomic weight}).$

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr

[Temperature, T; Electrical Resistivity, ρ , $10^{-8} \Omega \text{m}$]

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 1*</u>															
<u>DATA SET 6</u>															
2.35	25.9	293	14.1	1753	112.8	1723	116.9	1793	120.7	1813	117.5				
4.2	26.2	323	15.3	1763	113.8	1733	117.3	1803	121.1	1823	117.9				
20.6	26.7	373	17.5	1773	114.7	1743	117.8	1813	121.6	1833	118.5				
83	29.2	423	19.7	1783	115.8	1753	118.8	1823	122.0	1843	119.0				
290	43.8	473	22.1	1793	117.0	1763	118.8	1833	122.5	1853	119.5				
<u>DATA SET 2*</u>															
2.20	26.5	673	32.0	1833	120.5	1803	120.7	1873	124.2	1893	122.0				
3.01	26.6	723	34.8	1843	121.1	1813	121.2	1883	124.7	1903	122.7				
4.2	26.7	773	37.6	1853	121.8	1823	121.7	1893	125.1	1913	123.5				
20.6	27.0	823	40.4	1863	122.8	1833	122.1	1903	125.6	1923	124.3				
83	28.8	873	43.3	1873	123.8	1843	122.6	1913	126.1	1933	125.2				
290	43.8	923	46.1	1883	124.7	1853	123.0	1923	126.5	1943	126.0				
<u>DATA SET 3*</u>															
20.6	0.90	1023	51.8	1903	126.6	1873	123.8	1963	127.6	1973	128.5				
80	2.01	1073	54.9	1913	127.5	1883	124.3	1973	128.5						
292	17.2	1123	58.5	1923	128.5	1893	124.7								
<u>DATA SET 4</u>															
2.25	0.79	1223	65.6	1943	130.5	1913	125.6	1563	101.4	1563	105.1				
4.2	0.79	1273	69.5	1953	131.5	1923	126.2	1573	102.4						
20.6	0.80	1323	73.6	1963	132.5	1933	126.8	1583	103.3	1573	106.5				
80	2.01	1373	77.4	1973	133.5	1943	127.5	1593	104.3	1583	107.5				
293	17.2	1423	81.8	1983	134.5	1953	128.2	1603	105.2	1593	108.5				
<u>DATA SET 5*</u>															
1373	17.501	1583	96.9	2023	139.5	2033	140.9	1643	109.0	1643	110.4				
43.251	48.996	1613	99.6	2043	141.3	2053	142.7	1654	110.3	1673	110.3	1663	113.6	111.2	
373	48.996	1623	100.7	2063	144.1	2073	145.5	1663	111.7	1683	112.2	1633	112.6	112.2	
473	55.006	1633	101.6	2083	145.5			1673	112.9	1693	114.4	1683	114.9	114.9	
573	22.002	1643	102.6	2103	146.2			1683	114.2	1703	112.0	1693	115.4	115.4	
673	32.000	1653	103.6	2103	147.0			1693	115.6	1713	112.6	1703	115.9	115.9	
873	43.251	1663	104.5	2103	147.7			1703	116.5	1723	113.1	1713	116.4	116.4	
973	48.996	1673	105.4	2103	148.3			1713	117.0	1733	113.6	1723	116.8	116.8	
1073	55.006	1683	106.3	2103	149.5			1723	117.5	1743	114.1	1733	117.3	117.3	
1173	61.805	1693	107.2	2103	150.7			1733	118.0	1753	114.6	1743	117.7	117.7	
1273	69.493	1703	108.2	2103	151.8			1743	118.4	1763	115.1	1753	118.2	118.2	
1373	77.519	1713	109.4	2103	152.9			1753	118.9	1773	115.6	1763	118.6	118.6	
1473	86.130	1723	110.0	2103	154.0			1763	119.3	1783	116.0	1773	119.0	119.0	
1573	95.969	1733	110.9	2103	154.9			1773	119.8	1793	116.5	1783	119.4	119.4	
1673	105.374	1743	111.9	2103	155.9			1783	120.2	1803	116.9	1793	119.9	119.9	

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM (continued)

Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 26(cont.)</u>														
2002	98.5	143	5.1	312	12.6	310.8	13.58*	307.9	13.86	311.5	13.23			
2015	95.4	146	5.4	318	12.5	311.3	13.58*	309.1	13.83	313.2	13.28			
2049	101.0	148	5.5	325	12.7	312.6	13.61*	310.0	13.79	314.9	13.35			
2065	99.9	154	5.8	341	13.2	314.0	13.67*	310.6	13.75	316.8	13.42			
2103	102.3	160	6.2	347	13.5	315.1	13.69	311.3	13.68	320.0	13.55			
2103	110.2	183	7.5	357	13.8	316.1	13.75*	312.1	13.68	323.0	13.67			
2146	111.4	186	7.7	369	14.2	318.3	13.83*	313.2	13.70	326.3	13.79			
2194	113.6	189	7.9	377	14.5	320.2	13.88*	317.2	13.86	327.6	13.84			
						322.9	14.00*	320.2	13.97	329.5	13.93			
<u>DATA SET 27</u>														
1673	80.3	208	9.4	242.9	11.49	326.3	14.15*	322.3	14.06					
2053	100.0	216	9.9	247.4	11.63*	328.7	14.22*	330.8	14.35					
2113	101.5	219	10.1	249.1	11.72*									
2113	108.1	242	11.4	250.8	11.81*									
				251.9	11.86*									
<u>DATA SET 28*</u>														
				253	12.2	243.0	11.48							
				259	12.3	247.2	11.65							
				261	12.5	258.4	12.10*	249.1	11.72	258.0	11.96			
2013	132	277	13.0	260.8	12.20*	260.8	12.20*	250.8	11.81	262.3	12.13			
				281	13.2	264.4	12.36*	251.9	11.84	265.2	12.24			
				285	13.4	266.7	12.45*	254.6	11.95	269.0	12.41			
				288	13.5	268.8	12.52*	258.2	12.12	274.2	12.53			
1084	50.0	293	13.6	272.5	12.66	260.8	12.20	272.5	12.12	273.9	12.55			
1292	59.1	294	13.6	272.1	12.74*	264.4	12.36	264.4	12.36	278.6	12.70			
1501	68.9	297	13.7	276.3	12.83*	266.5	12.45	278.8	12.52	281.2	12.79			
1702	79.6	302	13.9	278.8	12.95*	268.8	12.52	286.7	12.99	286.7	12.98			
1911	89.5	307	13.9	279.7	12.97*	272.5	12.66	289.0	13.07	292.0	13.20			
2051	97.1	310	13.9	281.4	13.03*	273.9	12.74	292.0	13.16	294.1	13.26			
2136	107.5	315	13.8	283.1	13.11*	276.3	12.83	293.9	13.21	296.2	13.31			
2152	108.7	325	14.0	285.8	13.22*	278.8	12.94	295.4	13.25	297.9	13.32			
2214	112.5	334	14.2	289.0	13.34*	279.7	12.97	296.9	13.26	299.0	13.34			
2261	113.6	337	14.5	290.9	13.40*	281.1	13.04	298.1	13.28	300.2	13.35			
				337	14.5	291.8	13.44*	283.0	13.11	299.2	13.30			
<u>DATA SET 30*</u>														
				379	16.0	292.6	13.46	285.8	13.22	300.3	13.28			
				401	17.0	296.2	13.60*	288.8	13.32	301.3	13.28			
						299.6	13.72*	290.5	13.40	301.9	13.26			
<u>DATA SET 31*</u>														
						301.3	13.77*	291.8	13.44	303.0	13.23			
						302.4	13.79*	292.6	13.46	303.4	13.20			
						303.8	13.82*	296.2	13.61	303.9	13.14			
78	1.7	275	11.6	305.3	13.83*	299.2	13.73	304.3	13.09	306.0	13.11			
105	2.0	285	12.1	306.2	13.83*	300.9	13.78	304.7	13.07	306.8	13.12			
108	3.2	291	12.3	307.0	13.80*	302.1	13.82	305.1	13.03	308.5	13.21			
114	3.6	293	12.3	308.3	13.78*	303.6	13.86	306.0	13.04	310.2	13.28			
121	4.1	298	12.3	309.6	13.75*	304.9	13.86	307.0	13.06	313.0	13.37			
127	4.3	301	12.5	310.0	13.68*	306.2	13.88	308.5	13.12	317.2	13.54			
133	4.6	306	12.6	310.6	13.63*	307.2	13.86	310.2	13.18	321.0	13.68			
										326.3	13.87			

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	p	T	p	T	p	T	p	T	p	T	p	T	p
<u>DATA SET 37*</u>		<u>DATA SET 37 (cont.)*</u>		<u>DATA SET 38 (cont.)*</u>		<u>DATA SET 38*</u>		<u>DATA SET 39 (cont.)*</u>		<u>DATA SET 39*</u>		<u>DATA SET 40 (cont.)*</u>	
242.8	11.24	320.8	13.25	317.2	13.18	311.7	12.74	310.0	12.38	243.0	10.40		
247.0	11.39	322.7	13.30	321.0	13.31	314.3	12.85	312.1	12.48	249.1	10.60		
251.0	11.56	324.2	13.37	325.1	13.49	316.0	12.90	316.2	12.66	252.1	10.68		
252.3	11.61	327.2	13.50	329.1	13.63	318.3	13.00	316.9	12.78	255.3	10.77		
255.1	11.70	329.3	13.59			321.1	13.12	321.1	12.89	259.1	10.85		
256.1	11.75	331.4	13.68			323.8	13.23	323.6	13.00	264.0	10.95		
259.3	11.86					325.9	13.31	325.3	13.08	266.1	10.99		
262.1	11.98					327.4	13.39	326.4	13.14	267.0	10.99		
263.8	12.04					330.0	13.49	328.0	10.99				
264.6	12.08	242.8	11.24	251.3	11.32	331.2	13.56	329.1	10.99				
267.4	12.18	267.0	11.39	254.2	11.44	324.2	10.80	270.2	10.97				
269.1	12.23	251.0	11.56	258.3	11.61	260.2	11.68	271.0	10.96				
271.6	12.31	252.3	11.60	262.1	11.75	264.3	10.82	272.1	10.93				
273.5	12.37	254.9	11.71	266.2	11.84	268.3	10.92	272.7	10.91				
275.4	12.43	255.9	11.73	268.9	11.84	270.0	10.99	273.1	10.88				
278.0	12.51	259.1	11.87	266.1	11.90	266.8	10.91	273.6	10.86				
280.5	12.57	262.1	11.98	269.9	12.03	248.3	10.99	273.8	10.80				
283.1	12.65	263.6	12.04	273.1	12.14	250.0	11.05	273.8	10.76				
284.1	12.67	264.6	12.09	275.0	12.20	252.7	11.15	274.4	10.74				
287.1	12.75	267.4	12.17	277.1	12.26	253.6	11.20	275.0	10.74				
289.2	12.78	268.9	12.22	278.0	12.28	256.6	11.32	264.2	11.43				
290.9	12.80	271.6	12.31	279.0	12.31	260.2	11.43	268.0	11.66				
292.2	12.81	273.3	12.38	281.2	12.37	264.2	11.56	271.4	11.71				
293.3	12.83	275.4	12.43	282.9	12.41	268.0	11.66	282.3	11.77				
294.1	12.84	278.0	12.51	284.1	12.43	271.2	11.71	275.0	11.77				
294.9	12.84	280.5	12.66	285.6	12.43	273.1	11.72	275.9	10.77				
296.0	12.81	283.1	12.66	288.6	12.46	274.1	11.72	277.1	11.79				
296.9	12.81	284.1	12.67	290.1	12.46	275.0	11.72	279.7	11.77				
297.7	12.81	286.9	12.78	291.1	12.46	275.9	11.75	281.4	11.75				
298.8	12.79	288.8	12.80	291.6	12.46	277.1	11.75	282.4	11.68				
299.0	12.76	290.1	12.83	292.4	12.46	278.0	11.73	283.1	11.61				
299.4	12.74	291.8	12.84	293.3	12.43	279.1	11.73	283.7	11.54				
299.8	12.69	293.0	12.87	294.1	12.38	280.3	11.70	284.6	11.52				
300.3	12.66	294.1	12.87	294.3	12.32	281.0	11.68	285.0	11.54				
300.5	12.61	294.9	12.89	294.5	12.27	281.6	11.63	286.5	11.60				
300.7	12.56	296.0	12.89	294.7	12.23	282.9	11.58	287.8	11.65				
301.3	12.55	297.1	12.89	295.2	12.20	283.3	11.53	289.9	11.73				
302.2	12.56	298.6	12.84	296.4	12.20	283.3	11.48	293.1	11.83				
303.2	12.59	299.8	12.75	296.9	12.23	283.9	11.46	296.7	12.00				
304.1	12.61	300.5	12.70	297.1	12.26	285.2	11.48	300.9	12.15				
305.1	12.64	300.9	12.65	298.1	12.26	286.5	11.53	306.0	12.33				
307.7	12.71	301.3	12.60	300.1	12.34	289.0	11.60	312.1	12.60				
309.0	12.78	302.2	12.62	303.7	12.45	293.1	11.73	316.0	12.76				
313.8	12.94	303.9	12.69	305.1	12.50	295.0	11.82	321.1	12.98				
315.5	13.02	305.1	12.74	307.1	12.57	297.9	11.93	326.4	13.14				
317.7	13.08	308.1	12.84	309.2	12.65	303.7	12.13	327.4	13.14				
319.6	13.17	312.4	12.99	310.9	12.70	307.1	12.28	328.1	13.17				

* Not shown in figure.

DATA SET 41*

243.0	10.78
244.3	10.82
246.6	10.92
248.3	10.99
250.0	11.05
253.0	11.16
253.6	11.20
256.6	11.32
260.0	11.43
268.0	11.66
271.4	11.71
273.1	10.88
275.0	10.97
275.9	10.77
278.0	10.82
280.1	10.91
282.3	10.96
285.0	11.06
287.1	11.14
290.1	11.25
293.5	11.37
295.8	11.47
298.8	11.58
300.9	11.66
304.1	11.77
309.0	11.95
314.1	12.17
320.6	12.46
323.0	12.59
325.1	12.66

DATA SET 43*

243.0	10.30
247.5	10.44
251.5	10.55
255.7	10.60
257.4	10.69
259.5	10.73
261.4	10.77
264.4	10.82
267.5	10.86
270.5	10.91
273.1	10.99
275.9	11.05
278.0	11.16
280.1	11.25
282.3	11.37
285.0	11.47
287.1	11.58
290.1	11.66
293.5	11.77
295.8	11.86
298.8	11.95
300.9	12.05
304.1	12.15
309.0	12.25
314.1	12.35
320.6	12.46
323.0	12.59
325.1	12.66

TABLE 3.
EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM
(continued)

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM (continued)

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
DATA SET 71 (cont.)*													
118.6	2.66	122.3	3.012	108.7	2.186	120.7	2.766	126.1	3.020	123.6	2.888		
119.3	2.70	122.8	3.025	110.8	2.270	121.3	2.783	126.7	3.074	123.8	2.897		
120.2	2.75	123.8	3.058	112.7	2.362	122.3	2.802	128.3	3.172	124.2	2.918		
121.3	2.80	124.3	3.098	113.8	2.409	121.5	2.813	131.6	3.340	124.9	2.950		
121.6	2.84	125.3	3.160	114.7	2.452	121.8	2.831	135.3	3.390				
122.0	2.86	126.2	3.208	116.2	2.535	122.4	2.860	136.4	3.655				
122.6	2.87	129.0	3.387	117.3	2.587	123.3	2.901	137.6	3.742	111.93			
123.1	2.89	129.6	3.417	119.1	2.668	124.0	2.940	140.4	3.919	281.7			
123.6	2.90	130.8	3.500	120.2	2.741	124.6	2.969			292.3			
123.9	2.92	131.6	3.546	120.5	2.765	124.9	2.987			298.7			
124.4	2.95	132.5	3.616	121.3	2.784					302.0			
125.2	3.00	133.5	3.672	121.7	2.834					305.4			
125.9	3.03	135.3	3.787	122.6	2.834					307.1			
126.8	3.08	135.9	3.873	123.2	2.904	100.8	1.812	117.6	2.563	12.60			
127.8	3.15	136.9	3.916	124.1	2.956	101.7	1.848	117.7	2.558	12.61			
129.4	3.25	138.0	4.000	125.0	2.983	102.7	1.889	118.1	2.587	12.57			
130.1	3.29	139.1	4.080	125.8	3.036	104.1	1.944	118.2	2.593	311.0			
131.8	3.40	140.3	4.171	126.5	3.084	105.1	1.987	118.4	2.607	311.4			
132.8	3.46			127.4	3.133	105.9	2.014	118.6	2.613	311.6			
133.7	3.52			128.5	3.197	106.6	2.050	118.7	2.621	311.7			
135.1	3.60			129.8	3.298	107.4	2.077	119.1	2.642	312.5			
135.8	3.66	116.3	2.669	131.4	3.403	108.0	2.110	119.2	2.650	313.3			
136.9	3.74	116.8	2.699	133.3	3.504	108.7	2.138	119.5	2.662	314.2			
138.3	3.82	117.3	2.722	135.4	3.665	109.3	2.162	119.6	2.673	315.5			
138.8	3.87	118.2	2.770	137.7	3.825	110.3	2.200	119.8	2.678	318.0			
140.1	3.95	118.9	2.819	139.5	3.965	111.1	2.240	119.9	2.684	319.9			
141.7	4.07	119.3	2.834	140.4	4.028	112.0	2.280	120.0	2.692	328.7			
144.5	4.25	119.9	2.876			112.5	2.305	120.1	2.699				
		120.3	2.909			113.1	2.336	120.3	2.705				
		120.8	2.928			113.5	2.357	120.5	2.717				
		121.3	2.943			114.2	2.383	120.6	2.724				
100.8	1.976	121.7	2.961	117.0	2.576	114.6	2.410	120.7	2.770	3.03	0.135		
102.4	2.043	122.3	2.980	117.4	2.590	115.4	2.453	120.9	2.773	4.08	0.150		
105.0	2.153	122.6	3.004	117.9	2.615	116.5	2.503	121.1	2.778	4.08	0.144		
108.0	2.280	122.7	3.020	118.2	2.634	117.8	2.565	121.3	2.785	5.38	0.135		
111.5	2.440	123.4	3.050	118.5	2.652	118.6	2.611	121.4	2.791	5.49	0.153		
113.2	2.520	123.9	3.083	118.9	2.673	119.6	2.670	121.6	2.803	9.74	0.147		
114.2	2.558			119.4	2.695	120.6	2.724	121.7	2.815	10.8	0.153		
115.3	2.608			119.6	2.708	121.2	2.742	121.8	2.820	18.7	0.166		
116.2	2.670			119.8	2.722	121.7	2.780	121.9	2.820	21.1	0.159		
117.1	2.716	100.8	1.775	119.9	2.741	122.4	2.812	122.1	2.822	27.8	0.173		
118.5	2.769	101.8	1.891	120.0	2.741	122.4	2.855	122.1	2.825	43.8	0.224		
119.7	2.854	102.6	1.924	120.2	2.742	123.1	2.868	122.5	2.836	53.4	0.357		
121.0	2.910	104.0	1.976	120.3	2.743	123.8	2.900	122.9	2.858	63.8	0.474		
121.4	2.948	105.7	2.046	120.4	2.745	124.8	2.946	123.1	2.868	66.4	0.604		
121.8	2.993	107.2	2.110	120.5	2.747	125.4	2.986	123.4	2.877	76.3	0.941		

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	p	T	p	T	p	T	p	T	p	T	p	T	p
DATA SET 79(cont.)		DATA SET 81(cont.)*		DATA SET 82(cont.)		DATA SET 86*		DATA SET 90(cont.)*		DATA SET 91(cont.)*		DATA SET 91(cont.)*	
94.9	1.56	180	6.830	1764	82.6	1469	70.7	239.7	11.54	311.0	13.98		
118	2.64*	190	7.480	1829	84.4	1520	74.0	244.3	11.78	313.9	14.05		
140	4.03	200	8.130	1844	86.1	1545	75.5	249.9	12.09	318.7	14.15		
162	5.46	210	8.805	1900	89.2	1570	77.4	254.6	12.31	323.0	14.33		
201	8.01	220	9.460	1939	93.1	1603	79.2	259.3	12.48				
250	11.3	230	10.125	1967	97.1	1633	81.3	265.9	12.80				
282	12.2	240	10.755	1973	99.3	1693	85.1	269.6	12.99				
343	13.3	250	11.325					274.3	13.14				
		260	11.895					279.0	13.33				
		270	12.385					284.6	13.48				
		280	12.840	391	12.8	285.4	14.16	290.3	13.62	215.3	10.33*		
		290	13.230	498	16.3	289.1	14.27	295.0	13.67	224.7	10.93*		
		300	13.480	595	20.1	292.9	14.38	300.7	13.74	228.4	11.13		
		310	13.560	692	24.7	298.3	14.47	305.4	13.84	232.1	11.34*		
		320	13.745	800	29.3	303.4	14.52	308.2	13.87	239.6	11.68*		
		330	14.110	967	36.9	308.6	14.47	310.1	13.89	243.4	11.88*		
		340	14.460	1075	42.4	311.6	14.40	312.0	13.94	248.0	12.14*		
		350	14.830	1092	43.2	313.5	14.40	315.8	13.99	255.5	12.43*		
		360	15.190	1231	51.6	318.7	14.56	319.6	14.13	259.3	12.60*		
				1371	60.6	323.6	14.77	325.2	14.33	262.1	12.72		
		19.6	0.197	1469	66.1			330.8	14.47	265.9	12.87*		
		21.3	0.198	1564	71.6			334.6	14.67	273.3	13.23*		
		25.9	0.205	1628	75.0			340.2	14.86	275.2	13.31*		
		32.9	0.227	1750	82.5	281.9	16.40	346.8	15.06	280.9	13.43*		
		48.0	0.313	1850	90.0	288.2	16.56	350.5	15.27	286.5	13.57*		
		62.1	0.530	1905	97.3	293.1	16.70	358.1	15.47	289.3	13.67*		
		77.3	1.01	661	24.7	298.3	16.79	363.7	15.76	295.0	13.79*		
		82.0	1.14	757	29.1	303.5	16.74	369.3	15.93	299.7	13.84*		
		90.6	1.55	765	29.9	308.6	16.53	375.9	16.19	304.5	13.84		
		115	2.05	835	33.1	313.5	16.63	381.5	16.39	307.3	13.79*		
		168	6.27	849	33.8	318.7	16.83	388.1	16.70	310.2	13.70*		
		221	9.60	126	37.3	387	65.3	323.6	17.06	393.7	16.83		
		235	11.10	939	37.9	1443	69.1			397.5	17.07		
		286	13.00	1025	42.6	1498	72.5			405.9	17.33		
				1047	43.2	1560	76.5			411.5	17.60		
		1165	49.5	1614	79.8	77	0.8	414.4	17.70				
		1284	55.6	1664	83.0								
		1360	61.5	1704	85.5								
				1724	86.7								
		90	1.495	1460	67.5	198.5	9.48	283.0	13.51				
		100	1.935			207.9	9.89	287.9	13.63	161.2	14.72*		
		110	2.415	1402	63.9	214.4	10.21	292.3	13.71	143.1	14.77*		
		120	2.935			218.1	10.50	298.0	13.79	148.7	14.96		
		130	3.515	1510	70.3	1482	71.4	224.7	10.69	303.7	13.87*		
		140	4.190	1562	71.9	1511	73.5	230.3	11.00	305.7	13.91		
		150	4.870	1574	73.7	1651	82.4	234.0	11.30	308.6	13.93		
		160	5.515	1652	77.4	1682	84.3	1740	87.9				
		170	6.170	1740	80.8								

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 92 (cont.)</u>																			
400.3	17.04	310.1	12.40	56.0	1.26	300.1	12.86	204	8.20	123.6	3.22								
405.0	17.24*	310.4	12.38	59.4	1.32	301.4	12.88	216	9.02*	132.1	3.65								
408.7	17.46*	310.8	12.38	65.4	1.49	302.7	12.90	226	9.59*	149.1	4.50								
414.3	17.72*	311.2	12.38	72.7	1.63	303.9	12.90	237	10.39*	157.6	4.93								
424.7	18.13	311.7	12.39	78.7	1.85	305.2	12.91	248	11.01	174.6	5.79								
		312.3	12.40	79.8	1.90	306.0	12.92	260	11.69*	183.1	6.64								
		312.7	12.41	89.2	2.26	306.9	12.92	271	12.26*	191.6	7.50								
		313.0	12.41	101	2.76	308.2	12.92	282	12.77	204.4	8.14								
283.8	13.57	313.6	12.44	110	3.23	309.0	12.91	291	13.05*	217.2	9.00								
288.1	13.68	314.8	12.47	114	3.40	209.5	12.88	297	13.24*	225.7	9.64								
293.3	13.79	316.1	12.50	133	4.47	209.8	12.85			238.4	10.28								
296.3	13.84	318.5	12.58	136	4.64	309.9	12.80			251.2	10.93								
297.7	13.86	321.8	12.68	143	5.08	310.1	12.76			264.0	11.57								
305.0	13.82	323.8	12.77	149	5.33	310.4	12.74			300.3	13.29								
305.9	13.78	327.5	12.94	151	5.49	311.1	12.74			301.4	13.31								
306.4	13.75	152	5.60	311.7	12.76	302.5	13.33			298.0	13.07								
307.4	13.70	156	5.84	311.9	12.67	304.3	13.36			302.3	13.28								
308.8	13.80	163	6.23	314.1	12.73	305.3	13.37			306.3	13.07								
309.8	13.73	168	6.57	316.1	12.80	306.3	13.38			319.4	13.07								
310.7	13.79	173	6.84	319.7	12.93	307.7	13.38			327.9	13.50								
313.6	13.89	179	7.17	325.0	13.13	308.6	13.38			336.4	13.93								
318.0	13.98	184	7.45	330.1	13.30	309.6	13.37			349.2	14.14								
323.2	14.15	78	1.635	189	7.78	310.2	13.36			349.2	14.36								
		195	8.11			311.0	13.34			362.0	14.79								
						311.3	13.31			374.8	15.22								
						311.9	13.29			387.5	15.64								
						312.2	13.27			400.3	16.07								
						313.0	13.27					417.4	16.72						
						313.4	13.28					434.4	17.36						
						314.2	13.30					451.5	17.79						
						315.9	13.35					460.0	18.65						
						317.4	13.40					481.2	19.50						
						317.8	13.41					498.3	20.36						
												511.1	20.79						
												540.9	22.08						
												562.2	22.93						
												592.0	24.43						
												604.7	25.29						
												630.3	26.36						
												664.3	27.86						
												685.6	28.93						
												719.7	30.43						
												749.5	31.93						
												787.8	33.86						
												813.3	35.57						
												847.4	37.29						

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
DATA SET 102 (cont.)		DATA SET 104 (cont.)*		DATA SET 106 (cont.)		DATA SET 107 (cont.)*		DATA SET 109 (cont.)*		DATA SET 112									
885.7	38.57	303.8	13.81	850.4	39.30	318.3	13.86	311.5	12.91	295.9	12.366								
915.5	40.71	307.7	13.71	944.8	45.38	319.6	13.86	315.3	12.91	299.9	12.430								
949.6	42.00	310.6	13.71	982.7	47.41	320.2	13.99	320.4	12.79	304.7	12.506								
979.4	43.71	313.5	13.52	1046	51.21	327.3	14.25	328.1	12.92	306.2	12.518								
1004.9	45.00	318.4	13.71	1121	55.51	332.5	14.44	330.6	13.17	307.7	12.531								
1034.7	46.71	335.8	16.37	1235	62.86	323.5	16.37	335.7	13.30	308.8	12.531								
298.6	13.00*	359.1	15.12	127*	65.64	DATA SET 108*		339.5	13.42	309.9	12.506								
368.6	14.52	20	0.10	1543	83.62	122.8	2.98	347.2	13.68	311.0	12.381								
460.7	18.15	77	0.83	1575	85.90	135.0	3.50	351.0	13.81	312.5	12.381								
560.0	22.38	273	12.49	1587	86.91	145.6	4.47	356.1	14.06	312.9	12.406								
641.0	26.31	722.0	29.93	1612	88.68	182.4	6.93	300	14.4	315.1	12.482								
795.5	33.85	795.5	33.85	1637	90.46	208.7	8.59	400	19.2	315.8	12.482								
861.8	37.17	93.5	1.29*	1675	93.24	238.5	10.43	500	24.0	317.0	12.507								
953.7	42.00	112.5	2.05	1688	94.00	256.3	11.49	600	28.8	318.1	12.558								
1042.0	46.82	125.1	2.81*	1700	94.51	278.9	12.80	700	33.6	322.5	12.709								
1111.9	51.04	150.3	4.07	1707	95.52	283.9	13.07	800	38.4	327.7	12.860								
1181.8	54.96	162.9	5.09*	1747	96.52	294.7	13.24	900	43.231	332.8	13.037								
1236.9	57.97	169.1	6.35	194.3	7.36	273.2	12.77	1000	48.124	338.0	13.239								
1281.1	60.39	213.2	8.38*	213.2	8.38*	288.0	13.41	301.7	13.51	343.5	13.403								
DATA SET 104*		219.5	9.14	221.2	9.90*	329.8	13.94	308.7	13.50	344.3	13.491								
76.9	1.04	244.8	10.66	294.4	13.60	319.2	13.50	1100	53.079	DATA SET 110*									
83.6	1.13	251.0	11.16*	294.4	13.73	324.5	13.68	1200	58.096	315.1	12.482								
90.4	1.32	269.9	12.18*	296.4	13.73	329.8	13.94	1300	63.175	317.0	12.507								
100.1	1.70	276.2	12.68*	298.3	13.80	329.5	13.67	1400	68.316	322.5	12.709								
113.7	2.46	295.2	13.19	300.2	13.80	164.8	5.44	1500	73.519	327.7	12.860								
131.2	3.59	301.4	13.70*	301.5	13.86	188.6	6.82	1600	78.784	332.8	13.037								
146.7	4.63	307.7	14.20*	302.8	13.86	196.1	7.33	1700	84.111	338.0	13.239								
166.1	5.96	307.8	13.70	304.1	13.86	204.3	8.09	1800	89.500	343.5	13.403								
182.6	7.09	326.8	14.21*	304.7	13.93	214.5	8.60	1400	73.519	287.0	12.152								
200.1	8.23	339.4	14.46	306.4	13.86	224.7	9.23	1500	78.784	291.8	12.290								
224.3	9.93	345.7	14.91*	307.3	13.86	237.4	9.87	1600	84.111	295.1	12.391								
242.8	10.98	364.6	15.73	308.0	13.93	248.9	10.62	1700	89.500	309.2	12.480								
257.3	11.83	389.9	16.49	309.2	13.86	260.4	11.13	1800	89.500	314.3	12.581								
266.0	12.20	396.2	17.00*	311.2	13.86	270.6	11.51	1900	93.519	287.0	12.152								
277.8	12.68	415.2	17.51	312.5	13.86	280.8	12.15	2000	98.519	309.2	12.581								
281.6	12.96	440.4	18.77	312.5	13.74	287.2	12.27	2100	103.519	314.3	12.581								
287.4	13.24	560.3	24.35	313.1	13.74	292.3	12.40	2200	108.519	314.3	12.581								
291.2	13.53	610.8	26.88	313.8	13.74	296.1	12.65	2300	113.519	314.7	12.608								
297.1	13.62	673.8	30.43	315.1	13.80	301.2	12.66	2400	118.519	315.8	12.608								
300.9	13.71	781.0	35.75	316.4	13.86	307.6	12.91	2500	123.519	316.9	12.633								

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 113 (cont.)</u>																			
317.7	12.658	277.1	12.109	284.8	12.954	302.3	12.594	294.6	12.764	306.1	12.891								
322.5	12.809	282.4	12.307	289.8	12.916	305.1	12.611	294.8	12.768	306.4	12.889								
327.6	12.948	286.4	12.660	292.1	12.901	307.2	12.634	295.0	12.774	306.8	12.888								
332.4	13.087	292.4	12.610	294.9	12.883	309.9	12.659	295.3	12.776	307.1	12.886								
338.0	13.276	294.0	12.669	297.4	12.863	299.9	12.857	295.8	12.780	307.4	12.882								
350.2	13.667	300.5	12.789	302.4	12.833	304.9	12.810	296.0	12.789	307.6	12.879								
<u>DATA SET 114</u>																			
304.5	12.633	311.8	12.632	310.2	12.751	279.7	12.502	296.5	12.800	308.3	12.873								
305.4	12.648	312.0	12.646	312.8	12.661	284.6	12.522	296.8	12.804	308.6	12.867								
307.1	12.665	305.4	12.837	307.8	12.829	274.4	12.471	297.0	12.808	308.9	12.862								
308.1	12.662	309.0	12.662	320.1	12.906	269.9	12.879	297.7	12.502	297.2	12.813	309.2	12.855						
309.7	12.625	311.8	12.632	310.2	12.751	289.7	12.551	297.5	12.795	308.1	12.875								
310.1	12.620	<u>DATA SET 117</u>		284.8	12.816	292.2	12.562	297.2	12.813	309.2	12.855								
310.8	12.600	317.5	12.818	317.5	12.818	295.0	12.574	297.5	12.816	309.3	12.851								
311.1	12.497	271.5	12.274	292.3	12.790	297.3	12.591	297.7	12.818	309.5	12.847								
311.7	12.497	277.4	12.453	294.8	12.796	297.3	12.605	297.9	12.822	309.6	12.842								
312.1	12.514	282.4	12.610	297.4	12.795	279.7	12.571	299.4	12.826	309.7	12.837								
312.6	12.520	290.0	12.804	299.9	12.781	284.6	12.577	299.6	12.850	309.9	12.835								
312.6	12.523	294.5	12.888	302.4	12.781	290.1	12.599	299.9	12.852	310.3	12.830								
313.0	12.540	300.5	12.954	304.9	12.775	307.7	12.751	292.2	12.605	300.1	12.854	310.0	12.826						
314.1	12.577	305.4	12.947	310.0	12.751	296.5	12.611	300.4	12.859	310.5	12.796								
315.1	12.620	308.0	12.917	312.5	12.727	297.3	12.619	300.9	12.863	310.6	12.792								
316.1	12.646	310.4	12.837	312.5	12.701	302.3	12.648	301.2	12.866	310.6	12.790								
<u>DATA SET 115</u>																			
<u>DATA SET 118</u>																			
305.0	12.519	275.2	11.769	274.9	12.808	309.9	12.696	299.0	12.838	310.0	12.819								
306.0	12.539	277.6	11.871	279.9	12.790	<u>DATA SET 125</u>		299.2	12.843	310.2	12.819								
306.8	12.554	280.7	12.010	284.7	12.778	<u>DATA SET 123</u>		279.7	12.571	299.4	12.845	310.2	12.815						
308.0	12.551	287.3	12.270	289.8	12.764	<u>DATA SET 124</u>		274.7	12.665	299.6	12.850	310.3	12.810						
309.0	12.562	293.1	12.464	294.8	12.749	<u>DATA SET 122</u>		279.5	12.671	303.0	12.884	310.7	12.775						
309.1	12.534	297.3	12.592	299.6	12.743	<u>DATA SET 125</u>		284.6	12.671	303.4	12.884	310.8	12.766						
309.9	12.517	302.1	12.705	304.7	12.736	<u>DATA SET 123</u>		289.7	12.668	303.6	12.886	310.8	12.762						
310.5	12.500	306.8	12.756	307.2	12.728	<u>DATA SET 124</u>		294.5	12.668	303.8	12.887	310.9	12.756						
311.0	12.383	308.0	12.753	310.4	12.738	<u>DATA SET 122</u>		299.6	12.677	304.1	12.888	310.9	12.752						
311.4	12.372	310.9	12.716	304.6	12.688	<u>DATA SET 125</u>		301.9	12.873	310.7	12.785								
311.7	12.377	310.9	12.716	307.4	12.696	<u>DATA SET 123</u>		302.1	12.876	310.7	12.784								
312.1	12.380	<u>DATA SET 119</u>		284.8	12.477	<u>DATA SET 126</u>		302.4	12.877	310.7	12.780								
312.7	12.395	<u>DATA SET 119</u>		289.7	12.511	<u>DATA SET 126</u>		302.7	12.881	310.7	12.776								
313.0	12.403	269.7	13.098	295.0	12.534	<u>DATA SET 125</u>		274.7	12.665	303.0	12.884	310.7	12.775						
314.2	12.437	275.0	13.040	297.5	12.557	<u>DATA SET 123</u>		293.8	12.749	304.8	12.889	310.9	12.739						
315.3	12.475	279.8	12.004	300.0	12.574	<u>DATA SET 124</u>		296.1	12.753	305.5	12.890	311.0	12.722						
316.1	12.503	310.9	12.759	294.3	12.759	<u>DATA SET 125</u>		294.3	12.759	305.8	12.892	311.0	12.711						

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 126 (cont.)</u>															
<u>DATA SET 127 (cont.)</u>															
<u>DATA SET 127 (cont.)</u>															
311.1	12.707	305.0	12.732	311.2	12.671	311.2	3.86	0.10101	277.8	11.938	9.58	0.96180			
311.0	12.700	305.2	12.737	311.3	12.666	4.22	0.10100	282.4	12.225	10.17	0.96180				
311.1	12.698	305.5	12.739	311.5	12.666	4.79	0.10100	287.0	12.225	10.32	0.96184				
311.1	12.696	305.8	12.744	311.7	12.669	5.52	0.10102	289.3	12.416	10.92	0.96170				
311.1	12.693	306.3	12.748	312.0	12.671	6.25	0.10105	291.6	12.416	11.37	0.96167				
311.2	12.687	306.4	12.753	312.2	12.674	6.83	0.10110	298.6	12.606	11.82	0.96180				
311.3	12.685	306.7	12.753	312.5	12.679			300.9	12.606	12.42	0.96180				
311.3	12.681	306.9	12.756	312.7	12.684			305.5	12.510	13.17	0.96202				
311.4	12.676	307.1	12.758	312.8	12.689			310.1	12.605	13.77	0.96210				
311.3	12.675	307.4	12.759	313.0	12.692	4.68	0.861	314.7	12.700	14.68	0.96217				
311.5	12.671	307.7	12.760	313.1	12.698	11.6	0.956	319.4	12.705	15.75	0.96280				
311.6	12.670	307.9	12.762	313.4	12.703	20.8	0.859	321.7	12.891	16.06	0.96343				
311.7	12.670	308.1	12.762	313.7	12.709	20.8	0.955	328.6	13.177						
311.9	12.671	308.4	12.765	313.8	12.716	27.8	0.959								
312.0	12.672	308.6	12.765	314.2	12.726	30.1	0.954								
312.0	12.673	308.9	12.763	314.4	12.732	39.3	0.953								
312.1	12.674	309.1	12.763	314.6	12.737	48.5	1.047	279.7	12.154	2.09	0.86024				
312.4	12.677	309.3	12.763	315.1	12.752	57.8	1.046	282.1	12.229	2.54	0.86021				
312.5	12.680	309.5	12.762	315.4	12.757	69.3	1.333	288.0	12.342	2.83	0.86022				
312.6	12.683	309.6	12.761	315.6	12.765	74.0	1.523	289.2	12.530	3.28	0.86022				
312.7	12.685	309.9	12.761	315.8	12.772	78.6	1.714	293.9	12.568	3.57	0.86018				
312.8	12.689	309.9	12.756	316.1	12.780	90.1	2.001	299.8	12.681	3.87	0.86012				
312.9	12.691	310.0	12.754	316.3	12.788	99.4	2.382	305.6	12.737	5.35	0.86007				
314.0	12.726	310.1	12.753	316.6	12.794	106.3	2.573	310.3	12.699	5.94	0.85997				
314.8	12.741	310.1	12.751	316.8	12.800	111.0	2.764	315.1	12.739	6.53	0.85990				
314.8	12.748	310.3	12.749	317.0	12.808	115.6	3.147	315.1	12.775	6.81	0.85984				
316.7	12.799	310.3	12.747	317.3	12.815	120.2	3.338	319.8	12.906	7.42	0.85980				
317.0	12.806	310.3	12.745	318.3	12.844	129.5	3.719	324.5	13.094	7.57	0.85984				
317.5	12.822	310.4	12.741	318.5	12.852	134.1	4.102	330.4	13.208	8.01	0.85971				
317.7	12.829	310.6	12.739	318.7	12.861	138.8	4.293			9.05	0.85977				
318.0	12.837	310.6	12.735	318.9	12.869	148.0	4.867			9.49	0.85969				
320.1	12.906	310.6	12.732	319.3	12.875	159.6	5.536			10.09	0.85977				
<u>DATA SET 127</u>															
301.4	12.672	310.8	12.720	323.0	1.51	0.10106	1.51	203.7	6.110	4.39	0.96321				
301.6	12.679	310.8	12.716	311.0	1.77	0.10105	1.77	208.3	6.683	4.40	0.96323				
301.9	12.685	310.9	12.709	311.0	1.77	0.10105	1.77	217.6	6.110	5.13	0.96304				
302.1	12.689	311.0	12.703	311.0	2.05	0.10105	2.05	217.6	9.072	7.21	0.96250				
302.4	12.694	311.0	12.694	311.0	2.05	0.10105	2.05	229.1	9.045	7.53	0.96239				
302.6	12.699	311.0	12.692	311.0	2.33	0.10104	2.33	201.3	7.925	5.74	0.96237				
303.1	12.706	311.0	12.686	311.0	2.47	0.10103	2.47	238.4	10.315	7.95	0.96237				
303.3	12.706	311.0	12.681	311.0	2.78	0.10102	2.78	247.7	10.888	8.10	0.96222				
303.6	12.711	311.1	12.677	311.1	3.01	0.10102	3.01	257.0	11.079	8.39	0.96197				
303.8	12.715	311.1	12.674	311.1	3.24	0.10101	3.24	266.2	11.556	8.99	0.96201				
304.7	12.730	311.2	12.673	311.2	3.40	0.10101	3.40	270.8	11.748	9.58	0.96170				

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
DATA SET 133(cont.)													
3.30	0.37245	121.4	1.141	313.9	6.616	311.3	12.816	299.4	12.725	311.8	12.687		
4.20	0.34839	123.9	1.307	317.6	6.722	313.0	12.622	299.9	12.739	311.9	12.661		
4.79	0.18398	126.3	1.426	320.0	6.814	320.8	12.958	301.0	12.777	311.9	12.648		
5.70	0.39417	128.8	1.736	322.5	6.929	326.4	13.151	301.7	12.777	312.9	12.661		
6.45	0.79188	130.0	1.973	328.6	7.067							316.7	12.790
7.07	1.26000	130.6	2.140					302.4	12.790	318.5	12.854		
DATA SET 134													
DATA SET 137													
102.6	1.731	103.2	1.825	101.3	2.378	76.1	0.929	304.0	12.816				
105.3	1.801	105.1	1.966	103.8	2.673	90.1	1.407	305.4	12.841				
106.6	1.895	107.1	2.106	105.0	2.544	99.0	1.794	307.9	12.841				
108.6	1.941	109.6	2.224	106.3	2.639	123.6	3.239	310.0	12.816	295.2	12.609		
111.8	1.968	111.6	2.317	108.8	2.758	175.6	6.376	310.6	12.803	297.1	12.674		
113.8	2.034	113.5	2.411	111.3	2.972	225.3	9.512	311.2	12.790	300.0	12.725		
116.4	2.151	116.7	2.598	113.0	3.091	275.0	12.003	311.4	12.700	303.0	12.751		
119.1	2.291	119.3	2.785	116.9	3.115	311.3	12.764	311.5	12.738	305.2	12.803		
120.4	2.409			118.8	3.138	312.4	12.570	311.7	12.661	307.5	12.841		
124.3	2.572			122.5	3.281	320.8	12.958	312.7	12.635	309.6	12.816		
130.2	2.852			123.8	3.447	327.5	13.151	313.4	12.661	311.8	12.700		
DATA SET 138													
121.3	1.667	125.0	3.566	125.0	3.566	314.6	12.674						
122.0	1.739			129.1	2.077	296.1	12.880	315.2	12.725	299.4	12.545		
124.0	1.788			128.6	2.836	297.5	12.906	315.5	12.738	300.8	12.583		
128.6	1.836			129.9	1.957	299.9	12.930	316.1	12.764	302.1	12.622		
129.9	1.957			110.6	2.651	302.4	12.958	316.5	12.777	303.4	12.661		
131.3	1.957			111.3	2.740	303.1	12.971	316.9	12.803	304.7	12.700		
131.8	2.005			111.9	2.793	304.2	12.971	317.4	12.816	306.1	12.725		
133.8	2.005			115.2	2.865	304.9	12.971	318.0	12.841	307.2	12.738		
135.8	2.101			117.1	3.007	305.5	12.971			308.6	12.751		
139.1	2.078			118.4	3.102	306.5	12.958			309.9	12.751		
140.4	2.294			119.7	3.197	307.4	12.958			310.6	12.751		
141.7	2.391			122.3	3.269	308.3	12.945			311.1	12.738		
145.0	2.511			123.6	3.411	309.2	12.919			311.3	12.725		
148.3	2.559			126.2	3.625	311.3	12.880			311.4	12.712		
150.2	2.632			130.0	3.791	312.3	12.622			311.8	12.648		
152.9	2.704			130.7	3.886	314.1	12.687			311.9	12.635		
152.9	2.704			132.6	4.028	314.9	12.725			312.3	12.635		
DATA SET 139													
287.3	6.609			76.1	0.929	319.6	12.893			317.1	12.816		
290.9	6.655			99.0	1.988			311.1	12.829	318.7	12.84		
295.8	6.701			124.7	3.536			311.5	12.790	320.0	12.906		
303.1	6.746			175.0	6.814			311.5	12.764				
307.9	6.792			225.4	10.041			311.6	12.751				
312.7	6.723			275.6	12.390			311.7	12.725				
DATA SET 140													
DATA SET 139(cont.)													
DATA SET 142													
DATA SET 143													
DATA SET 144													
DATA SET 145(cont.)													
DATA SET 146													
DATA SET 147													

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

DATA SET 149		DATA SET 151(cont.)		DATA SET 153		DATA SET 154 (cont.)		DATA SET 155 (cont.)		DATA SET 157	
T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
299.1	12.725	163.6	5.273	32.5	0.0370	233.2	6.96	232.4	6.58	216.1	6.79
301.8	12.790	168.9	5.494	40.0	0.062	237.6	7.18	236.6	6.82	228.4	7.87
304.4	12.829	174.3	5.716	44.4	0.062	242.9	7.43	240.9	7.07	240.0	8.83
307.0	12.854	178.5	5.852	49.8	0.123	247.1	7.61	247.3	7.23	252.3	9.83
309.6	12.829	183.9	6.049	55.2	0.172	251.4	7.83	252.6	7.48	263.9	10.65
DATA SET 150		193.5	6.209	59.5	0.259	256.7	8.06	256.9	7.70	274.0	11.40
2.4	0.0149	198.9	6.344	63.8	0.370	262.0	8.28	262.2	7.92	280.5	11.87
4.2	0.0149	202.6	6.270	69.1	0.480	266.3	8.50	266.3	8.50	286.3	12.13
20.4	0.0157	207.6	6.209	74.5	0.591	271.6	8.75	275.8	9.02	289.2	12.31
78	0.0939	213.0	6.320	83.1	0.788	284.1	0.899	290.2	1.02	292.1	12.43
DATA SET 151		218.3	6.511	84.1	0.899	295.7	1.252	297.8	1.256	297.8	12.56
9.73	0.0616	221.5	6.677	88.4	1.12	300.0	1.394	300.0	1.394	306.5	12.65
15.1	0.0616	221.0	6.936	93.7	1.26	306.5	1.47	308.6	1.57	310.8	12.51
20.6	0.0616	232.2	7.096	98.0	1.39	308.6	1.57	310.8	1.57	310.8	12.51
24.9	0.0616	232.2	7.096	102.3	1.56	310.9	1.66	310.9	1.66	310.9	12.51
29.2	0.0616	74.5	0.616	144.1	2.66	312.0	1.75	312.0	1.75	312.0	12.51
34.6	0.0862	75.5	0.702	149.4	2.83	312.0	1.84	312.0	1.84	312.0	12.51
40.0	0.123	78.8	0.788	154.7	3.06	312.0	1.93	312.0	1.93	312.0	12.51
45.4	0.148	82.0	0.702	159.0	3.24	312.0	2.02	312.0	2.02	312.0	12.51
48.7	0.172	107.5	1.946	164.3	3.41	312.0	2.11	312.0	2.11	312.0	12.51
55.1	0.259	113.9	2.193	168.6	3.63	312.0	2.20	312.0	2.20	312.0	12.51
59.4	0.370	118.2	2.415	177.1	4.04	312.0	2.29	312.0	2.29	312.0	12.51
63.7	0.456	123.5	2.599	183.5	4.26	312.0	2.38	312.0	2.38	312.0	12.51
70.2	0.616	129.9	2.883	187.7	4.48	312.0	2.47	312.0	2.47	312.0	12.51
73.4	0.727	133.1	3.129	194.2	4.68	312.0	2.56	312.0	2.56	312.0	12.51
77.6	0.899	138.4	3.289	198.4	4.89	312.0	2.65	312.0	2.65	312.0	12.51
84.0	1.121	144.8	3.462	202.7	5.06	312.0	2.74	312.0	2.74	312.0	12.51
89.4	1.281	149.1	3.622	209.1	5.31	312.0	2.83	312.0	2.83	312.0	12.51
93.7	1.528	153.4	3.683	217.6	5.73	312.0	2.92	312.0	2.92	312.0	12.51
100.0	1.749	158.8	3.622	222.9	5.94	312.0	3.01	312.0	3.01	312.0	12.51
104.3	1.971	164.2	3.794	227.7	6.16	312.0	3.10	312.0	3.10	312.0	12.51
108.5	2.242	173.8	4.152	233.2	6.96	312.0	3.19	312.0	3.19	312.0	12.51
113.8	2.550	180.2	4.349	242.9	7.43	312.0	3.28	312.0	3.28	312.0	12.51
120.2	2.821	184.5	4.570	247.1	7.61	312.0	3.37	312.0	3.37	312.0	12.51
124.4	3.043	198.3	5.174	251.4	7.83	312.0	3.46	312.0	3.46	312.0	12.51
128.6	3.351	202.6	5.359	256.7	8.06	312.0	3.55	312.0	3.55	312.0	12.51
134.0	3.622	207.9	5.581	262.0	8.28	312.0	3.64	312.0	3.64	312.0	12.51
139.3	3.868	212.1	5.778	266.3	8.50	312.0	3.73	312.0	3.73	312.0	12.51
144.6	4.139	216.4	5.975	271.3	8.75	312.0	3.82	312.0	3.82	312.0	12.51
148.8	4.447	222.8	6.184	275.8	9.02	312.0	3.91	312.0	3.91	312.0	12.51
156.2	4.780	227.7	6.58	281.6	9.29	312.0	4.00	312.0	4.00	312.0	12.51
159.4	5.002	226.9	6.79	286.3	9.56	312.0	4.09	312.0	4.09	312.0	12.51

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM (continued)

* Not shown in figure.

TABLE 3. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF CHROMIUM Cr (continued)

T	P	
DATA SET 162 (cont.)		
312.20	12.624	
312.31	12.626	
312.42	12.628	
312.58	12.634	
312.69	12.638	
312.80	12.642	
312.95	12.644	
313.07	12.650	
313.22	12.653	
313.37	12.658	
313.44	12.662	
DATA SET 163*		
4.2	0.100	
7	0.101	
10	0.102	
15	0.107	
20	0.113	
25	0.126	
30	0.146	
40	0.209	
50	0.314	
60	0.470	
70	0.690	
80	0.983	
90	1.36	
109.5	2.37	
125	3.35	
150	4.92	
175	6.48	
200	8.01	
225	9.51	
250	10.99	
273	12.33	
300	13.90	

* Not shown in figure.

3.2. Cobalt

There are 55 sets of experimental data available for the electrical resistivity of cobalt with purity higher than 99.9%. The information on specimen characterization and measurement condition for each of the data sets is given in table 5. The data sets are tabulated in table 6 and shown partially in figures 3 and 4.

Since cobalt is a transition element and is ferromagnetic, its electrical resistivity is expected to resemble those of nickel and iron. As it can be surmised from the size of the available data, the electrical resistivity of cobalt is not investigated as extensively as either that of iron or of nickel. Nonetheless, some features of the behavior of the electrical resistivity of iron and nickel have also been reported for cobalt, such as the T^2 variation in the temperature dependence of the electrical resistivity at low temperatures. The coefficient of this T^2 term becomes larger when measured in an applied magnetic field than when measured in the absence of an applied field [75].

Judging from the impurity analyses reported by some of the authors, cobalt specimens of purity higher than 99.999% are available commercially: Laubitz and Matsumura [76] (data set 43), White and Woods [77,21] (data sets 27, 28, 39), Kierspe et al. [78] (data set 16). However, there are wide disagreement between the reported residual resistivity ratios, even for specimens from the same manufacturer and having nearly the same impurities, as illustrated by the specimens of data sets 27 and 39. Since cobalt is nearly as strongly magnetic as iron (the spontaneous magnetization of 20.8 kG vs. 22 kG for iron), effects due to magnetic structure of specimens and due to the measuring current densities, etc. are expected to be significant. Unfortunately, there is very scarce information on these effects for cobalt specimens. In addition, the morphology of cobalt may have significant influence also. Even though the temperature of the α - β phase transformation of cobalt is greater than 700 K, this cph-fcc transformation is very sluggish, and the high-temperature fcc phase has been reported to persist at lower temperatures [79]. It is not unlikely for a specimen to contain a mixture of these two phases, depending on its thermal and mechanical history [76].

Amongst the available data for high-purity polycrystalline cobalt specimens, Laubitz and Matsumura [76] (data set 43) reported the highest residual resistance ratio ($\rho_{273\text{ K}}/\rho_{4\text{ K}}$) of 140 ± 10 . The impurity analysis reported also indicated

that their specimen was one of the purest. For comparison, the residual resistance ratio of a whisker specimen by Marker et al. [75] (data set 19) was reported to be 388. There are available only a few data sets giving the electrical resistivity of high-purity cobalt over a temperature range extending from ~ 4 to 300 K: White and Woods [77] (data sets 27, 28), and Price and Williams [80] (data set 26). Aside from these data sets, White and Woods [21] (data set 39) reported data from 126 to 273 K, Semenenko et al. [81] (data set 3), Olsén-Bar [82] (data sets 4, 5), and Radhakrishna and Nielsen [83] (data set 9) reported data for low temperatures (< 20 K) only. In addition, Loegel and Gautier [84] (data sets 47, 48) reported the temperature dependent part of the resistivity of specimens of unspecified purity for temperatures below 80 K. Most of these authors reported a T^2 dependence for the temperature dependent part of the resistivity for temperatures below 10 K. The coefficient of this T^2 component was reported to be $1.6 \times 10^{-11} \Omega \text{m K}^{-2}$ by White and Woods [77] and $\leq 1.0 \times 10^{-11} \Omega \text{m K}^{-2}$ by Radhakrishna and Nielsen [83]. Loegel and Gautier [84] reported, together with a T^5 component, a coefficient of $1.06 \times 10^{-11} \Omega \text{m K}^{-2}$ for temperatures up to 30 K. Semenenko et al. [81] reported an additional T component for temperatures 1.4-4.2 K; however, Radhakrishna and Nielsen [83] concluded from their data that the T component, if present at all, was not significant. Marker et al. [75] also reported the T^2 dependence for their whisker specimen with a coefficient of $1.5 \times 10^{-11} \Omega \text{m K}^{-2}$ in the temperature range 1.1-4.2 K.

The present analysis of the electrical resistivity of cobalt at low temperatures follows the same method as employed in the analysis of that of iron and nickel, i.e., by fitting the resistivity data to the expression

$$\rho = \rho_0 + \alpha T^2 + A \left(\frac{T}{\theta_R} \right)^5 \int_0^{\theta_R/T} \frac{x^5 e^x}{(e^x - 1)^2} dx \quad (8)$$

However, because of the small number of available data sets and because of the apparent large deviation of the electrical resistivity of cobalt from the Mattheissen's rule, the coefficients α and A cannot be determined simultaneously with small uncertainties. Therefore, the value of α is taken to be $1.00 \times 10^{-11} \Omega \text{m K}^{-2}$, a value close to the mean of the coefficients reported by Radhakrishna and Nielsen [83] and by Loegel and Gautier [84]. Using a Debye

temperature of 445 K approximately as the value for θ_R , the value of A was determined from eq (8) with the data of White and Woods [77] (data sets 27, 28). A value of $70 \times 10^{-8} \Omega m K^{-2}$ was obtained. With these values of α and A, the resistivity values calculated from eq (8) agree to within 2% with the experimental data for temperatures below ~ 25 K. For higher temperatures, the calculated values do not agree well with the experimental data, and therefore in the temperature range ~ 35 to 90 K, the recommended values were obtained by interpolating the low-temperature values calculated from eq (8) and the data of Laubitz and Matsumura [76] (data set 43).

Two data sets are available covering a very wide temperature range (~ 80 -1700 K): by Laubitz and Matsumura [76] (data set 43) and by Kierspe et al. [78] (data set 16). Except for temperatures below ~ 200 K, where the latter data set appears to be in error, the agreement between these two data sets is within $\sim \pm 3\%$. The recommended values from 90 to 1700 K are therefore based on these, with more weight given to that of Laubitz and Matsumura, especially for temperatures below 250 K. In this temperature range, cobalt undergoes two transitions: one polymorphic at ~ 715 K, from cph(α) to fcc(β), and one ferromagnetic-paramagnetic at ~ 1395 K. The polymorphic transformation is martensitic and is very sluggish, due to the small associated free energy change. Thus the temperature range in which this transformation occurs has been reported to vary from about 660 K [85] (data set 14) to about 740 K [86] (data set 1), and thermal hysteresis is generally reported. The careful study of Laubitz and Matsumura [76] on a specimen which had been x-ray analyzed to contain no detectable fcc phase at room temperature showed that the range of transformation was about 703-710 K upon heating and about 686-693 K upon cooling (data sets 44, 45). The resistivity of the β phase is generally reported to be lower than that of the α phase. Kierspe et al. [78] did not report details of the transformation, even though their data appeared to have a strange behavior at the transformation, which occurred at $\sim 720 \pm 5.0$ K. These authors reported a temperature coefficient that shows a decrease ($\sim 30\%$) at the transition, instead of the usual positive-negative-positive change in the temperature coefficient indicated by a number of the other works (see, e.g., Laubitz and Matsumura [76] (data sets 44, 45), Powell [85] (data sets 11-14), and Fraser et al. [86] (data sets 1, 2)). A possible reason for the behavior of the data of Kierspe et al. was that their specimen might have been heated or cooled at too fast a rate.

The α - β phase transition temperature of 715 K indicated in figures 3 and 4 is based actually on specific heat measurements. At temperatures above the α - β transition, the temperature coefficient reported by Kierspe et al. [78] showed a gradual rise to a flat maximum at \sim 1150 K, and decreased gradually again. It became almost constant at temperatures above \sim 1500 K. There was no sharp δ -function like maximum as in the cases of nickel and iron at the Curie temperature. This behavior of their data is consistent with the data of Laubitz and Matsumura [76] (data set 43), which appeared to have a change of slope at \sim 1250 K. At temperatures above the Curie temperature, the data of Seydel and Fucke [87] (data set 42) are in good agreement with those of Laubitz and Matsumura [76] and of Kierspe [78] and are also taken into account.

There are eight data sets for the electrical resistivity of molten cobalt [87-94] (data sets 7, 18, 40-42, 50-52). Of these, the data of Güntherodt et al. [92] (data set 41) and of Seydel and Fucke [87] (data set 42) agree to within $\pm 1\%$. In addition, their data for the solid phase at the melting point agree to within $\pm 1.5\%$ of the recommended value. The recommended values for the molten state are therefore based on their data. The linear temperature dependence of the electrical resistivity of molten cobalt was reported also by Ono and Yagi [89] (data set 18), and by Kita et al. [93] (data sets 50,51).

The recommended values both uncorrected and corrected for thermal expansion of the material are presented in table 4, while only the uncorrected values (except those for the liquid state) are shown in figures 3 and 4 along with the experimental data. The values are for polycrystalline cobalt of purity 99.99% or higher; however, those values for temperatures below 200 K are applicable only to cobalt having a residual resistivity of $0.0370 \times 10^{-8} \Omega \text{m}$. The estimated uncertainty in the recommended values is about $\pm 5\%$ for the solid state and $\pm 7\%$ for the molten state.

As mentioned earlier, the electrical resistivity of cobalt appears to deviate from the Matthiessen's rule fairly large. For specimens with somewhat higher residual resistivities, the application of Matthiessen's rule is likely to underestimate the electrical resistivity by up to a few percent. For example, for the specimens of White and Woods [77] (data sets 27,28) which have residual resistivities of about $0.09 \times 10^{-8} \Omega \text{m}$, Matthiessen's rule appears to be applicable for temperatures below \sim 15 K with resulting error less than -1%, but the error increases with temperature to -2% at \sim 20 K, -5% at \sim 35%, and -6% at 200 K and higher. For the specimen of Price and Williams [80] (data set 26) which has

a residual resistivity of $\sim 0.13 \times 10^{-8} \Omega\text{m}$, the errors are approximately +2% at ~ 20 K, -6% from ~ 35 to 60 K, -5% at 100 K, and -4% from 200 to 300 K. Unfortunately, there are no available data sets for specimens of higher residual resistivity covering more or less continuously from low to room temperatures, so that a more extensive comparison could be made. The earlier measurement by McLennan et al. [50] (data set 30) on a specimen of residual resistivity $0.45 \times 10^{-8} \Omega\text{m}$ indicates that the use of Mattheissen's rule yields an error of only -1% at 20.6 K, but the error jumps to -20% at 83 K and reduces to $\sim -10\%$ at 293 K. The more recent measurement by Wilkes [95] (data set 46), whose specimen has a residual resistivity of $\sim 0.17 \times 10^{-8} \Omega\text{m}$, shows that the errors are -1% at ~ 77 K, +1% at ~ 200 K, and +1% at ~ 300 K. It is interesting to note that the total impurity content of this specimen, $\sim 0.08\%$, is more than ten times higher than that of the specimen of White and Woods [77] (data sets 27, 28). However, it has been determined by Laubitz and Matsumura [76] that the specimen of Wilkes contains approximately 33% of the fcc phase at room temperature. It is evident that the phase constitution of a specimen has significant influence on the resistivity of cobalt, especially below the α - β transition. The presence of the fcc phase below 700 K is likely to lower the resistivity. On the other hand, the low-temperature cph phase is not likely to be stable at temperatures much higher than 700 K so that the higher temperature resistivity of cobalt of reasonable purity should not deviate by more than two or three percent from the recommended values.

The recommended values uncorrected for thermal expansion given in table 4 can be represented approximately by the following expressions to within $\pm 0.5\%$.

1-35 K:

$$\rho = 0.0370 + 1.00 \times 10^{-5} T^2 + 70 \left(\frac{T}{445} \right)^5 \int_0^{445/T} \frac{x^5 e^x}{(e^x - 1)^2} dx \quad (19)$$

35-90 K:

$$\rho = 8.20 \times 10^{-2} - 5.261 \times 10^{-3} T + 1.477 \times 10^{-4} T^2 - 8.559 \times 10^{-8} T^3 \quad (20)$$

90-700 K:

$$\rho = -9.98 \times 10^{-1} + 1.865 \times 10^{-2} T + 4.237 \times 10^{-6} T^2 + 3.777 \times 10^{-8} T^3 \quad (21)$$

715-1250 K:

$$\rho = 31.71 - 1.0987 \times 10^{-1} T + 1.7872 \times 10^{-4} T^2 - 5.098 \times 10^{-8} T^3 \quad (22)$$

1250-1400 K:

$$\rho = -117.61 + 1.8101 \times 10^{-1}T + 2.042 \times 10^{-8}T^2 - 1.773 \times 10^{-8}T^3 \quad (23)$$

1400-1767 K:

$$\rho = -342.15 + 7.2544 \times 10^{-1}T - 4.1393 \times 10^{-4}T^2 + 8.201 \times 10^{-8}T^3 \quad (24)$$

1767-3000 K:

$$\rho = 94.80 + 1.128 \times 10^{-2}T \quad (25)$$

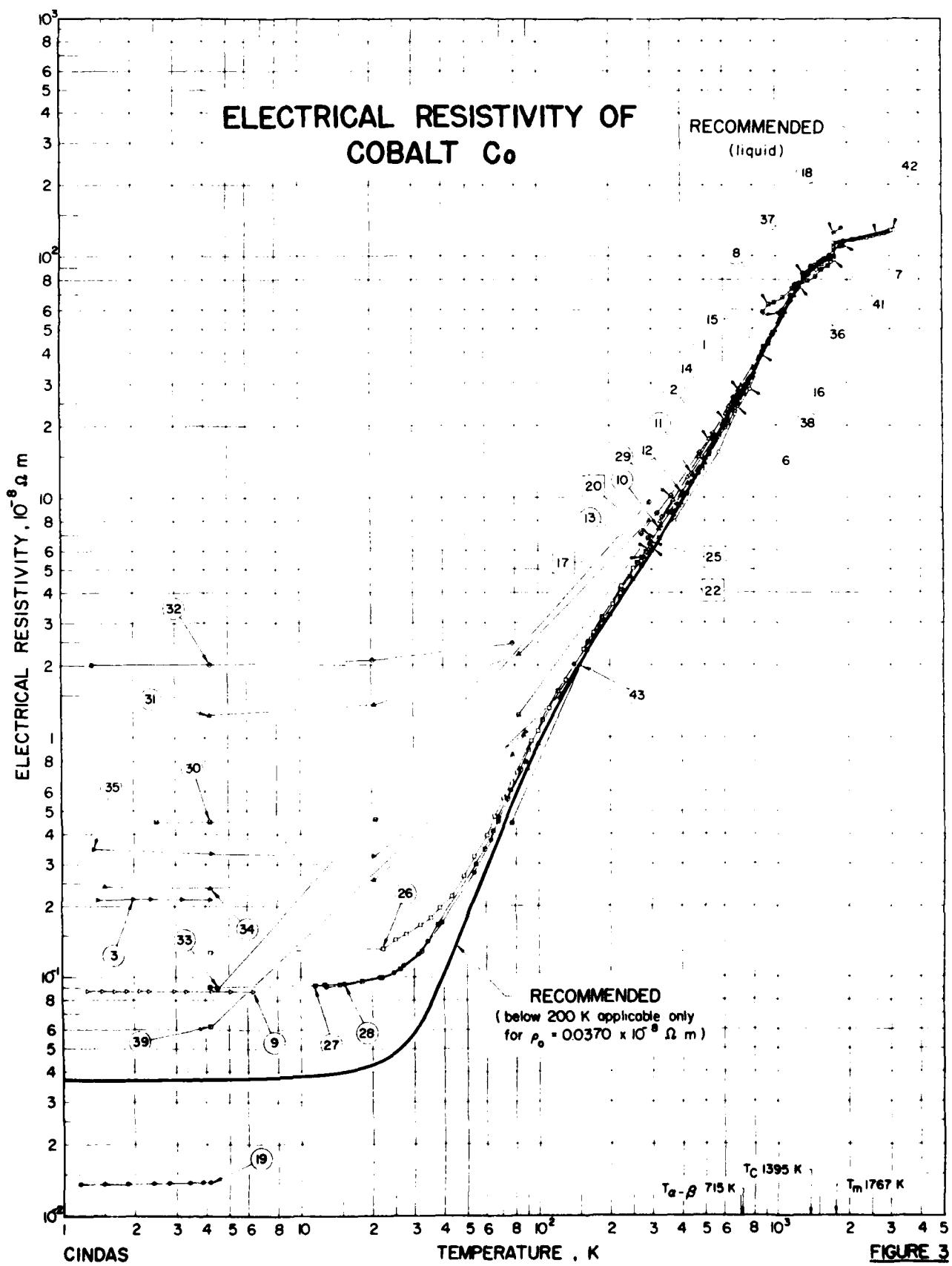
It should be stressed that these expressions do not necessarily suggest any theoretical justification, and should be treated, most appropriately, as numerical aids only. It should also be understood that giving these expressions does not imply a recommendation for the temperature derivative of the electrical resistivity.

TABLE 4. RECOMMENDED VALUES FOR THE ELECTRICAL RESISTIVITY OF COBALT^a[Temperature, T, K; Electrical Resistivity, ρ , $10^{-8} \Omega \text{m}$]

T	ρ		T	ρ	
	uncorrected	corrected		uncorrected	corrected
1	0.0370	0.0370	1100	59.26	60.05
4	0.0372	0.0372	1200	69.14	70.18
7	0.0375	0.0374	1300	78.79	80.11
10	0.0381	0.0380	1400	87.20	88.83
15	0.0396	0.0395	1500	91.46	93.34
20	0.0426	0.0425	1600	94.81	96.94
25	0.0481	0.0480	1700	97.76	100.15
30	0.0581	0.0580	1767	99.75(β)	102.32(β)
40	0.102	0.102	1767		114.7 ^b (λ)
50	0.178	0.178	1800		115.1 ^b
60	0.280	0.279	1900		116.2 ^b
70	0.408	0.407	2000		117.4 ^b
80	0.563	0.562	2100		118.5 ^b
90	0.742	0.740	2200		119.6 ^b
100	0.947	0.945	2300		120.7 ^b
150	2.02	2.02	2400		121.9 ^b
200	3.20	3.20	2500		123.0 ^b
250	4.52	4.52	2600		124.1 ^b
273	5.18	5.18	2700		125.2 ^b
293	5.78	5.78	2800		126.4 ^b
300	6.00	6.00	2900		127.5 ^b
350	7.67	7.67	3000		128.6 ^b
400	9.56	9.57			
500	14.11	14.15			
600	19.88	19.97			
700	27.09(α)	27.25(α)			
715	25.89(β)	26.07(β)			
800	32.09	32.36			
900	40.43	40.83			
1000	49.58	50.15			

^a The values are for polycrystalline cobalt of purity 99.99% or higher, but those below 200 K are applicable only to cobalt having a residual resistivity of $0.0370 \times 10^{-8} \Omega \text{m}$. The columns headed uncorrected and corrected refer to values uncorrected and corrected for thermal expansion, respectively. Solid line separating tabular values indicates solid to liquid state transformation, while dotted line indicates solid phase transition.

^b α: cph; β: fcc.
Provisional value.

**FIGURE 3**

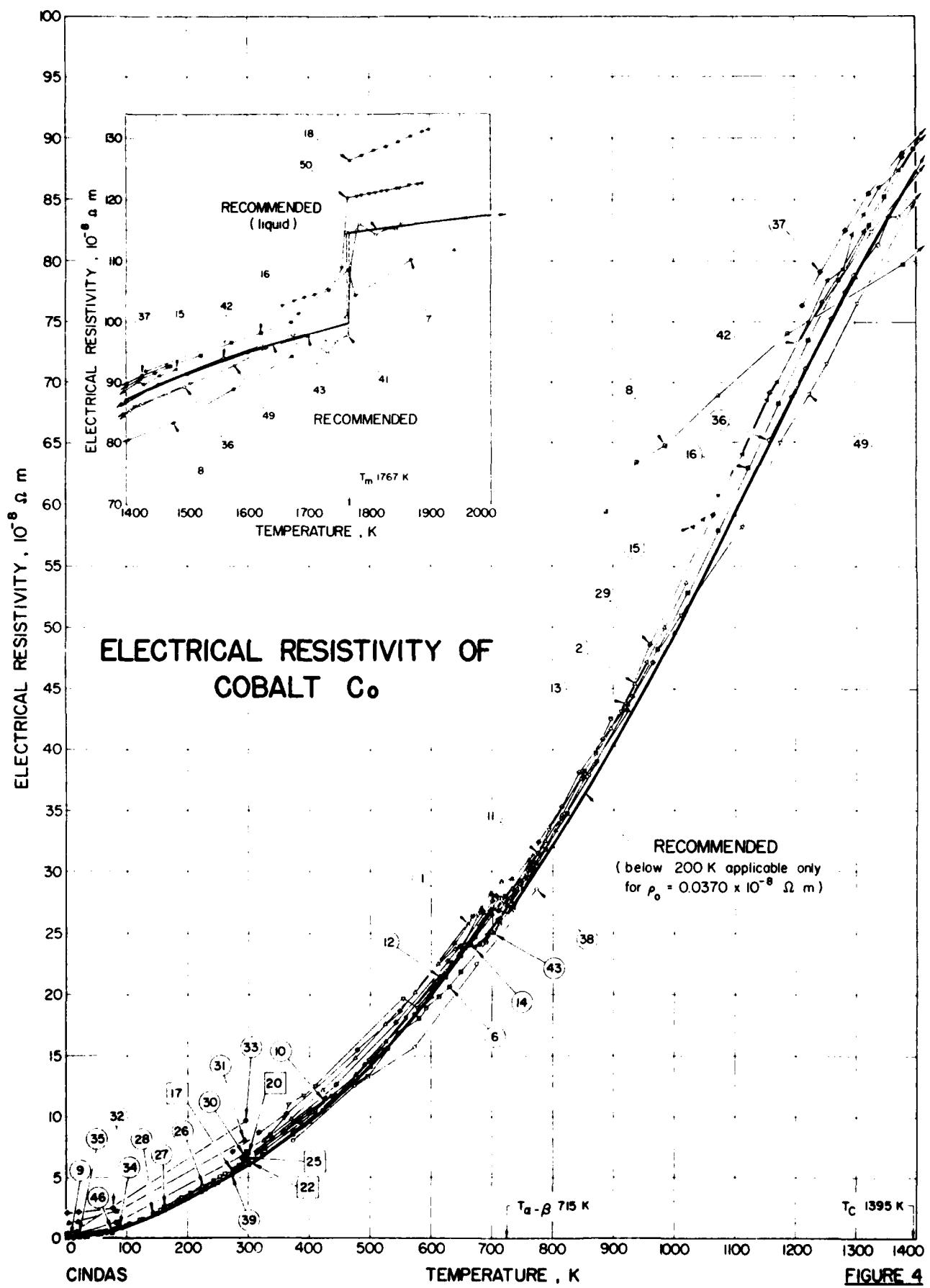


FIGURE 4

TABLE 5. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COBALT Co

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
1 86	Fraser, R.W., Evans, D.J.L., and Mackiw, V.N.	1964	293-1020			99.9 pure; 99.5 Co + Ni, 0.07 Ni, 0.005 Fe, 0.001 Cu, 0.005 S, and 0.008 C by chemical analysis; <0.001 Ag, Al, Be, Ca, Cr, Hg, Mg, Mn ₂ , Mo, Pb, Sb, and Zn each by spectrographical analysis; 8.99 x 10 ⁻⁶ O ₂ , <2.4 x 10 ⁻⁶ N ₂ , and 1.9 x 10 ⁻⁶ H ₂ for specimen hot rolled to 0.127 cm (0.050 in.); 1.47 x 10 ⁻³ O ₂ , 1.19 x 10 ⁻³ N ₂ , and 4.3 x 10 ⁻⁶ H ₂ for specimen hot rolled to 0.127 cm (0.050 in.) and cold rolled to 0.0162 cm (0.030 in.); 1.31 x 10 ⁻³ O ₂ , 4.8 x 10 ⁻⁶ N ₂ , and 3.9 x 10 ⁻⁶ H ₂ for specimen annealed at 1273 K after hot and cold rolling; gas impurities determined by gas analysis; strip specimens from Sherrit Gordon Mines; prepared from powder; rolled and compacted, sintered in hydrogen, hot rolled and cold rolled to desired thickness, and annealed at 1203 K for 1 h; density 8.85 x 10 ³ kg m ⁻³ ; Rockwell hardness 45T 50-70; α+β transformation temperature 778 K upon heating and 668 K upon cooling; TC 1394 K; data extracted from heating curve.	
2 86	Fraser, et al.	1964	325-1020			The above specimen; data extracted from cooling curve.	
3 81	Semenenko, E.E., Sudovtsov, A.I., and Volkenstein, N.V.	1964	A	1.4-4.2		99.9984 pure; specimens prepared by electric-spark cutting from rod 5 mm in diam; cross section of ~0.30 x 0.25 mm ² and ~35 mm long; residual resistivity ratio, R(273 K)/R(0 K) 26.19; values calculated from reported R(T)/R(273 K) with ρ(273 K) = 5.57 x 10 ⁻⁸ Ω m, taken from Bridgman, P.W., Proc. Am. Acad. Arts Sci., 79, 149, 1940; measured with terrestrial magnetic field compensated by means of Helmholz coils.	
4* 82	Olsén-Bär, M.	1956	C	4.2-20.2		Spectroscopically pure wire; obtained from Johnson Matthey Co.; 0.1 mm in diam and 3 to 5 cm long; annealed for several hours in high vacuum at approximately two thirds of the melting temperature by passing a current through it; Debye temperature = 385 K; values calculated from reported ρ(T)/ρ(90 K), with ρ(90 K) = 0.744 x 10 ⁻⁸ Ω m, taken from Data Set 43.	
5* 82	Olsén-Bär, M.	1956	C	4.2-20.4		Same as above.	
6 96	Chevessushkina, A.V. and Vasil'eva, R.P.	1965	374-895			Cobalt samples consist of an orthogonal parallelepiped with dimensions 3 x 6 x 120 mm; magnetized along the long axis of a solenoid producing magnetic fields up to 3000 Oe; data extracted from figure.	
7 88	Eliutin, V.P., Turov, V.D., and Maurakh, M.A.	1965	R	1433-1940		98.5-99.0% pure; electrolytic cobalt; data extracted from figure.	
8 97	Kovenskiy, I.I. and Samsonov, G.V.	1963	+	888-1673		99.82 Co, 0.12 C, 0.008 Ni, 0.004 Fe, 0.002 Cu, and 0.001 Mn and S each; measured by a direct-heating method.	
9 83	Radhairishna, P. and Nielsen, M.	1965	D	1.3-6.4		Pure; polycrystalline wire from Johnson Matthey Co.; 1 mm in diam and ~6.6 cm long; annealed at 1313 K for 3 h at a pressure less than 4 x 10 ⁻⁵ PA; samples were demagnetized and the earth's field were compensated; data extracted from figure.	

* Not shown in figure.

TABLE 5. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COBALT Co (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
10	85	Powell, R.W.	1964	A,+ [*]	293-427		99.97% pure; 0.951 cm in diam and 4.346 cm long; supplied by Metallurgy Division of the National Physical Laboratory; data obtained from figure; resistivity measured by passing a measured current both forward and reverse through the sample; and using thermocouples as potential leads.
11	85	Powell, R.W.	1964	A,+ [*]	290-965		Similar to the above specimen except heated to 973 K.
12	85	Powell, R.W.	1964	A,+ [*]	290-923		Similar to the above specimen except cooled from 973 to 293 K.
13	85	Powell, R.W.	1964	A,+ [*]	290-955		The above specimen heated up to 973 K again.
14	85	Powell, R.W.	1964	A,+ [*]	384-756		The above specimen except cooled from 973 to 293 K.
15	98	Schröder, K. and Giannuzzi, A.J.	1969		1032-1483		99.7 pure; samples in wire form; annealed in an inert gas atmosphere consists of 92% He and 8% H for 2 h at ~150 K above the Curie temperature; values calculated from reported resistivity ratio, $\rho(T)/\rho(T_C) = 87.45 \times 10^{-6} \Omega \text{ m}$ taken from Data Set 16.
16	78	Kierspe, W., Kohlhass, R., and Gonska, H.	1967	+ [*]	77-1673	Bulk Co	99.999 ⁺ pure, <0.0001 Ag, Al, Ca and Cu each, 0.0003 Fe and Si each, 0.0002 Mn and 0.0001 Mg; supplied by Koch-Light Laboratories Ltd., England; a non-compensated Thomson bridge is used; values from table.
17	99	Bennett, M.R. and Wright, J.G.	1972	V,+ [*]	273	Bulk Co	99.998 ⁺ pure with major impurities of 0.002 C, 0.0001 to 0.02 O ₂ , 0.004 N ₂ , and 0.0001 H ₂ ; amorphous specimen with a cross section of ~5 x 10 mm ² ; supplied by Koch Light Laboratories Ltd.; resistance measured by a standard four-terminal technique using thick silver lands evaporated on to the substrate prior to mounting in the ultrahigh vacuum system; a 0.03% Fe in gold-chromel thermocouple from Johnson Matthey Co. was damped to the surface of the substrate for temperature measurement from 4 to 500 K.
18	89, 90	Ono, Y. and Yagi, T. Ono, Y.	1972 1977	R	1768-1898		99.9 ⁺ pure; in molten state in a vacuum induction furnace; values calculated from the reported equation $\rho(\mu\Omega\text{-cm}) = \alpha T(\text{°C}) + \beta$ with $\alpha = 0.0384$ and $\beta = 69.07$.
19	75	Marker, D.L., Reichardt, J.W., and Coleman, R.V.	1971	1.1-4.2	Co DIN 20		Cobalt whisker grown by the hydrogen reduction of CoBr ₂ at 673-773 K in a reducing atmosphere of argon; residual resistance ratio $R(295\text{ K})/R(4.2\text{ K}) = 388$; data extracted from figure of $R(T)/R(295\text{ K})$ as function of square of temperature; reference value of $\rho(295\text{ K}) = 5.8 \mu\Omega\text{ cm}$, taken from White and Woods, Phil. Trans. Roy. Soc., London, A251, 273, 1959; used to calculate resistivity.
20	100	Pleves, J.T. and Bachmann, K.J.	1973	D	299	Specimen No. 13	99.999 pure Co; 0.0250 N, 0.0190 O, <0.0010 C, <0.0003 Si, Mg and Fe each; determined by emission spectrograph and vacuum fusion analysis; samples consist of 0.025 cm thick strips cold rolled to 0.011 cm, cut to ~20 cm in length by 0.25 cm in width; supplied by Johnson Matthey Co.; the center of the hysteresis gap found at 690 K; resistivity was monitored by superimposing an ac voltage on the ramp and measuring differentially the ac voltage drop across the specimen against an 0.010 Ω standard using a phase sensitive detection; reproducibility of measurement 0.1%.

TABLE 5. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COBALT CO (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Specimen Designation	Name and Composition (weight percent), Specifications and Remarks
21* 100	Pleves, J.T. and Bachmann, K.J.	1973	D	299	Specimen No. 13	Similar to the above specimen except heated to 573 K for 46 h after cold rolled, representing a fully recovered structure.
22 100	Pleves, J.T. and Bachmann, K.J.	1973	D	299	Specimen No. 13	The above specimen after 100 heat cycles carried out in a diffusion-pumped vacuum system which could be evacuated to 1.33×10^{-6} PA.
23* 100	Pleves, J.T. and Bachmann, K.J.	1973	D	299	Specimen No. 11	Similar to the above specimen except only cold rolled.
24* 100	Pleves, J.T. and Bachmann, K.J.	1973	D	299	Specimen No. 11	The above specimen heated to 1073 K for 10 minutes representing a fully recrystallized structure.
25 100	Pleves, J.T. and Bachmann, K.J.	1973	D	299	Specimen No. 11	The above specimen after 100 heat cycles carried out in a diffusion-pumped vacuum system which could be evacuated to 1.33×10^{-6} PA.
26 80	Price, D.C. and Williams, G.	1973	V	4.2-292		99.985% pure; dimensions of 10 cm x 0.2 cm x 0.15 cm; supplied by Johnson Matthey Co.; annealed in vacuo for 2 h at 1173 K and then quenched; ideal resistivity ρ_1 were reported from 22 to 292 K; data from table, uncorrected for thermal expansion; total resistivity calculated from data of ideal resistivity by the relation $\rho(T) = \rho_1(T) + \rho(4.2 \text{ K})$; temperatures stabilized and measured to better than 0.5%; area to length ratio determined to within 0.5%.
27 77	White, G.K. and Woods, S.B.	1957	G	4.2-286	Col. a	Pure; 0.0002 Si, <0.0005 Fe, ~0.0001 Al, and <0.0001 Mg and Cu each; by spectrographic analysis; rod specimen 5 to 8 cm long and 2 mm in diam; supplied by Johnson Matthey Co.; annealed in vacuum for ~2 h at 973 K; residual resistance ratio $\rho(295 \text{ K})/\rho(4.2 \text{ K}) = 65.36$; total resistivity calculated using $\rho = \rho_1 + \rho_0$; ideal resistivity ρ_1 extracted from figure; measurement error $\sim \pm 2\%$.
28 77	White, G.K. and Woods, S.B.	1957	G	4.2-279	Col. b	The above specimen remounted in a second cryostat and resistivity and thermal conductivity determined together; residual resistance ratio $\rho(295 \text{ K})/\rho(4.2 \text{ K}) = 64.52$.
29 101	Tsothalas, I.A.	1974		273-1378		99.99 (nominal) pure; polycrystalline; dimension $1 \times 5 \times 0.1 \text{ cm}^3$; martensitic transformation at 660 K from fcc to bcc; values extracted from figure.
30 50	McLennan, J.C., Niven, C.D., and Wilhelm, J.O.	1928		2.5-293	Cobalt(aged)	Pure; supplied by Belga American Trading Corp., New York; cut into strip and annealed in vacuum for 4 h at a dull red heat; values extracted from table.
31 50	McLennan, J.C., et al.	1928		4.2-293	Cobalt(unaged)	Similar to the above specimen, unannealed.
32 102	Meissner, W.	1928	1.4-273	Col(27)		Specimen annealed for 2.5 h at 600 K; 50 mm in length and 2.5 x 0.5 mm cross section; resistance ratio reported; reference value of $\rho(273) = 5.57 \mu\Omega \text{ cm}$, taken from Bridgman, P.W., Proc. Am. Acad. Arts Sci., 79, 149, 1940, used to calculate resistivity from resistance ratio.

* Not shown in figure.

TABLE 5. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COBALT Co (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
33 103	Horak, J.A. and Blewitt, T.H.	1972	A	4.5-295		Poly-crystalline; ~5 cm long, 0.025 cm diam; annealed, values extracted from table.	
34 104	Weissner, W. and Voigt, R.	1930	+	1.5-273	Co 2	Sample in sintered polycrystalline form; 0.5 mm in diam and 57.6 mm in length; specimen obtained from Heraeus, von A.E.G.; sample annealed at 773 K in vacuum for 2.5 h; measured by compensation method; relative resistance data reported; reference value of $\rho(273) = 5.57 \mu\Omega \text{ cm}$, taken from Bridgman (Proc. Am. Acad. Arts Sci., <u>79</u> , 149, 1940), used to calculate resistivity.	
35 104	Weissner, W. and Voigt, R.	1930	+	1.3-273	Co 3	Pure; 0.05 Cr, 0.01 Mn and <0.05 Fe; dimension 12.5 mm in length and 2.5 mm thick; obtained from Kahlb; sample melted in vacuum; measured by compensation method; reference value of $\rho(273) = 5.57 \mu\Omega \text{ cm}$, taken from Bridgman (Proc. Am. Acad. Arts Sci., <u>79</u> , 149, 1940), used to calculate resistivity.	
36 105	Jain, S.C., Narayan, V., and Goel, T.C.	1969	B,+ B,-	1158-1496	Specimen 1	99.998 pure; specimen in rod form 15 cm long and 0.5 cm in diam; supplied by Koch Light Laboratories, United Kingdom; sample heated by electric current; the potential drop across the length of the uniform-temperature region was measured with a Tinsley ac/dc coordinate potentiometer type 4580; current through the sample determined by measuring the potential difference across a non-inductive standard resistor type 660 of 0.001 Ω in series with the specimen; values extracted from graph.	
37 105	Jain, S.C., et al.	1969	B	1213-1468	Specimen 2	Similar to the above specimen except contains a total impurity concentration of about 0.001% of Si, Ni, Cu, Fe, Mg and Ag; sample supplied by Johnson Matthey Co.	
38 106	Kirichenko, P.I.	1969		373-773		99.7 pure; 3 mm in diam and 30 cm long; annealed in vacuum for 24 h at 1273, oven-cooled; measured in a vacuum of $4 \times 10^{-4} \text{ mmHg}$; measurement error: 1-1.5% in resistivity and 0.1 K in temperature; minimum of resistivity versus temperature reported to occur at 655 K upon heating and 655 K upon cooling; values extracted from figure.	
39 21	White, C.K. and Woods, S.B.	1959	C	4.2-273	Co 2	99.999 pure; 0.0002 Si, 0.0005 Fe, >0.0001 Al, and <0.0001 Mg and Cu; wire specimen 0.05 mm in diam and about 6 to 8 cm long, from Johnson Matthey Co. (JM948); annealed in vacuum at 973 K; Debye temperature reported to be 380 K; residual resistance ratio $R(295 \text{ K})/R(0 \text{ K}) = 90.9$; values calculated from reported ideal resistivity, extracted from graph, and reported $\rho_0 = 0.062 \times 10^{-8} \Omega$ from Table 1.	
40* 91	Levin, E.S., Ayushina, G.D., and Gel'd, P.V.	1972	R	1923		99.98 pure; electrolytic.	

* Not shown in figure.

TABLE 5. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COBALT CO (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
41 92	Güntherodt, H.J., Häuser, E., Künni, H.U., and Müller, R.	1975	A	1720-1854		99.999 pure from Johnson Matthey Co.; measured by a four probe method in which the sample material was enclosed in an alumina tube with four protrusion serving as current and potential contacts.
110	Müller, R.	1976				
42 87	Seydel, U. and Fuchs, W.	1977	+	1205-3108		99.99 pure, 0.0007 Fe, 0.0005 Si, 0.0003 Cu, 0.0002 Ag and Ni, 0.0001 Al, Ca, Mg, and Sn each, <0.0001 Bi, Cr, and Mn each; measured by an exploding wire technique; measurement error 4%; smoothed values from curve; values corrected for thermal expansion.
43 76	Laubitz, M.J. and Matsunaga, T.	1973	A	90-1700		99.999 pure, 0.00070 C, 0.00060 Ni, 0.00050 O ₂ , 0.00016 Fe, 0.00010 K, 0.00008 Na, 0.00007 Na, 0.00004 Mo, 0.00003 Al, 0.00002 Ga and S each, 0.00001 P, 0.000007 Cl, 0.000006 Ca, Cr, and Cu each, 0.000002 Mg, and 0.000008 Ag and Pd each (at.Z), by semi quantitative mass spectrographic analysis; from Metals Research Ltd., England; material originally rod shape ~2 cm in diam and 20 cm long; polycrystalline; annealed at 1500 K for 4 h in a vacuum of 5×10^{-6} Torr; cooled at 100 K hr ⁻¹ , except in the range 710 to 670 K, where it is cooled at 0.5 K hr ⁻¹ ; residual resistance ratio 140 ± 10; density 8.831 × 10 ³ kg m ⁻³ ; at 293 K; grain size ~0.1 cm; specimen trimmed to a nominal diam of 2 cm and length of 20 cm with no machining of the region on which measurements were made; one specimen then measured from 300 to 1250 K; residual resistivity ratio after measurement 120; a second specimen, 1 cm in diam and 10 cm long were cut from the first and measured from 90 to 370 K; no change in residual resistivity ratio, and in ice point resistivity were detected; the second specimen measured again from 1000 to 1750 K; grain size increases to 0.5-1.0 cm after high temperature measurement; residual resistivity ratio unchanged; but specimen geometry is changed; smoothed values from table; these values are reported to be averages in the temperature range where the two measurements overlap; values uncorrected for thermal expansion; values above 1300 K had been adjusted by +0.8% by the authors to avoid discontinuity in resistivity values between the large and the small specimens; measurement error reported 0.5%; smoothed values from table.
44*	Laubitz, M.J. and Matsunaga, T.	1973	A	680-710		The smaller of the above specimens, measured after the high temperature measurements; measured while heating.
45*	Laubitz, M.J. and Matsunaga, T.	1973	A	685-715		The above measured while cooling.
46 95	Wilkes, K.E.	1968	A	78-300		99.92 pure, 0.040 Fe, 0.012 Ni, 0.004 C, 0.001 Ca, Cu and Si each, 0.0008 S, 0.0003 Al and Mn each, 0.0002 Mg, and 0.0001 Pb; rod specimen 1.000 cm in diam and 10.05 cm long; supplied by Centre D'Information on Cobalt, Brussels, Belgium; density 8.805 × 10 ³ kg m ⁻³ ; at 296 K; values from cable; residual resistivity ratio measured by M.J. Laubitz and T. Matsunaga, Can. J. Phys., 51(2), 1247, 1973, to be 31, and reported to change to 48 after being "carefully reannealed".

* Not shown in figure.

TABLE 5. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COHALT Co (continued)

Date Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
47* 84	Loegel, B. and Gautier, F.	1973		6.8-79		"Pure cobalt," no other details reported; only temperature dependent part of resistivity reported.
48* 84	Loegel, B. and Gautier, F.	1973		5.6-33		Similar to the above.
49 107	Zinov'yev, V.F., Krentsil, R.P., Perova, I.N., and Gel'd, P.V.	1968	A,R	295-1730		99.95 pure; 0.2 mm thick, 8 mm wide and 8 mm long; ground from rolled stock; annealed at 1200 K for 7 h under a pressure of 1×10^{-5} mmHg; $\rho(288 \text{ K})/\rho(4.2 \text{ K}) = 86$; α - β transition reported at 703 K; measured by potentiometric method below 1330 K, and by rotating field method above 1400 K; hysteresis at α - β transition reported but resistivity values given for heating only; uncertainty in temperature measurement 10-15 degrees.
50 93	Kita, Y., Ohguchi, S., and Morita, Z.	1978	+	1658-1888		0.137 Fe, 0.09 Ni, 0.017 Si, 0.012 Mn, 0.011 S, and 0.008 C; measured in a vacuum of 10^{-4} Torr, with a four probe method in which the electrodes are of the same material as the specimen; data points are taken at temperatures in the following sequence: 1788, 1811, 1829, 1850, 1870, 1888, 1881, 1867, 1846, 1820, 1801, 1781, 1765, 1755, 1735, 1711, 1690, 1678 and 1658 K; values from table supplied by authors.
51* 93	Kita, Y., et al.	1978	+	1764-1895		Same as the above, a second melt; temperature sequence: 1795, 1809, 1823, 1843, 1863, 1878, 1895, 1883, 1869, 1854, 1836, 1819, 1801, 1782, and 1764 K.
52* 94	Samaran, A.M.	1962	R	1767-2000		Measured by the rotating field method; apparatus calibrated with iron; using resistivity value reported by R.W. Powell, Philos. Mag., 44, 772, 1953; resistivity value calculated from reported conductivity $(1.12-0.228 \times 10^{-4} \text{ T}^2 \text{ C}) \times 10^{-4} \Omega^{-1} \text{ cm}^{-1}$; upper temperature limit issued to be 2000 K.
53* 108	Shimanki, H.	1914	A	20.2-273		Wire specimen 1-2 m long; resistivity values calculated from reported $R(T)/R(273 \text{ K})$ ratio, with $\rho(273 \text{ K})$ taken to be $5.178 \times 10^{-6} \Omega \text{m}$.
54 109	Thomas, J.G. and Mendoza, E.	1952		1.2-4.2		99.95 pure, from New Metals and Chemical Ltd., 0.13 mm in diam; drawn; x-ray show hcp structure; resistivity value calculated from reported $R(T)/R(273 \text{ K})$ with $\rho(273 \text{ K})$ taken to be $5.178 \times 10^{-6} \Omega \text{m}$.
55 109	Thomas, J.G. and Mendoza, E.	1952		0.06-4.2		Similar to the above except annealed for 3 h in vacuo at 1273 K; contains a small amount of fcc structure.

* Not shown in figure.

TABLE 6. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COBALT
[Temperature, T; K; Electrical Resistivity, ρ , $10^{-6} \Omega \cdot m$]

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 1</u>															
293	6.3	983	50.0	4.16	0.1499	1765	108.6	293	6.46	644	23.18				
325.15	8.0	1020	53.7	4.80	0.1500	1773	104.3	294	6.27*	650	23.58*				
370	9.8			5.22	0.1501	1868	110.3	324	7.43	655	23.80*				
422	12.2			5.75	0.1502	1940	111.8	327	7.63	661	24.02*				
476	14.8			6.10	0.1502			356	8.64	666	24.13*				
525	17.6			6.62	0.1504			359	8.88	677	24.03				
573	20.2			7.24	0.1506			399	10.28	686	24.53*				
611	22.5			7.92	0.1505			424	11.41	694	25.03				
638	24.2			8.54	0.1506			427	11.56	705	25.73*				
660	25.7			9.08	0.1507			986	64.7	713	26.29				
682	27.0			9.54	0.1507			1073	68.9	724	27.01*				
698	28.2			10.15	0.1508			1188	74.0	732	27.56				
715	29.2			10.83	0.1508			1379	79.7	290	6.45	742	28.39*		
733	29.4			11.56	0.1511			1478	83.3	339	8.19	767	30.08		
753	30.9			12.43	0.1519			1576	88.9	444	12.66	805	33.35		
788	32.5*			20.38	0.1547			1673	92.2	542	17.71	852	37.74		
814	34.6*									627	22.75	923	43.24		
847	37.6*									648	23.93				
895	41.7*									701	27.64				
935	45.4*									704	28.00*				
983	50.0*									707	28.00				
1020	53.7*									722	27.38				
<u>DATA SET 2</u>															
325.15	8.0	0.1578		529	15.6	2.12	0.087168	738	28.43	498	14.71				
370	9.8	0.1576		546	16.8	2.31	0.087176	747	28.93	626	22.07				
422	12.2	0.1579		580	18.0	2.49	0.087187*	749	29.00*	644	23.39*				
476	14.8	0.1581		592	18.9	2.74	0.087200*	760	30.05	679	25.67				
525	17.6	0.1581		612	19.8	2.96	0.087212*	776	31.43	695	26.76				
573	20.2	0.1581		630	20.6	3.16	0.087223*	814	34.33	701	27.14				
611	22.5	0.1565		649	21.8	3.34	0.087238	869	38.74	705	27.75*				
638	23.7	0.1566		690	24.3	3.56	0.087248*	931	44.36	711	27.83				
664	26.4	0.1585		712	25.8	3.75	0.087263*	965	47.16	714	27.88*				
683	25.7	0.1589		733	27.1	3.96	0.087281*			718	28.00				
700	26.7	0.1584		752	28.6	4.22	0.087302			718	28.05*				
716	27.7	0.1595		764	30.3	4.61	0.087317*			721	27.51				
733	28.6	0.1595		789	31.8	4.82	0.087355*			721	27.73				
761	30.5	0.1585		815	34.6*	5.11	0.087381	401	10.6	725	27.59*				
788	32.5	0.1589		851	38.2	5.28	0.087400*	435	11.62	730	27.88				
814	34.6	0.1594		870	39.7	5.49	0.087423*	476	13.47	735	28.13				
847	37.6	0.1600		895	42.5	5.69	0.087445*	490	14.24	742	28.60				
895	41.7	0.1604						505	14.66	749	29.10*				
935	45.4	0.1612		1433	91.8	6.16	0.087497*	526	16.13	757	29.77				
		0.1622		1685	101.4	6.36	0.087521	596	20.47	768	30.51				
								613	21.42	860	37.95				
								633	22.53	919	43.80				
										955	47.15				

* Not shown in figure.

TABLE 6. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COBALT
(continued)

T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P
<u>DATA SET 14</u>															
DATA SET 15(cont.)															
DATA SET 17															
384	9.44	1428	89.72	273	5.6	299	6.90	131.8	1.7419	4.2	0.0907*				
458	12.39	1455	91.04					141.9	1.9810*	12.91	0.0922				
559	18.15	1458	91.21*	DATA SET 18		DATA SET 21*		156.3	2.3155	15.31	0.0933				
605	21.05	1461	91.82*					171.8	2.7038	18.07	0.0958*				
626	22.14*	1483	92.17	1768	126.478	299	6.25	182.0	2.9324*	21.53	0.0991				
645	23.24*			1788	127.246			191.4	3.2178	24.83	0.1048				
652	23.66	DATA SET 16		1808	128.014	DATA SET 22		206.5	3.5710	27.42	0.1122				
659	23.94*			1828	128.782			225.9	4.2580	31.05	0.1250				
665	24.00*	77	0.44	1848	129.550	299	6.24	253.5	5.0140	34.36	0.1418				
667	24.00*	173	2.65	1868	130.318			261.2	5.2917	39.81	0.1707				
669	23.92*	223	3.84	1888	131.086	DATA SET 23*		271.0	5.4120	53.95	0.2786				
671	23.89	273	5.25	1998	131.470			292.4	6.1254*	63.10	0.3804				
673	23.85*	323	6.81			299	6.91			68.55	0.4726				
674	23.87*	373	8.52	DATA SET 19				DATA SET 27		76.38	0.6047				
676	23.91*	423	10.50							86.31	0.7970				
677	24.02*	473	12.80	1.18	0.013658	DATA SET 24*				88.31	0.7970				
680	24.22	523	15.45	1.31	0.013668	299	6.48	4.2	0.0902	143.5	2.0322				
684	24.63*	573	18.38	1.39	0.013668			11.56	0.0914	317	8.7				
692	24.97	623	21.48	1.49	0.013675	DATA SET 25		12.74	0.0921	362	10.2				
709	26.16	673	26.72	1.60	0.013680			12.88	0.0919*	479	15.5				
725	27.29	698	26.55	1.69	0.013684	299	6.58	14.59	0.0926						
734	28.00	723	28.00	1.78	0.013688			15.49	0.0933*	273	7.1				
756	29.43	748	29.25	1.88	0.013693	DATA SET 26		16.07	0.0943*	317	8.7				
		773	30.65	1.97	0.013698			16.83	0.0942*	362	10.2				
		823	34.72	2.08	0.013705			18.20	0.0958	479	15.5				
		873	39.05	2.19	0.013711	DATA SET 27		19.59	0.0974						
1032	58.24	923	43.66	2.28	0.013715			22.1	0.1328	22.03	0.0998	668	26.4		
1049	58.85	973	48.20	2.40	0.013732			25.2	0.1441	26.24	0.1088	684	26.8		
1074	60.87	1023	52.85	2.50	0.013732			27.9	0.1516	28.91	0.1172*	698	26.8		
1114	64.10	1073	57.92	2.59	0.013732			31.8	0.1660	32.06	0.1295	711	26.8		
1133	68.56	1123	62.95	2.69	0.013740			35.3	0.1788	34.91	0.1495*	745	28.7		
1154	68.56	1173	68.20	2.80	0.013746			38.7	0.1965	37.84	0.1664	775	32.4		
1171	70.05	1223	73.48	2.89	0.013765			43.1	0.2208	54.83	0.2972	815	35.3		
1223	74.94	1273	78.45	3.00	0.013772			48.5	0.2662	59.70	0.3461	843	38.1		
1231	76.69	1323	82.97	3.09	0.013780			53.5	0.3203	64.27	0.4445	882	40.8		
1255	78.44	1348	85.27	3.19	0.013790			60.7	0.3954	67.45	0.4508	916	43.2		
1280	79.32	1373	87.45*	3.29	0.013797			65.3	0.4726	74.30	0.5655	960	48.6		
1283	80.63*	1398	89.17	3.40	0.013810			71.6	0.5660	84.33	0.7359	1065	59.2		
1373	87.45	1423	90.60	3.50	0.013822			73.3	0.5974*	91.62	0.8827	1159	69.1		
1407	88.85	1468	91.62	3.59	0.013834			77.4	0.6547	105.9	1.184	1246	76.6		
1420	90.07	1473	92.65	3.69	0.013843			81.3	0.7177	122.2	1.563	1315	82.4		
1440	86.05	1523	94.35	3.79	0.013859			84.7	0.7791*	162.6	2.506	1378	88.5		
1470	87.45	1573	96.52	3.89	0.013867			89.7	0.8671*	187.5	3.159				
1474	87.45	1623	98.17	3.99	0.013875			93.8	0.9612*	205.6	3.646				
1477	99.95	1673	100.0	4.09	0.013888			100.0	1.0694	224.4	4.136				
1482	99.95	1673	100.0	4.18	0.013898			105.2	1.1966*	243.2	4.630				
1484	83.86*	1321	84.27											2.5	0.45
1485	86.05	1340	87.45*											4.2	0.45
1486	87.45	1373	87.45											20.6	0.46

Not shown in figure.

TABLE 6. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COBALT
(continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	$T - \rho_0$		
<u>DATA SET 30(cont.)</u>																
		<u>DATA SET 36(cont.)</u>				<u>DATA SET 41</u>				<u>DATA SET 43(cont.)</u>		<u>DATA SET 45(cont.)*</u>		<u>DATA SET 47 (cont.)*</u>		
83	1.24	1261	75.2	1720	95.8	800	32.056	690.8	24.786	41.1	0.0701					
293	6.85	1284	77.4	1732	94.8	900	40.377	691.0	24.561	44.1	0.0807					
		1298	78.8	1746	96.8	1000	49.562	691.4	24.481	46.1	0.0998					
		<u>DATA SET 31</u>	81.3	1765	97.8	1100	59.259	692.0	24.348	50.6	0.1118					
4.2	1.24	1356	83.6	1769	109.3	1200	69.116	693.0	24.308	50.6	0.132					
20.6	1.37	1372	83.6	1780	115.1	1250	73.995	694.0	24.348	56.6	0.507					
83	2.22	1407	85.4	1784	116.1	1300	78.78	694.8	24.467			<u>DATA SET 48*</u>				
293	8.07	1423	86.3	1811	114.3	1400	87.17	696.0	24.493							
		1434	86.5*	1828	115.3	1500	91.37	696.0	24.625							
1.35	2.0230	1470	88.1	1844	115.3	1600	94.86	700.2	24.757	5.61	0.000189					
4.22	2.0498	1488	89.6*	1854	116.3	1700	97.62	702.0	24.903	6.44	0.000545					
		<u>DATA SET 32</u>	1496	89.2		<u>DATA SET 42</u>			<u>DATA SET 44*</u>	707.0	25.114	7.40	0.000659			
20.44	2.1004	2044	2.4653	1213	76.3	1205	73.2	679.8	25.212	705.0	25.246	7.57	0.000834			
273.2	5.57	1242	79.1	1452	89.7	1327	82.4	684.8	25.595	707.0	25.866	8.13	0.000628			
		<u>DATA SET 33</u>	1284	82.5	1561	93.9	1452	88.2	688.2	25.846	<u>DATA SET 46</u>	9.56	0.000916			
4.5	0.0896	1427	91.1	1675	97.8	1675	97.8	696.7	26.493	77.84	0.655	11.5	0.00127			
295	9.677	1468	92.7	1379	88.8	1763	100.8	697.9	26.599	194.4	3.158	18.3	0.00368			
		<u>DATA SET 34</u>	1470	91.1	1763	114.7	1763	100.8	699.1	26.652	273.2	5.23*	22.0	0.00512		
86.92	1.0188	773	28.50	3057	129.3	2231	118.7	701.1	26.823	273.2	5.23*	23.1	0.00801			
273.2	5.57			3108	129.8	2995	120.7	701.7	26.876	299.0	6.02*	24.7	0.00923			
		<u>DATA SET 35</u>	4.2	0.062		<u>DATA SET 43</u>	4.2	0.062	299.7	6.04*	299.7	6.04*	28.4	0.0196		
1.36	0.3476	126	1.512	90	0.744	706.0	25.763	703.1	26.929	299.7	6.04*	30.4	0.0273			
4.22	0.3387	163	2.312	100	0.939	703.5	26.942	703.5	26.942	703.5	26.942	8.13	0.0314			
20.41	0.3258	183	2.862	125	1.461	704.5	26.498	704.5	26.498	704.5	26.498	9.56	0.000157			
20.55	0.3264*	190	3.052	150	2.018	705.3	26.107	705.3	26.107	705.3	26.107	10.0	0.000914			
78.30	0.8844*	230	4.062	200	3.214	706.0	25.763	706.0	25.763	706.0	25.763	10.7	0.001018			
88.16	1.0589	244	4.402	250	4.527	708.8	25.497	708.8	25.497	708.8	25.497	11.7	0.001113			
		<u>DATA SET 36</u>	250	4.582*	300	5.995	709.0	25.497	710.0	25.497	710.0	25.497	11.0	0.001113		
1158	65.2	273	5.182	400	9.542	687.6	25.515	687.6	25.515	687.6	25.515	12.6	0.00161			
1195	68.8	2118	71.1	1923	109	500	14.118	688.4	25.462	27.1	0.0155	57.8	19.7	33.4	43.1	
		<u>DATA SET 40*</u>	600	19.872	600	25.382	689.4	25.382	689.4	25.382	689.4	25.382	101.1	51.0	51.0	
			700	26.590	701	25.015	690.2	25.051	690.2	25.051	690.2	25.051	111.4	58.2	58.2	

* Not shown in figure.

TABLE 6. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COBALT Co (continued)

T	P	T	P
<u>DATA SET 49 (cont.)</u>			
1224	69.0	1883	122.8
1253	71.5	1895	123.05
1304	76.5		
1414	86.0		
1506	89.9		
1579	92.7	1767	128.3
1627	95.6	1800	129.6
1730	98.5	1900	133.5
		2000	137.7
<u>DATA SET 50</u>			
1658	102.9		
1678	103.5	20.2	2.02
1694	104.0	81.8	2.38
1711	104.5	198.4	3.89
1735	105.25	273.09	5.18
1755	109.0		
1765	120.4		
1781	120.75		
1788	120.85	1.20	0.828
1801	121.1	4.2	0.839
1811	121.25		
1820	121.5		
1829	121.6		
1846	121.95	0.06	0.157
1850	122.0	1.20	0.157
1867	122.35	1.36	0.156
1870	122.4*	4.2	0.156
1881	122.6		
1888	122.75		
<u>DATA SET 51*</u>			
1764	120.5		
1782	120.8		
1795	121.15		
1801	121.2		
1809	121.4		
1819	121.55		
1823	121.65		
1836	121.9		
1843	122.05		
1854	122.25		
1863	122.4		
1869	122.5		
1878	122.7		

* Not shown in figure.

3.3. Iron

The electrical resistivity of iron has been studied extensively. There are 223 sets of experimental data available for iron specimens of purity 99.8% or higher. The information on specimen characterization and measurement condition for each of the data sets is given in table 8. The data are tabulated in table 9 and shown partially in figures 5 and 6.

Because of magnetic effects, the residual resistivity of iron has been studied with intense interest. Berger and De Vroomen [111] suggested that the residual resistivity measured in the absence of an applied magnetic field is not an indication of the purity of an iron specimen. Fujii and Morimoto [112] suggested that the magnetic contribution to the residual resistivity is $\sim 0.02 \times 10^{-8} \Omega \text{m}$; a value also agreed upon by Volkenshteyn and Yakina [113]. Thus, even for zone-refined iron, the residual resistance ratio, RRR, has low values of ≤ 400 as compared with values of a few thousand or even higher for other pure metals. The more recent results of Takaki and Igaki [114] seem to indicate that even for iron that has been highly purified by anion exchange separation, floating-zone melting and hydrogen treatment, the residual resistance ratio has a limiting value of about 500. It is worth noting, however, that the quantity RRR_H , the residual resistance ratio obtained as the minimum value from resistivity measurement as a function of an applied longitudinal magnetic field, of some of their specimens are greater than 2000. The same group of authors [115] later reported RRR_H values of over 10,000 on specimens that had been electrolytically polished to remove silicon contamination on the surface layer (of thickness $\sim 100 \mu\text{m}$). The resistivity of iron is also dependent on the density of the measuring current [114]. The results of Takaki and Igaki [114] on specimens of various purity showed that the current density dependence is negligible for specimens having RRR (or RRR_H) values of ≤ 100 . For RRR values higher than 200, or RRR_H values of ≥ 1000 , the resistivity may still be increasing with measuring current at current density values of $> 6 \times 10^6 \text{ A m}^{-2}$. The limiting RRR value of 500 quoted above was for a measuring current density of $\sim 5 \times 10^5 \text{ A m}^{-2}$ [114]. This result appears to agree with that of Glaeser et al. [116], even though the magnetic field and current density dependences reported by these two works show some discrepancies. The recommended value for the electrical resistivity of iron at the temperature of 1 K is based on these

references and subject to the condition that the measuring current is $< 1 \times 10^6 \text{ A m}^{-2}$ in the absence of an applied magnetic field. It should represent the value for the electrical resistivity of iron purified by modern electron-beam zone-refining techniques.

The electrical resistivity of iron is dependent on other factors. The most notable factors are the external magnetic field and the magnetic domain structure of the specimen itself. The effects of the former have been investigated mostly at 4 K [112,116-120], and those of the latter have been investigated chiefly for single crystal whisker specimens [121-125]. These effects, together with the effect of the measuring current, are inter-related and are not fully investigated. A resolution of these effects is clearly beyond the scope of this work. Hence, only the conditions "in the absence of an external applied magnetic field" and "with a measuring current of $< 1 \times 10^6 \text{ A m}^{-2}$ " are specified. The latter condition is chosen such that the (transverse) magneto-resistance due to the self-induction of the measuring current would not adversely affect the resistivity value.

The electrical resistivity of iron at low temperatures has been reported to contain a T^2 component; see, for example, White and Woods [21], Volkenshtein and Yakina [113], Semenenko and Sudovtsov [126], Fert and Campbell [127], Price and Williams [80], and Janos et al. [128]. However, Kondorskii et al. [129] reported $T^{1.5}$ and T^5 components. More recently, Isshiki and Igaki [115] reported that the temperature dependent part of the resistivity, when measured in a longitudinal magnetic field of 60 K A m^{-1} , can be fitted to a T^2 term and a Bloch-Grüneisen term with $\theta_R = 467 \text{ K}$ for temperatures 1 to 250 K.

A similar analysis [115] on the data of Kemp et al. [130] (data set 31), Kemp et al. [131] (data set 11), White and Woods [21] (data set 86), Fert and Campbell [127] (data set 119), Schwerer et al. [132] (data set 107), Volkenshtein and Yakina [113] (data set 209), and of Hust and Giarratano [133] (data set 47) indicates that, even without an applied longitudinal magnetic field, the electrical resistivity of iron can be represented by eq (8) for temperatures up to about 100 K. The values of A and θ_R in the Bloch-Grüneisen term were taken to be $58.1 \times 10^{-8} \Omega \text{m}$ and 467 K [115], respectively. The coefficient of the quadratic term varies approximately from 1.1 to $3.4 \times 10^{-13} \Omega \text{m K}^{-2}$. There seems to be some correlation between the values of the coefficient and the residual resistivities, i.e., a specimen with a low residual resistivity seems

to have a low coefficient (data sets 11, 86, 209) and vice versa (data sets 31, 47). However, with only a few data sets available, a definite relationship between the residual resistivity and the coefficient in the quadratic term cannot be established. Furthermore, the reported T^2 dependence of the electrical resistivity extends probably to temperatures below 1 K [126], whereas most of the authors report data to 2 K or higher. One way of circumventing this problem is to assume that the resistivity can be fitted to a residual term plus a quadratic term below 20 K (the T^5 or the Bloch-Grüneisen term is negligible compared with the other two terms at these temperatures), and the residual term, taken to be the value at 1 K, is obtained by extrapolation. The recommended values for the electrical resistivity of iron below 100 K are obtained by this procedure. The values of the quantities A and θ are taken to be the same as those given by Isshiki and Igaki [115], i.e., $58.1 \times 10^{-8} \Omega m$ and 467 K, respectively. The value of the coefficient of the T^2 term is $1.3 \times 10^{-13} \Omega m K^{-2}$. This was obtained both by a graphical method where the logarithm of the quantity

$$\left(\rho_{\text{measured}} - \rho_0 - A \left[\frac{T}{\theta R} \right]^5 \int_0^{\theta R/T} \frac{x^5 e^x}{(e^x - 1)^5} dx \right)$$

is plotted against $\log T$, and also by numerically fitting the same quantity to a quadratic function in temperature. This value is in agreement with that suggested by White and Woods [21], but is somewhat below the value of $2.2 \times 10^{-13} \Omega m K^{-2}$ given by Isshiki and Igaki [115] for their highly purified specimens measured in an applied magnetic field of $60 KAm^{-1}$.

At temperatures above ~ 100 K, there is a slight change in the temperature dependence of the electrical resistivity. A log-log plot of the quantity

$$\rho_{\text{measured}} - \rho_0 - A \left[\frac{T}{\theta R} \right]^5 \int_0^{\theta R/T} \frac{x^5 e^x}{(e^x - 1)^2} dx$$

against T for the data of White and Woods [21] (data set 86), Richter and Kohlhaas [134] (data set 43), Moore et al. [135] (data set 17), Fulkerson et al. [136] (data set 16), Hust and Giarratano [133] (data set 47), Kohlhaas and Richter [137] (data set 34), and of Dewar and Fleming [138] (data set 53) shows a decrease from the T^2 line starting at ~ 100 K. This departure from the T^2 line is at a maximum of about $0.05 \times 10^{-8} \Omega m$ at ~ 140 K. At higher temperature,

the temperature dependence becomes stronger, with a temperature dependence that approaches a T^3 function. It is interesting to note that the same plot on the data of Kemp et al. [130] (data set 31) shows a slight increase at ~ 100 K. It is not obvious whether this behavior is purely a magnetic effect or an impurity effect. The specimens of Isshiki and Igaki [115] (data sets 219-223) are supposed to be purged of metallic impurities and to contain approximately 0.001 at.% C, 0.0007 at.% O, and <0.0001 at.% N, whereas the specimen of White and Woods [21] (data set 86) contains about 0.03% of mostly metallic impurities. The electrolytic iron specimen of Hust and Giarratano [133] (data set 47) contains about 0.1% also of mostly metallic impurities. The specimen of Moore et al. [139] (data set 15) contains $\leq 0.01\%$ Ni, $\leq 0.01\%$ Si, and lesser amounts of other impurities, and the specimen of Fulkerson et al. [136] (data set 16) contains $\leq 0.02\%$ Si, 0.014% C, $<0.01\%$ Ni, and lesser amounts of other impurities. On the other hand, the magnetoresistance of iron is positive at room temperatures (see, for example, Kornetzki [140], Schindler and La Roy [118]), and negative at helium temperatures (see, for example, Fujii and Morimoto [112], Glaeser et al. [116], and Arajs et al. [119]). From the only available data by Shirakawa [141] and by Matuyama [142] on electrolytic iron at intermediate temperatures, the magnetoresistance of iron changes sign at ~ 77 K. For the lack of definite conclusion, this behavior is ignored at the present, and the resistivity value is assumed to follow the relation

$$\rho = \rho_0 + \alpha T^2 + A \left(\frac{T}{\theta_R} \right)^5 \int_0^{\theta_R/T} \frac{x^5 e^x}{(e^x - 1)^2} dx \quad (8)$$

up to 200 K. This assumption may result in a maximum probable error of only $\pm 1\%$ or $-0.03 \times 10^{-8} \Omega m$ at ~ 150 K.

At temperatures above 150 K, and up to the Curie temperature, there are a number of data sets that agree with each other to within $\pm 2\%$: Moore et al. [139] (data set 15), Fulkerson et al. [136] (data set 16), Wallace et al. [143] (data set 21), Pallister [144] (data set 22), Jaeger et al. [145] (data set 24), Kohlhaas et al. [137] (data set 33), Kierspe et al. [78] (data set 39), Richter and Kohlhaas [134] (data set 43), Powell et al. [146] (data set 77), and Lauchbury and Saunders [147] (data set 217). Among these sources, Fulkerson et al. [136] (data set 16) reported also the resistivity at 4 K, and Moore

et al. [135] (data set 17) reported the residual resistivity ratio. Greater weight is given to the data of Moore et al. Most of these data sets appear to have resistivity values slightly higher than $9 \times 10^{-8} \Omega\text{m}$ at 273 K, except for data sets 17 and 22. Judging from the ice point resistivity values and from the temperature variation of the solute resistivities of various elements in iron (see, for example, Schwerer and Cuddy [148]), it appears that the specimen of Moore et al. [135] (data set 17) is the purest among these groups, and its resistivity values at 90 K are within 2% of the recommended values based on the analysis of the available low temperature data described earlier. The recommended values within the range of ± 100 K of the ice point are, therefore, based on data set 17, and in the higher temperature range up to 900 K they are based on the data sets mentioned above. Both graphical and numerical methods in curve fitting are employed. It is found that the electrical resistivity of iron can be represented by a cubic polynomial at temperatures from about 200 to 900 K.

For temperatures higher than 900 K and up to the Curie temperature, the electrical resistivity of iron increases more rapidly with temperature. Even though there are detailed accounts on the temperature derivative of the resistivity, the agreement between them is not good (see, for example, Lauchbury and Saunders [147] and Seehra et al. [149], the values of $d\rho/dT$ from these two accounts differ by $\sim 40\%$ at 1030 K). The value of the Curie temperature has been reported to be 1040.3 ± 1 K (Seehra et al. [149]), 1038–1043 K (Fulkerson et al. [136]), 1051–1055 K (Morris [150]), 1044 ± 2 K (Arajs and Colvin [151]), 1037 K (Richter and Kohlhaas [134]), 1027 K (Kohlhaas and Richter [137]), 1042.7 K (Lauchbury and Saunders [147]), and 1036 K (Wallace et al. [143]). The last authors also reported a Curie temperature of 1042 K from their specific heat measurements. In view of the wide spread of the reported values, a Curie temperature of 1043 K is adopted from the AIP Handbook [152]. The recommended values below this temperature are based on the data of Lauchbury and Saunders [147] (data set 217), with slight adjustments so that they would merge smoothly with the recommended values at lower temperatures. The recommended value at the Curie temperature, $101.1 \times 10^{-8} \Omega\text{m}$, is within 0.3% of the values given by Lauchbury and Saunders [147].

At temperatures above the Curie point, the differences between reported resistivity values from the above references become greater, even though they

are generally still within 2% of each other. The recommended values from the Curie temperature to the α - γ transition are based mainly on the results of Fulkerson et al. [136] (data set 16), Wallace et al. [143] (data set 21), and also of Powell et al. [146] (data sets 75-77). There are other detailed accounts on the resistivity at temperatures close to the α - γ transition: Kohlhaas and Richter [137] (data sets 37-38), Arajs and Colvin [151] (data sets 57-58), and Bullock [153] (data sets 98-99). However, there are wide discrepancies among these data sets. The data of Bullock and of Kohlhaas and Richter are too high and too low, respectively. The specimen of Arajs and Colvin showed some unexplained behavior, its residual resistivity ratio changed by +13% after the high temperature measurement, and the resistivity value at room temperature appeared to be too high for a zone-refined specimen. The onset of the α - γ transition, Ac_3 point, has been reported at 1188-1189 K (Moore et al. [139]), 1189 K (Kohlhaas and Richter [137]), 1189.7 K (Richter and Kohlhaas [134]), and has been inferred from graphical illustrations at about 1182 K (Powell et al. [146] data set 75), 1183 K (Arajs and Colvin [151] data set 57), 1187 K (Kohlhaas and Richter [137] data set 37), and 1186 K (Bullock [153] data set 98). Because of the lack of general agreement, the transition temperature is taken to be 1185 K, a value deduced from thermal expansion data [42].

As mentioned earlier, there are detailed reports on the behavior of the electrical resistivity at the α - γ transition. Not surprisingly, all these reports show that the transition occurs over a finite temperature range: ~ 4 K according to Powell et al. [146], Arajs and Colvin [151], and Bullock [153], and ~ 5 K according to Kohlhaas and Richter [137]. All reported a hysteresis effect: in the transition region, the resistivity values measured at decreasing temperatures were lower than those measured at increasing temperatures. The temperature for the onset of the γ - α transition upon cooling, the Ar_3 point, is also reported to be somewhat lower than the Ac_3 point. The latter three groups of authors also reported that the resistivity of α -iron at temperatures about one degree below the Ar_3 point after being cooled from the γ phase is higher than that of the α -iron after being heated from lower temperatures. In view of these and of the lack of such evidence from the data of Powell et al. [24] (data sets 75-77), this behavior is ignored at the present time. It is probable that such behavior is dependent upon specimen purity and its thermal history and mechanical history as well. Even though recommended values are

given at a single transition temperature (for both the α and the γ phases), the transition for a given specimen may be expected to occur over a small temperature range of approximately 1180-1190 K. Its resistivity below 1185 K may be somewhat ($<0.5 \times 10^{-8} \Omega\text{m}$) lower than the recommended value and vice versa above 1185 K.

There are relatively fewer data sets available for temperatures above the α - γ transition. The data sets which are considered reliable and from which the recommended values are derived are generally for temperatures less than ~ 1300 K. For higher temperatures, close to the γ - δ transition, the data of Cezairliyan and McClure [154] (data sets 62-63) appear to merge well with extrapolations of the data of Fulkerson et al. [136] (data set 16) and of Wallace et al. [143] (data set 21). The recommended values from the α - γ transition to the γ - δ transition are based on these data sets. At temperatures immediately above the α - γ transition, the data of Powell et al. [146] (data sets 75-76) are also taken into account.

There are only a few data sets for the electrical resistivity of δ -iron. The recommended values are based on the results of Cezairliyan and McClure [154] (data sets 62 and 64), Güntherodt et al. [92] (data set 206), and Powell [155] (data set 138). The slight upturn in the resistivity value at temperatures close to the melting point is based on the latter two data sets. This upturn seems to be substantiated by the data of Baum et al. [156] (data set 114) and of Kita et al. [93] (data sets 212-214). There exists only two reports on the change of resistivity value at the γ - δ transition, by Cezairliyan and McClure [154] (data sets 62-65), and by Kierspe et al. [78] (data set 41). Both indicate a slight increase in resistivity from the γ to the δ phase. No hysteresis has been reported.

There are in excess of 10 data sets available for the electrical resistivity of molten iron. Some of these: Güntherodt et al. [92] (data set 206), Kita et al. [93] (data sets 211-213), Baum et al. [156] (data set 114), Arsentiev et al. [157] (data sets 215-216), Ono and Yagi [89] (data set 115), and Eliutin et al. [88] (data set 92) cover the transition from the solid to the molten state. The last authors reported a decrease in resistivity upon melting for an impure specimen ($\sim 99.0\%$ purity), in agreement with an earlier measurement on Armco iron by Mokrovskii and Regel [158], whose result has been widely quoted. However, the more recent measurements on purer specimens reported

in the references mentioned above all show an increase. The majority of the reported data show a linear dependence on temperature, and the data of Seydel and Fucke [87] (data set 205) which were obtained by a pulse-heated exploding wire technique show that the linear dependence is applicable up to 3000 K. The recommended values are based on the data of Güntherodt et al. [92] (data set 206) and Kita et al. [93] (data sets 212-214), both of which are obtained by steady state methods. Values above 1900 K are extrapolated according to a linear temperature dependence. The value at 3000 K is about 7% higher than that of Seydel and Fucke [87]. A few of the available data sets are obtained by the rotating field method: Ono and Yagi [89] (data set 115), Levin et al. [91] (data set 112), Baum et al. [156,159] (data sets 114,121), and Samarin [94] (data set 137). The reported data among this group show relatively large variations, but are still within 4% of the recommended values.

The recommended values both uncorrected and corrected for thermal expansion of the material are presented in table 7, while only the uncorrected values (except those for the liquid state) are shown in figures 5 and 6 along with the experimental data. These values at temperatures above 200 K are for iron of purity 99.99% or higher, while those below 200 K are applicable only to highly purified zone-refined iron having a residual resistivity of $0.0200 \times 10^{-8} \Omega\text{m}$. The estimated uncertainty in the recommended values is $\pm 5\%$ below 100 K, $\pm 3\%$ from 100 to 200 K, and $\pm 2\%$ above 200 K up to the melting point. The uncertainty at temperatures immediately above the melting point is about $\pm 5\%$, increasing to $\pm 10\%$ at the highest temperatures.

For slightly less pure iron having different residual resistivity, its electrical resistivity values can be calculated from the recommended values using the Matthiessen's rule, which will not introduce serious errors. For example, using Matthiessen's rule for the specimen of Moore et al. [135] (data set 17) gives discrepancies of $+1.7\%$ (compared with the measured data) at 90 K, -2% at 260 K, and $<0.1\%$ at 400 K. That for the specimen of White and Woods [21] (data set 86) gives discrepancies of -0.5% at 11 K, -1.3% at 22 K, $+1.6\%$ at 98 K, -1.8% at 178 K, and -1.4% at 273 K. And that for the specimen of Fulkerson et al. [136] (data set 16) gives -1% at 77.5 K, $+0.6\%$ at 194 K, and -1% at 273 K. Thus, it does appear that using the Matthiessen's rule and the recommended values will give resistivity values for a specimen with residual resistivity lower than $0.4 \times 10^{-8} \Omega\text{m}$ to within $\pm 2\%$, subject to the uncertainties

in the recommended values specified in the preceding paragraph. The applicability of Matthiessen's rule, to within the possible error of $\pm 2\%$, also seems to be confirmed for a more commonly available material, the electrolytic iron. For example, using the rule and comparing with the data of Hust and Giarratano [133] (data set 47) for SRM Iron-1265 gives discrepancies of -1% at 100 K, -0.9% at 200 K, and -1.5% at 280 K. Since deviations from the Matthiessen's rule for dilute iron alloys are positive (see, for example, Bass [160]), its application in calculating the electrical resistivity of an iron specimen lower in purity is likely to result in an underestimate, especially around room temperature where the deviation from Matthiessen's rule approaches a maximum. At high temperatures, the relative error introduced by the application of Matthiessen's rule should diminish with increasing temperature.

The recommended values uncorrected for thermal expansion given in table 7 can be represented approximately by the following expressions to within $\pm 0.1\%$.

1-200 K:

$$\rho = 0.02 + 58.1 \left(\frac{T}{467} \right)^5 \int_0^{467/T} \frac{e^x x^5}{(e^x - 1)^5} dx + 1.3 \times 10^{-5} T^2 \quad (26)$$

200-900 K:

$$\rho = -1.120747752 + 2.261529506 \times 10^{-2} T + 3.913892564 \times 10^{-5} T^2 + 2.952608182 \times 10^{-8} T^3 \quad (27)$$

900-1020 K:

$$\rho = -513.9789758 + 1.70577020 T - 1.804410343 \times 10^{-3} T^2 + 7.034546961 \times 10^{-7} T^3 \quad (28)$$

1020-1143 K in the vicinity of the Curie temperature, T_C :

$$\rho = 101.13 - 2.984305206 \times 10^{-1} (T_C - T) + 1.905714112 \times 10^{-3} (T_C - T)^2 - 1.3355493086 \times 10^{-5} (T_C - T)^3 \quad (29)$$

1043-1070 K:

$$\rho = 101.13 + 2.020277018 \times 10^{-1} (T - T_C) - 5.420505212 \times 10^{-3} (T - T_C)^2 + 1.294364953 \times 10^{-4} (T - T_C)^3 - 1.243596538 \times 10^{-6} (T - T_C)^4 \quad (30)$$

1070-1185 K:

$$\rho = -1309.064808 + 3.419572717 T - 2.773870769 \times 10^{-3} T^2 + 7.595259559 \times 10^{-7} T^3 \quad (31)$$

1185-1667 K:

$$\rho = 55.0861977 + 5.289665269 \times 10^{-2}T + 9.77621850 \times 10^{-12}T^2 - 4.0798019 \times 10^{-9}T^3 \quad (32)$$

1667-1811 K:

$$\rho = -11976.94918 + 21.0981583 T - 1.226701138 \times 10^{-2}T^2 + 2.378811917 \times 10^{-6}T^3 \quad (33)$$

1811-3000 K:

$$\rho = 135.2 + (T-1811) \times 1.545 \times 10^{-2} \quad (34)$$

It should be emphasized that these expressions do not necessarily suggest any theoretical justification, and should be treated, most appropriately, as numerical aids only. It should also be understood that giving these expressions does not imply a recommendation for the temperature derivative of the electrical resistivity.

TABLE 7. RECOMMENDED VALUES FOR THE ELECTRICAL RESISTIVITY OF IRON^a[Temperature, T, K; Electrical Resistivity, ρ , $10^{-8} \Omega \text{m}$]

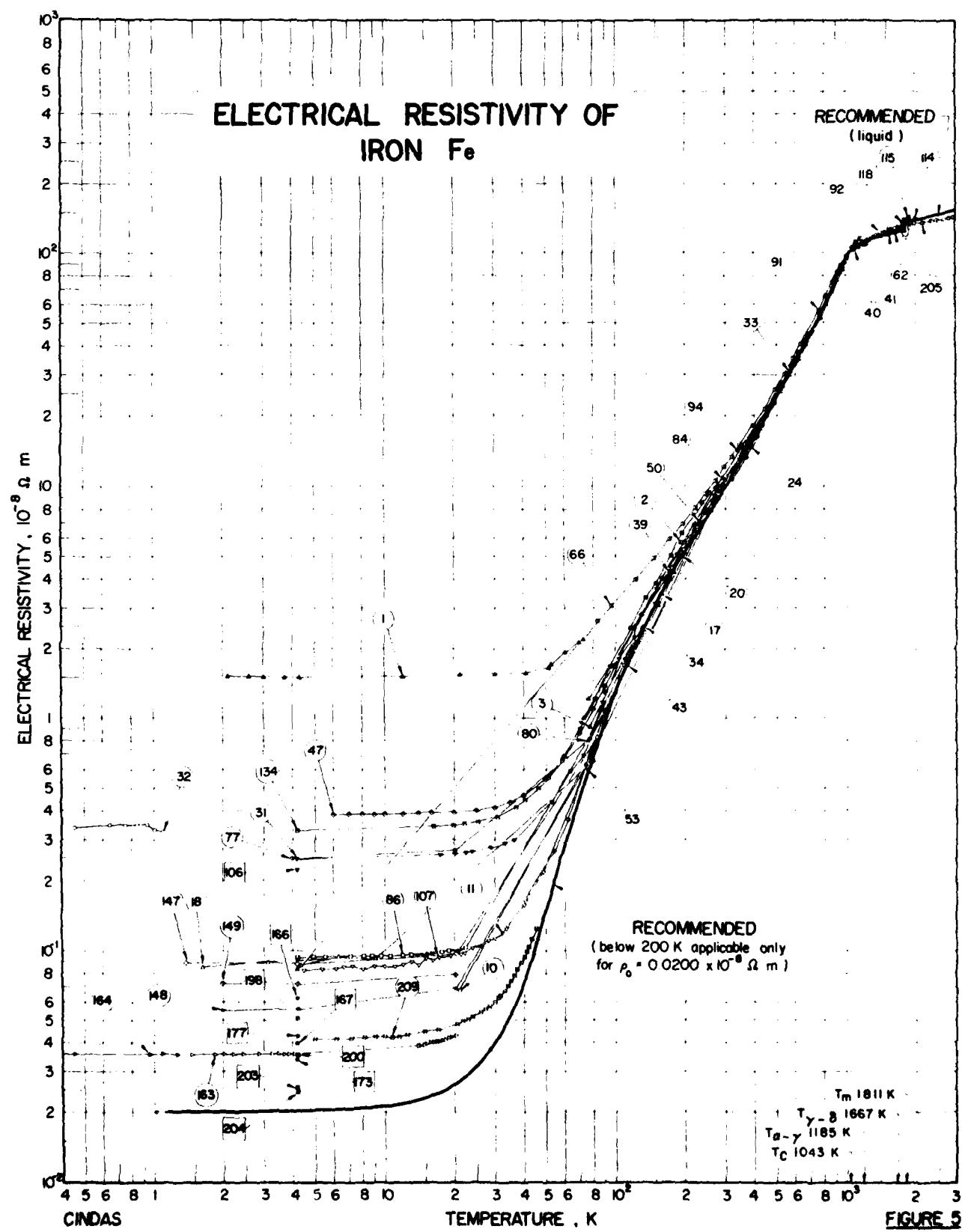
T	ρ		T	ρ	
	uncorrected	corrected		uncorrected	corrected
1	0.0200	0.0200	800	57.14	57.56
4	0.0202	0.0202	900	72.46	73.11
7	0.0206	0.0206	1000	90.80	91.76
10	0.0213	0.0212	1043	101.1 ^b	102.2 ^b
15	0.0232	0.0231	1100	107.0	108.3
20	0.0262	0.0261	1150	110.1	111.5
25	0.0313	0.0312	1185	111.9(α)	113.4(α)
30	0.0396	0.0395	1185	111.0(γ)	112.1(γ)
40	0.0733	0.732	1200	111.5	112.6
50	0.145	0.145	1300	114.9	116.4
60	0.268	0.267	1400	117.9	119.7
70	0.449	0.448	1500	120.7	122.8
80	0.690	0.689	1600	123.0	125.4
90	0.964	0.962	1667	124.4(γ)	127.0(γ)
100	1.28	1.28	1667	124.6(δ)	
150	3.16	3.16	1700	125.4	
200	5.20	5.19	1800	127.9	
250	7.44	7.44	1811	128.6(δ)	
273	8.57	8.57	1811		135.2 ^c (ℓ)
293	9.61	9.61	1900		136.6 ^c
300	9.98	9.98	2000		138.2 ^c
400	16.08	16.10	3000		153.6 ^c
500	23.66	23.72			
600	32.92	33.06			
700	44.02	44.27			

^a The values are for iron of purity 99.99% or higher, but those below 200 K are applicable only to iron having a residual resistivity of $0.0200 \times 10^{-8} \Omega \text{m}$. Columns headed uncorrected and corrected refer to values uncorrected and corrected for thermal expansion, respectively. Dotted lines separating tabular values indicate solid phase transitions and solid line indicates solid to liquid state transformation.

^b α : bcc; γ : fcc; δ :bcc.

^c Value at the Curie temperature.

^c Provisional value.

**FIGURE 5**

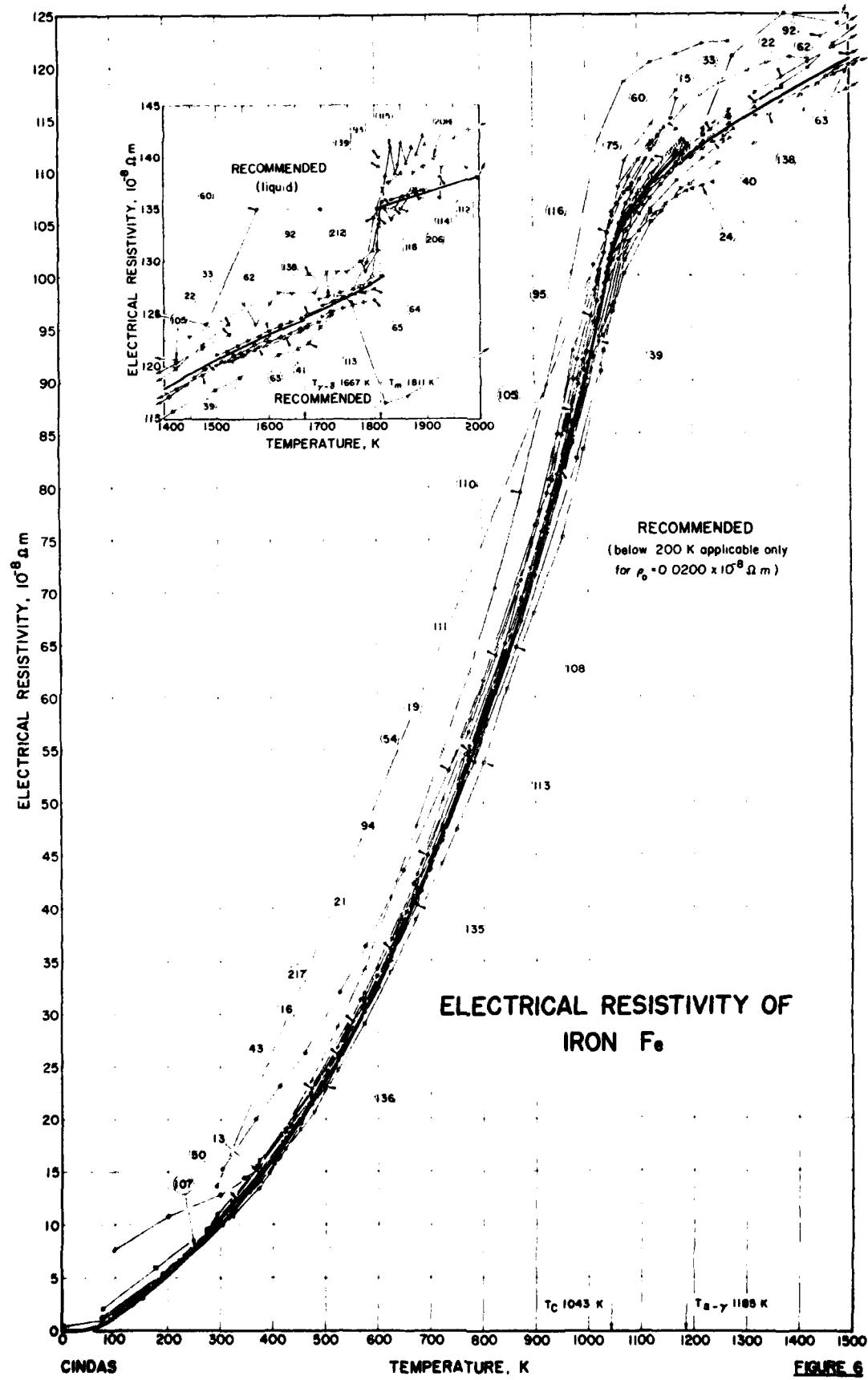


TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
1 129	Kondorskii, E.I., Galkina, O.S., and Chernikova, L.A.	1958		2.1-73		"Chemically pure"; annealed in vacuum at 1173 K for 1 h; furnace cooled; residual resistivity $1.458 \times 10^{-8} \Omega \text{m}$.
2 161	Broom, T.	1952	B	90-373		99.99 ⁺ Fe, 0.005 Ni, and 0.002 Cu (spectrographic analysis); wire specimen 0.056 cm (0.022 in.) in diam; drawn from 0.183 cm (0.072 in.) in diam; annealed at 873 K for 2 h; furnace cooled.
3 95	Wilkes, K.E.	1968	A	78-299	18 AF 3	99.96 Fe, 0.007 Cu, 0.0058 C, 0.004 Mn, 0.004 Si, 0.003 S, 0.0023 N, 0.002 Cr, 0.001 Al, 0.001 P, and 0.0008 O; 3.167 cm (1.247 in.) in diam and 10.44 cm long; prepared by National Physical Lab., England; density 7.872 g cm^{-3} at 297 K; resistivity values corrected for thermal expansion.
4* 162	Adroct, F. and Bristow, G.A.	1935	A	323-423	Batch 5	0.0045 C, 0.002 Mn, 0.0015 S, 0.0001 P, 0.0001 H, 0.0001 N, 0.0006 Ni, 0.0005 O, 0.0002 Si, traces of Al and Mg; prepared by chemical reduction of ferrous chloride; cold-rolled from 3 cm bar to 1 cm in diam; annealed at 1223 K for 2 h; density at 292 K, $7.871 \pm 0.002 \text{ g cm}^{-3}$; smoothed values from table.
5* 163	Eucken, A. and Dittrich, K.	1927		80,273	Electrolytic Iron; 1	Coarse-grained
6* 163	Eucken, A. and Dittrich, K.	1927		80,273	Electrolytic Iron; 2	Fine-grained
7* 163	Eucken, A. and Dittrich, K.	1927		80,273	Electrolytic Iron; 3	Obtained from Firma Heraeus.
8* 164	Grünsisen, E. and Goens, E.	1927		21-273	Iron 2	Technically pure; polycrystalline; electrolytically precipitated; unannealed.
9* 164	Grünsisen, E. and Goens, E.	1927		21-273	Iron 3	Electrolytic; repeatedly hammered; annealed at 773 K for 1 h.
10 164	Grünsisen, E. and Goens, E.	1927		21-273	Iron 1	Twice electrolytically refined; hammered and annealed.
11 131	Kemp, W.R.G., Klemens, P.G., and Tainish, R.J.	1959	A	4.2-293		Doubly refined electrolytic iron; $2.4 \times 1.7 \times 30 \text{ mm}$; cut from a precipitated plate; annealed at 1223 K; compressed, and reannealed in vacuum at 1223 K; sample material believed to be the same as Data Set 10 above.
12* 165	Powell, R.W. and Tye, R.P.	1967	A	323-523	Pure iron Sample No. 1	0.025 Ni, 0.01 Cu, 0.01 Mo, 0.007 Cr, 0.005 C, 0.004 O, 0.004 S, 0.004 V, 0.003 P, 0.001 Mn, <0.001 Si, 0.0006 N, and 0.000048 H; type 1, 1.27 cm in diam and 15 cm long; supplied by Metals Research, submitted for test by Tube Investments Ltd.

* Not shown in figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
13	165	Powell, R.W. and Tye, R.P.	1967	A	323-1073	Pure iron Sample No. 2	0.0055 Ni, 0.0053 Si, 0.0038 Al, 0.0035 S, 0.0002 Co, 0.0017 P, 0.0014 C, 0.001 Cr, <0.001 Mn, 0.0008 O, 0.0007 N, and 0.000016 H; short rod 1.27 cm diam prepared by Metallurgy Division of National Physical Lab.; machined from a disk.
14*	165	Powell, R.W. and Tye, R.P.	1967	A	323-523	Purefree iron Sample No. 6	0.08 Si, 0.03 C, 0.015 P, 0.01 Mn, and 0.01 S; 2.54 cm in diam and 20 cm long; supplied by Low Moor Best Yorkshire Iron Ltd.; 1) the above specimen measured at increasing temperatures; 2) the above specimen measured at decreasing temperatures.
15	139	Moore, J.P., Fulkerson, W., and McElroy, D.L.	1964	A	73-1273	High purity iron	0.001-0.01 Ni, 0.001-0.01 Si, 0.003 S, 0.0025 C, 0.0011 P, 0.0001-0.001 Al, 0.0001-0.001 Ca, 0.0001-0.001 Cu, 0.0005 N, and 0.0001 H; atomic percent, data here rounded off; prepared by arc melting Armco iron stock in pure inert atm to produce pancake shaped billets, rolled into sheets and cut to make feed stock for electron beam melting, then cast into 10.16 cm (4 in.) in diam and 15.24 cm (6 in.) long billet; trimmed off outside edges; rod specimen 38.10 cm (0.15 in.) in diam and 7.62 cm (3 in.) long, cut from center portion of billet; measured in vacuum at 10 ⁻³ to 10 ⁻⁷ Torr; data corrected for thermal expansion except points at 73, 189, and 273 K.
16	136	Fulkerson, W., Moore, J.P., and McElroy, D.L.	1966	A	4.0-1273	High purity iron	99.95 Fe, 0.002-0.02 Si, 0.014 C, 0.00095-0.0095 Ni, 0.0088 O, <0.0056 H, 0.0052 S, 0.00021-0.0021 Al, 0.002 P, 0.00014-0.0014 Ca, and 0.00009-0.0009 Cu, in atomic percent; obtained by electron beam melting of Armco iron; homogeneous to ±0.19; rod specimen 38.10 cm (0.15 in.) in diam and 7.62 cm (3 in.) long; free of voids; immersion density 7.881 g/cm ³ ; smoothed data extracted from table; data corrected for thermal linear expansion; resistivity measured with current densities of 6.8, 11 and 11 A/cm ² at 4, 77.5 and 194.1 K respectively.
17	135	Moore, J.P., McElroy, D.L., and Berisotti, M.	1966	A	90-40	Grade 1	Cylindrical specimen machined from electron beam zone-refined iron (3-pass); produced by Materials Research Corp.; density 7.824 g/cm ³ ; electrical resistivity ratio $\rho(273\text{ K})/\rho(4.2\text{ K}) = 201$; smoothed data from table.
18	166	McDonald, W.J., Jr.	1962	A	1.63-80.7		Cut from a zone-refined ingot; prepared at BMI; machined into a rectangular parallel piped 0.157 x 0.157 x 0.381 cm (0.062 x 0.062 x 1.5 in.).
19	167	Bengardt, K. and Spyra, W.	1965		293-1373		0.03 Ni, 0.015 C, 0.007 S, and traces Al, Mo, P, and Si; cylindrical specimen.
20	168	Bohn, R. and Wachtel, E.	1969		196-406		0.005 Ni, 0.004 C, and 0.003 O; cylindrical specimen 10 mm in diam.

* Not shown in figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
21	143	Wallace, D.G., Sildes, P.H., and Danielson, G.C.	1959	B	298-1323	High purity iron	0.03 C, 0.01 N and O each, <0.0005 Ni, 0.0001 Cu, <0.0001 each of Mg, Si, Ag, and Na; wire specimen 0.025 mm to 0.0346 cm in diam and 4 to 7 cm long; from Johnson and Matthey Co.; drawn and annealed at 1273 K for 1 h, cooled at a rate of 40 K/h, while measurement was made; with some specimens, measurements here made upon reheating, and data "accurately reproduced"; smoothed values from table, representing data for two specimens; uncorrected for thermal expansion; values do not reflect a discontinuity of 0.6% upon cooling at 1173 K.
22	144	Pallister, P.R.	1949	A	273-1548		99.99 ⁺ Fe; 1 cm in diam and 30 cm long; density 7.87 ± 0.005 g cm ⁻³ ; uncorrected for thermal expansion; data extracted from table.
23*	169	Bäcklund, N.G.	1961	A	90-290	Pure iron Data Set 1	Three types of specimens: 1) "very pure iron" wire; 2.5 mm in diam; from Phillips Research Lab.; 2) spectroscopically standardized pure iron wire; 5 mm in diam; from Johnson and Matthey Co.; 3) pure iron wires; 1.0 and 2.0 mm in diam; from Heraeus Inc.; all specimens annealed at 773.2 K for 10 h; data reported as average of all three types.
24	165	Jaeger, F.H., Rosenblom, E., and Zutithoff, A.J.	1938		293-1243	Pure iron	Pure; 0.25 mm in diam and 925 mm long; data corrected for thermal expansion.
25*	170	Cleaves, H.E. and Riegel, J.M.	1942	293	Ingot #2		0.0002 S, <0.0002 Cu, 0.001 C and Si each, <0.001 Be, and <0.0005 P; 2 mm in diam and about 1 meter long; ingots produced by recrystallization of ferric nitrate, conversion to ferric oxide, reduction to sponge iron, and melting under hydrogen and in a vacuum, forged, cold-rolled, swaged, and drawn; annealed in vacuum for 15 min at 1123 K.
26*	170	Cleaves, H.E. and Riegel, J.M.	1942	293	Ingot #7		0.0002 O and S each, <0.0002 Cu, 0.001 Si, and <0.001 C; dimensions, fabrication method, and heat treatment same as the above specimen.
27*	170	Cleaves, H.E. and Riegel, J.M.	1942	293	Ingot #14		0.0002 O and Si each, 0.0002 Cu, 0.001 C and S each; dimensions, fabrication method, and heat treatment same as the above specimen.
28*	170	Cleaves, H.E. and Riegel, J.M.	1942	293	Ingot #11		0.0004 O, <0.0002 Cu, and 0.001 S; dimensions, fabrication method, and heat treatment same as the above specimen.
29*	170	Cleaves, H.E. and Riegel, J.M.	1942	293	Ingot #19		0.0004 O, 0.0002 S, <0.0002 Cu, and <0.001 C; dimensions, fabrication method, and heat treatment same as the above specimen.
30*	170	Cleaves, H.E. and Riegel, J.M.	1942	293	Ingot #6		0.0004 O, <0.0002 Cu, 0.0001 S and Si each, and <0.001 Be and C each; dimensions, fabrication method, and heat treatment same as the above specimen.
31	130	Keep, W.R.G., Klemens, P.C., and White, G.K.	1956	A	4.2-293	JM 5092	99.99 Fe, 0.005 Ni, 0.0002 Cu, 0.0001 Ag, and traces Mg and Mn; 2 mm in diam rod; supplied by Johnson and Matthey Co.; annealed at 1023 K (750 °C) for 4 h in vacuum; resistivity values calculated from reported ideal electrical resistivity and $\rho_0 = 0.248 \cdot 10^{-8} \Omega \cdot m$.

* Not shown in figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
32	171	Yoshida, I.	1965		0.5-1.1		No details given.
33	137	Kohlhaas, R. and Richter, F.	1962	B	293-1523	Fe ₁	0.0640, 0.0002 S, 0.001 Mn, N, and Si each; 0.5 cm in diam and 25 to 30 cm long; turned from square bar, transition temperatures: $Ac_2 = 1027$ K (754 C), $Ac_3 = 1189$ K (916 C) and $Ar_3 = 1175$ K (902 C); smoothed data from table.
34	137	Kohlhaas, R. and Richter, F.	1962	B	90-291	Fe ₁	The above specimen.
35*	137	Kohlhaas, R. and Richter, F.	1962	B	969-1080	Fe ₁	The above specimen at temperatures about the Curie point; measured while heating.
36*	137	Kohlhaas, R. and Richter, F.	1962	B	972-1079	Fe ₁	The above specimen at temperatures about the Curie point; measured while cooling.
37*	137	Kohlhaas, R. and Richter, F.	1962	B	1176-1198	Fe ₁	The above specimen at temperatures about the α - γ transition; measured while heating.
38*	137	Kohlhaas, R. and Richter, F.	1962	B	1164-1195	Fe ₁	The above specimen at temperatures about the α - γ transition; measured while cooling.
39	78	vierspa, W., Kohlhaas, R., and Gonska, H.	1967	B	73-1715		0.0060 S, 0.0050 C, O, and Si each, 0.0016 M, 0.0010 N, and P each; wire specimen from Prof. W.A. Fischer, Max-Planck-Institute for Iron Research; smoothed values from figure.
40	78	Kierspe, W., et al.	1967	B	1103-1283		The above specimen at temperatures about the α - γ transition.
41	78	Kierspe, W., et al.	1967	B	1553-1713		The above specimen at temperatures about the γ - δ transition.
42*	208	Kohlhaas, R. and Kierspe, W.	1965		83-353		0.0027 C, 0.0002 S, 0.0001 Mn, N, and Si each, and trace of Cr.
43	134	Richter, F. and Kohlhaas, R.	1964		93-1273		0.0120, 0.0008 P, 0.007 C, and Al each, 0.004 S, and 0.002 N; disk specimen 63 mm outer diam; annealed for several hours at 1193 K (900 C); Curie point 1037 K (664 C); α - γ transition: $Ac_3 = 1189.7$ K (916.7 C), $Ar_3 = 1186.3$ K (913.3 C).
44*	172	Jaeger, W. and Diesseihorst, H.	1900		291-373	Eisen I	0.1 C, metallic impurities not determined; 1.3007 cm in diam and 27.0 cm long; density 7.84 g cm ⁻³ .
45*	173	Lorenz, L.	1881		273-373		No details reported.
46*	174	Brown, H.M.	1928	A	312		0.0794 cm ² x 10 cm.

* Not shown in figure.

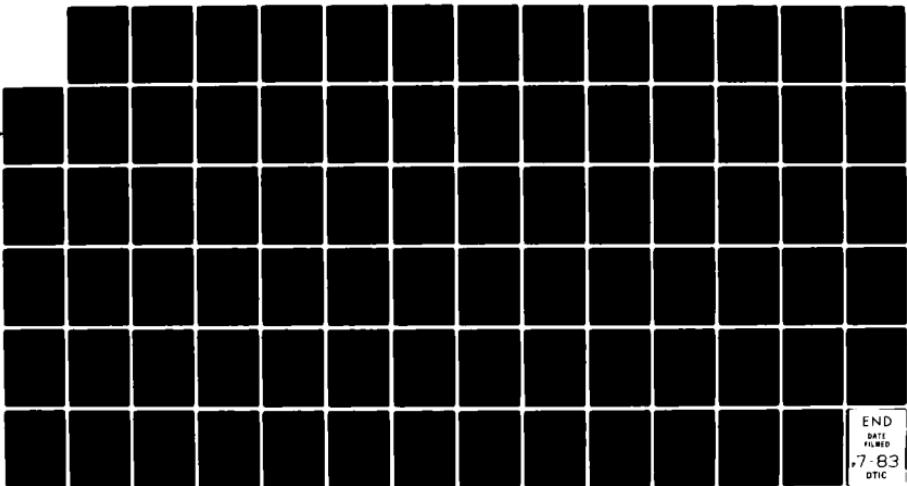
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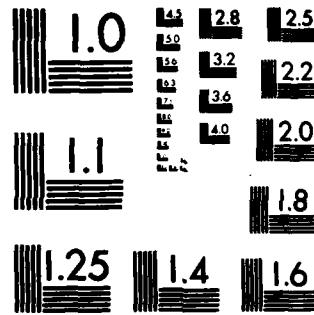
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TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Date Ref. Set No.	Author(s) No.	Author(s) Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
47 133	Hust, J.C. and Giarratano, P.J.	1975	4-280	NES	NES electrolytic iron	99.9+ Fe, 0.041 Ni, 0.0080 Si, 0.0072 Cr, 0.007 Co, 0.0067 C, 0.0059 S, 0.0058 Cu, 0.0057 Mn, 0.005 Mo, 0.0025 P, 0.0007 Al, 0.0006 Ti and V each, 0.0002 As, 0.00013 S, 0.00002 Pb; chemical composition certified by NBS, SRM 1265; grain size 0.05 mm for annealed condition; rod specimen 3.6 mm in diam and 23 cm long, apparently annealed; density 7.867 ± 0.005 g cm ⁻³ , for annealed condition; Rockwell hardness B24, for annealed condition; mean residual resistivity ratio ρ(273 K)/ρ(4 K) is 23; residual resistivity 0.385 × 10 ⁻⁸ Ω m, average ρ(273 K) 8.71 × 10 ⁻⁸ Ω m; data uncorrected for thermal expansion; data smoothed with linear least squares methods to the expression ρ = $b_1(\ln T)^{1/2}$, where $b_1 = 1.52995843 \times 10^{-5}$, $b_2 = 6.57221842 \times 10^{-5}$, $b_3 = 1.28083300 \times 10^{-5}$, $b_4 = -1.50027718 \times 10^{-5}$, $b_5 = -1.17943860 \times 10^{-5}$, $b_6 = -6.57740194 \times 10^{-5}$, $b_7 = 2.67952461 \times 10^{-5}$, $b_8 = -8.08151541 \times 10^{-6}$, $b_9 = 1.80581011 \times 10^{-6}$, $b_{10} = -2.95519976 \times 10^{-7}$, $b_{11} = 3.44669418 \times 10^{-8}$, $b_{12} = -2.70952664 \times 10^{-9}$, $b_{13} = 1.28939040 \times 10^{-10}$ and $b_{14} = -2.80388287 \times 10^{-12}$, the b's presented on p. 18 of Hust, J.C. and Sparks, L.L., "Thermal Conductivity Standard Reference Materials from 4 to 300 K: II OSRM Iron-1265," NBS Report 9771, 35 pp., 1970; data presented here are from table on p. 24 and 25, and are different from values calculated from the above polynomial.
48* 138	Dewar, J. and Fleming, J.A.	1893	B	76-471	Iron A	0.25 Mn, 0.01 S, very free from C, Si, and P; wire specimen 0.02657 cm mean diam and 100 cm long; from Armstrong's works, sent by Colonel Dyer of Elswick Ordnance Works; resistance 0.4223, 1.1909, 1.5086, 1.9104, 2.0737, 2.4167, 2.8368, 3.4091, and 4.1935 Ω at 76.1, 191.3, 229.3, 244.55, 291.65, 325.25, 363.7, 412.0, and 470.5 K, respectively; temperature below 273 K (0 °C) measured by platinum resistance thermometer; data uncorrected for thermal expansion, length and mean diameter measured at 288 K; data extracted from table.
49* 138	Dewar, J. and Fleming, J.A.	1893	B	54,76	Iron A	Longer specimen cut from the same piece as Data Set 48; resistance 2.983 and 3.834 Ω at 53.8 and 76.1 K, respectively; data uncorrected for thermal expansion, length measured at 288 K; data extracted from text; temperatures measured by platinum resistance thermometer.
50 138	Dewar, J. and Fleming, J.A.	1893	B	76-469	Iron H.W.	High degree of purity; wire specimen 0.023078 cm mean diam and 100 cm long; from Messrs. Hopkins and Williams; very soft and well annealed, cold worked under the hammer and drawn without heating, into a very uniform wire; resistance 0.2918, 1.2713, 1.7137, 2.1791, 2.3940, 2.9546, 3.4976, 4.2536, and 5.1395 Ω at 76.1, 191.3, 234.0, 273.85, 291.40, 333.40, 371.25, 418.6 and 469.3 K, respectively; mean temperature coefficient between 273 and 373 K, 0.00625; data uncorrected for thermal expansion, length and mean diameter measured at 288 K; data extracted from table; temperature below 273 K (0 °C) measured by platinum resistance thermometer.

* Not shown in figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent). Specifications and Remarks
51* 138	Dewar, J. and Fleming, J.A.	1893	B	51-76	Iron H.W. Coil (a)	Longer coil cut from the same wire as the above specimen, 2600 cm long; resistance 3.839, 4.154, and 7.091 Ω at 51.0, 54.0 and 76.1 K, respectively; data uncorrected for thermal expansion, length measured at 288 K; data extracted from table; temperature measured by platinum resistance thermometer.
52* 138	Dewar, J. and Fleming, J.A.	1893	B	51-76	Iron H.W. Coil (b)	Still longer coil cut from the same wire as the above specimen; wire specimen 3700 cm long; resistance 5.222, 5.257, and 9.815 Ω at 50.5, 50.8, and 76.1 K, respectively; data uncorrected for thermal expansion, length measured at 288 K; data extracted from table; temperature measured by platinum resistance thermometer.
53	Dewar, J. and Fleming, J.A.	1892	B	76-370	Pure soft iron; wire specimen had probable dimensions of 0.0076 (0.003 in) in diam and 50 or 100 cm long; from Messrs. Griffin and Co.; annealed; mean diameter of wire measured to nearest 0.0000254 cm (0.0001 in); measurement of resistance repeated several times; mean observed specific resistance reported; data uncorrected for thermal expansion; data extracted from table.	
54	Honda, K. and Saito, T.	1917	A	30 ^a -1174	Cylindrical specimen, 0.5 cm in diam and 20 cm long.	
55* 151	Arajs, S. and Colvin, R.V.	1964	A	300-1291	0.00300 O, 0.00115 Ni, 0.0012 Co, 0.0005 C and Ge each, 0.0004 Cr, 0.0003 N, 0.00015 Cu, 0.00008 Zn, 0.00004 Ga, 0.00003 Nb, 0.000025 Ti, 0.00002 V, 0.000009 As, <0.000004 Mn, and <0.000007 Others; zone refined; 0.1 × 0.3 × 2.0 cm; $\rho(4.2 \text{ K})/\rho(298 \text{ K}) = 3.76 \times 10^{-3}$ before high temperature test and 4.30×10^{-3} after test; Curie temperature 104.2 K; measured with a current density of $\sim 12.9 \times 10^4 \text{ A/mm}^2$; corrected for thermal expansion; data extracted from figure.	
56* 151	Arajs, S. and Colvin, R.V.	1964	A	1018-1068	The above specimen in the neighborhood of Curie temperature; corrected for thermal expansion; data from figure.	
57* 151	Arajs, S. and Colvin, R.V.	1964	A	1151-1197	The above specimen measured through α-γ transition; temperature increasing; uncorrected for thermal expansion; data from figure.	
58* 151	Arajs, S. and Colvin, R.V.	1964	A	1150-1186	The above specimen measured while cooling through α-γ transition; temperature decreasing; uncorrected for thermal expansion; data from figure.	
59* 176	Kondorshii, E.I. and Sedov, V.L.	1960	A	4.2	Technically pure; 0.59 cm in diam and 11.2 cm long; vacuum annealed at 1273 K for 8 h; oven cooled; measured under saturation magnetization 1751 g.	
60	Ibragimov, Sh.Sh.	1962	A	293-1698	Iron	0.06 Si, 0.04 C, 0.02 Mn and Cr each; annealed at 1033 K.
61* 178	Butler, E.H., Jr. and Pugh, E.H.	1940		313-343		Electrolytical iron; annealed in hydrogen.

^a Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
62 154	Cesairliyan, A. and McClure, J.L.	1973		1500-1660	Y iron 1	Tubular specimen 6.3 mm O.D., 0.5 mm thick and 102 mm long; fabricated from rods by electro-erosion technique; Y-δ transition reported at 1682 K; melting point 1808 K; specimen heated to measuring temperature in one second by passing current through; uncorrected for thermal expansion; smoothed data from table.
63 154	Cesairliyan, A. and McClure, J.L.	1973		1500-1660	Y iron 2	Similar to the above specimen (one of this or the above specimen has an electrical resistivity value of $10.2 \times 10^{-8} \Omega \text{ m}$ at 273 K).
64 154	Cesairliyan, A. and McClure, J.L.	1973		1700-1800	δ iron 1	The same specimen as for Data Set 62.
65 154	Cesairliyan, A. and McClure, J.L.	1973		1700-1800	δ iron 2	The same specimen as for Data Set 63.
66 179	Niccolai, G.	1908	B	84-673	0.5 mm in diam and 5 mm long; from Firms C.A.F. Kahlebaum.	
67* 180	Wruck, D. and Wert, C.	1955	V	293	99.95 pure; 0.04 O, little metallic impurity.	
68* 180	Wruck, D. and Wert, C.	1955	V	93	Same as above; foil polycrystal, 0.008 cm x 0.2 cm x 4 cm; Run II.	
69* 180	Wruck, D. and Wert, C.	1955	V	93	Same as above; Run II.	
70* 180	Wruck, D. and Wert, C.	1955	V	93	Same as above; Run IV.	
71* 180	Wruck, D. and Wert, C.	1955	V	77	Same as above except wire specimen; 0.0762 cm in diam and 15 cm long; grain size ~0.6 cm; decarbonized.	
72* 180	Wruck, D. and Wert, C.	1955	V	77	Same as above.	
73* 180	Wruck, D. and Wert, C.	1955	V	77	Same as above.	
74* 181	Rosenberg, H.M.	1955	A	1.8-77	JM 4975 (Run 2)	99.99 pure (excluding gases); from Johnson and Matthey Co.; polycrystalline; 0.202 cm in diam and 2.89 cm long; annealed in vacuum for several hours.
75 146	Powell, R.W., Tye, R.P., and Woodman, H.J.	1961	A	1088-1196	18 AF 3	0.007 Cu and Ni each, 0.0058 C, 0.004 Mn and Si each, 0.003 S, 0.0023 N, 0.002 Cr, <0.001 Al, <0.001 P, 0.0008 O, and <0.000005 H; measured during heating of the sample at a rate of 0.25 K min ⁻¹ , data uncorrected for thermal expansion.
76* 146	Powell, R.W., et al.	1961	A	1160-1191	18 AF 3	The above specimen measured during cooling.
77 146	Powell, R.W., et al.	1961	A	4-1073	18 AF 3	The above specimen measured at lower temperatures; smoothed values from table.

* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
78*	123	Taylor, G.R., Istin, A., and Coleman, R.V.	1963	A	77-191	Specimen #25	One of iron whisker specimens 100-300 μ in diam and about 2 cm long.
79*	123	Taylor, G.R., et al.	1963	A	77-300		Same as the above; resistivity values calculated from reported resistance ratios $R(T)/R(77\text{ K})$ and $\rho(77\text{ K})$ given in the above data set; average of seven specimens.
80	182	Soffer, S., Diesner, J.A., and Pugh, T.M.	1965	A	76-300		<0.0185 metallic impurities; zone-refined; 0.1 cm x 1 cm x 10 cm.
81*	183	Toshihawa, A. and Okamoto, M.	1967	A	77,273		Zone refined iron (total impurity less than 0.001%); grain <70 μ in diam; decarburized at 973 K for 7 days in wet hydrogen stream; ultrasonically cleaned; chemically polished with HF + H ₂ O ₂ ; heat treated at 773 K for 14 days in hydrogen purified by zirconium hydride; annealed at 773 K for 30 min; then cooled at 15 K hr ⁻¹ ; room temperature value calculated from reported resistance ratio ($\rho_{73\text{K}}/\rho_{77\text{K}}$).
82*	184	Takamura, S., Maeta, H., and Okuta, S.	1968	A	4.2,293		99.996 pure, 0.0008 C, 0.007 N and O each, from Materials Research Corp.; wire specimen 0.12 mm in diam; as received condition; value at room temperature calculated from reported resistivity ratio and residual resistivity.
83*	184	Takamura, S., et al.	1968	A	4.2,293		Same as the above specimen except annealed at 773 K for 1 h in vacuum and then at 973 K for 1 h.
84	184	Takamura, S., et al.	1968	A	4.2,293		Similar to the above.
85*	184	Takamura, S., et al.	1968	A	4.2,293		Similar to the above.
86	21	White, G.K. and Woods, S.B.	1959	A	4.2-295	Fe 2	99.97 pure, ~0.006 Si, <0.004 Co, Cu, and Mn and Ni each, ~0.003 Mo and Mn each, <0.0015 N, and traces Pb and Zr; 0.05 mm x 1 mm x 6-8 cm; from Vacuum Metals Co.; zone-melted in wet hydrogen to obtain large crystals; electrically annealed at 873 K to remove hydrogen; resistivity calculated from reported $\rho_1(T)$, $\rho(4.2\text{K})/\rho(295\text{K}) = 9.61 \times 10^3$, and $\rho_1(295\text{K}) = 9.82 \times 10^{-8} \Omega\text{m}$.
87*	185	Smith, A.W., Gregory, J.H., and Lynn, J.T.	1946	B	293		"Chemically pure"; wire specimen 0.1019 cm in diam and 15.2 cm long.
88*	185	Smith, A.W., et al.	1946	B	293		"Chemically pure"; wire specimen 0.0823 cm in diam and 15.5 cm long.
89*	185	Smith, A.W., et al.	1946	B	293		"Chemically pure"; wire specimen 0.0406 cm in diam and 5.0 cm long.
90*	185	Smith, A.W., et al.	1946	B	293		"Chemically pure"; wire specimen 0.0201 cm in diam and 3.4 cm long.

* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
81	Shaw, G., Shel'chikov, Sokolovskii, Sokolovskii, Petrov, L.N., and Gal'd, P.G.	1973	A	289-1167		0.03 impurities; well annealed iron supplied by Johnson and Matthey Co.; average grain size 2 mm; measured in vacuum (0.10 mmHg) under quasistatic condition with heating rate not more than 1 K/min.
82	Shaw, G., Tiwari, P.P., Tiwari, P.P., and Kumar, N.A.	1965	A	1449-2094		99.0 pure; by carbonyl method or electrolytically; liquid state obtained by melting in graphite crucible either in a helium atm or in vacuum.
83	Shashkov, B.J. and Mazet, B.G.	1973	C	1608		99.998 pure, from Johnson and Matthey Co., in liquid state; temperature = 1800 K assumed.
84	Tschalow, I.A.	1974	A	344-1015		99.99 ⁺ pure; from Goodfellow Metals Ltd., England; 1.0 cm x 2.0 cm x 4.0 cm; annealed at 1473 K for 24 h under vacuum.
85	Bullock, G.	1956	V	928-1150		0.027 Mn, 0.02 C, 0.018 P, 0.017 S, 0.007 Si, 0.005 N and traces Ni; Armco iron manufactured by the basic O.H. technique; inclusions not detectable by microscope; 1.3 cm in diam and about 15 cm long; measured with a current of 20-30 A, and in vacuo; this curve represents coincident values during both heating and cooling (rate 1-1.5 K/min).
86*	Bullock, G.	1956	V	1004-1221		The above specimen while cooling.
87*	Bullock, G.	1956	V	1003-1220		The above specimen while heating.
88*	Bullock, G.	1956	V	1174-1198		The above specimen heating at a rate of 0.25 K min ⁻¹ .
89*	Bullock, G.	1956	V	1163-1186		The above specimen cooling at a rate of 0.25 K min ⁻¹ .
90*	Kaufmann, L., Clogherby, E.V., and Weiss, R.J.	1953		325-1425		Specimen same as used in Kaufmann, L., Leyenar, A., and Harvey, J.S., Progress in Very High Pressure Research, p. 89, Wiley, New York, 1961; swaged; α-γ transition 1.183 K; resistivity calculated from reported magnetic resistivity: ρ (magnetic) = ρ - 0.029T (1.0-0.002P); values from table.
91*	Morris, D.M.	1897	B	273-1036	Specimen A	Charcoal Iron; from Messrs. Jos. Sankey and Sons; ring shape specimen of cross sectional area 0.131 cm ² and mean ring diameter 2.35 cm; density 7.775 g cm ⁻³ ; measured during heating.
102*	Morris, D.M.	1897	B	273-1323	Specimen A	The above specimen; measured during cooling after heated to 1323 K; Curie temperature 1068 K.
103*	Morris, D.M.	1897	B	289-1158	Specimen A	The above specimen after reheating to 1193 K; measured during cooling.
104*	Morris, D.M.	1897	B	273-1099	Specimen B	0.075 impurities, including C, P and Si, and traces of Mn; Swedish transformer iron from Messrs. Jos. Sankey and Sons; ring shape specimen with cross sectional area 0.143 cm ² and mean ring diam 2.23 cm; density 7.461 g cm ⁻³ ; measured during cooling after annealing at 1113 K; Curie temperature 1055 K.

* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks	
105 150	Morris, D.M.	1897	B	273-1623	Specimen B	The above specimen measured during cooling after annealing at 1623 K Curie temperature 1051 K.	
106 190	Arajs, S., Schaeffer, F.C., and Fisher, R.M.	1969	A	4.2	99.9 ^a pure; electrolytic; about 5 mm in diam and 50 mm long.		
107 132	Schaeffer, F.C., Connor, J.W., and Arajs, S.	1969	A	4.5-300	0.002 C and 0.001 N, "high purity iron standard"; 0.508 cm in diam and 5 cm long; annealed at 1273 K for 1 week under vacuum; machined, re-annealed at 1123 for 2 h; data at $T \geq 50$ K calculated from reported residual resistivity ($0.08 \times 10^{-8} \Omega \text{m}$) and smoothed ideal resistivity (from graph); measured with a current of 0.1 A.		
108 141	Shirakawa, Y.	1939		78-1123		0.05 P and Si each, 0.04 C, 0.02 Co and Mn each, 0.01 Al and 0.003 S; electrolytic from Nippon-Deukai-Seitetsusho; 0.0617 cm in diam and 5.25 cm long; annealed at 1273 K for 1 h under vacuum with specimen axis in the east-west direction; slow-coded; lead wires of nickel soldered by pure silver; reannealed at 1123 K for 1 h under vacuum and slow-cooled; measurement done with sample axis in east-west direction.	
109* 191	Meyer, A.R.	1911	V	273-1273		Chemically pure; ~0.015 SiO ₂ , 0.004 Cu and Ni each, <0.001 Mn and trace Si; from Kahlaum; impurities analyzed by Physikalisch-Technischen Reichsanstalt; measured by AC voltage-current method; smoothed values from table; except for value at 293 K which is measured separately by a DC voltage-current method.	
110 191	Meyer, A.R.	1911	V	273-1273		99.94 pure charcoal iron from Armaco; other information same as above.	
111 191	Meyer, A.R.	1911	V	273-1173		<0.008 S, 0.007 P and traces C, Cu, Mn, and Si; from Langbein-Pfunhauser-Werke; other information same as above.	
112 91	Levin, E.S., Ayushina, G.D., and Gel'd, P.V.	1972	R	1923		99.988 pure, carbonyl iron class V-3; measurements carried out in aluminum or zirconium oxide crucibles covered with lapped lids in purified helium at a pressure of 760 mbar; pure tungsten used as comparison standard.	
113 192	Ganenya, V.S. and Lebedev, V.V.	1959		309-1718		High purity iron obtained by vacuum distillation; total impurity 0.02%; estimated from residual resistivity; specimen 3-6 mm in diam and 50-100 mm long; annealed at 1373 K for 4 h in high vacuum; measured in a vacuum of $10^{-5}-10^{-6}$ mmHg.	
114 156	Basm, B.A., Gel'd, P.V., and Tyagunov, G.V.	1967	+	1551-2018		99.99 pure carbonyl iron; remelted in a hydrogen atm and degassed in vacuum in the molten state; measured by "refluence method" of Baum et al., Izv. Akad. Nauk SSSR, Neorg. Materialy, 1, 1289 (1965) in pure helium at a pressure of 780 mbar; tungsten used as comparison standard.	

^a Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON-Fe (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
115 89	Oso, Y. and Yagi, T. Ono, Y.	1972 1977	R R	1773-1898		99.9 ^a pure; liquid state; contained in a 10 mm I.D. recrystallized alumina crucible at a pressure of 0.05-0.1 mmHg; density data of Saito et al. (Bull. Res. Inst. Min. Metall., Tohoku Univ., 25, 67, 109, 1969) used for calculating specimen volume.	
116 149	Seehra, M.S., Capun, V.I., and Siliinsky, P.	1974	A	1000-1087		0.02 Mn, 0.01 Cr, and <0.01 Co; single crystal; 0.2 x 0.3 x 1.5 cm; polished and etched in HCl + 10% H ₂ O ₂ ; Curie temperature 1040 ± 1 K; uncorrected for thermal expansion; data in table form supplied by the first author.	
117 193	Dubini, E., Esin, O.A., and Vatolin, N.A.	1969		1873		"High purity"; measured in purified helium.	
118 194	Lebedev, S.V., Savchenko, A.I., and Smirnov, Yu.B.	1974	+	1809		<0.2 C; in liquid state; measured by an exploding-wire technique, wire heated by an almost rectangular shape pulse (~10 ⁻⁶ s); current density ~4 x 10 ¹³ A/m ² ; voltage and current measured by pulse oscilloscope.	
119* 127	Fert, A. and Campbell, I.A.	1976	A	2-4-63		"Pure"; obtained by zone melting; residual resistivity ratio 25; only temperature dependent part of resistivity reported.	
120* 127	Fert, A. and Campbell, I.A.	1976	A	2-4-78		Same as the above.	
121* 159	Baum, B.A., Tyagunov, G.V., Gel'd, P.V., and Khasin, G.A.	1971	R	1573, 1873		Specimen contained in either alumina or zirconia crucible, measured in an atm of helium.	
122* 195	Tanaka, K. and Watansbe, T.	1972	A	77,298	JM	0.0166 Ni, 0.0048 C, 0.0036 O, 0.0003 Si, 0.0002 Cu and Mn each, and <0.0001 Al and P each; grain diam 50 ± 20 μm; 0.5 mm in diam and 170 mm long; from Johnson and Matthey; heated at 1246 K for 48 h in wet hydrogen; and 2 h in dry hydrogen; cold rolled from 5 mm to 2 mm in diam; annealed at 823 K for 1 h in dry hydrogen; drawn to wire; annealed at 923 K for 3 h in vacuum; carbon or nitrogen in solution <0.0002.	
123* 195	Tanaka, K. and Watansbe, T.	1972	A	77,298	RE	0.0060 Si, 0.0040 C, Mn and Si each; 0.0030 P and 0.0020 Cu; re-electrolytic iron supplied by Denko Co.; melted by induction heating and cast in vacuum; surface layer removed; hot-swaged into rod of 7 mm in diam; wire specimen prepared in similar manner as above.	
124* 195	Tanaka, K. and Watansbe, T.	1972	A	77,298	TI	0.0400 Ti; "C, Ni, O and B atoms in solid solution extremely low"; prepared from re-electrolytic iron by alloying with Ti; specimen preparation same as the above except for no annealing in wet hydrogen.	

^a Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
125*	196 Wagenblast, H., Scheerer, F.C., and Horak, J.A.	1971	A	4.2	0.005 interstitial C; specimen prepared from vacuum melted iron with <0.1 at.% impurities; drawn and swaged to 0.6 mm in diam and 13.3 cm long wire; annealed at 1023 K for 15 min; annealed 1058 K for 5 h in wet hydrogen and furnace cooled in dry hydrogen to reduce carbon and nitrogen to 0.004 and 0.0004 at.%, respectively; carbonized by heating at 998 K for 16 h in a hydrogen-methane mixture; quenched in brine.	
126*	196 Wagenblast, H., et al.	1971	A	4.2	Similar to the above except containing 0.022 interstitial C.	
127*	196 Wagenblast, H., et al.	1971	A	4.2	Similar to the above except containing 0.005 interstitial C.	
128*	196 Wagenblast, H., et al.	1971	A	4.2	Similar to the above except containing 0.098 interstitial C.	
129*	196 Wagenblast, H., et al.	1971	A	4.2	0.012 interstitial N; specimen preparation similar to the above except nitrogenized by heating at 748 K in a hydrogen-ammonia mixture.	
130*	196 Wagenblast, H., et al.	1971	A	4.2	Similar to the above except containing 0.057 N.	
131*	196 Wagenblast, H., et al.	1971	A	4.2	Similar to the above except containing 0.104 N.	
132*	196 Wagenblast, H., et al.	1971	A	4.2	Similar to the above except containing 0.138 N.	
133*	196 Wagenblast, H., et al.	1971	A	4.2	Similar to the above except containing 0.158 N.	
134	80 Price, D.C. and Williams, G.	1973	A	4.2-276	99.9985 pure; 0.15 x 0.2 x 10 cm; supplied by Johnson and Matthey Co.; prepared by cold rolling rod stock between Melinex sheets; etched; annealed in vacuum at 1173 K for 2 h; quenched; resistivity calculated from reported $\rho(4.2 \text{ K}) = 0.3390 \times 10^{-8} \Omega \text{m}$ and temperature dependent part of the resistivity, ρ_T ; $\rho = \rho_T + \rho(4.2 \text{ K})$.	
135	197 Vasil'eva, R.P. and Kadryov, Ya.	1974		373-773	No details reported.	
136	148 Scheerer, F.C. and Cuddy, L.J.	1970	V	4.2-1200	$\sim 1.8 \text{ mm}$ in diam; zone-refined iron; swaged; average of two specimens; $\rho(4.2 \text{ K}) \sim 0.04 \times 10^{-8} \Omega \text{m}$; smoothed values from graph.	
137*	94 Semarin, A.M.	1962	R	1811-2000	Measured by the rotating field method in a helium atm; apparatus calibrated against the resistivity value of molten iron reported in Data Set 139; resistivity value calculated from reported conductivity: $[1.47-0.50 \times 10^{-3} T(\text{C})] \times 10^{-8} \Omega^{-1} \text{cm}^{-1}$; upper temperature limit assumed 2000 K.	
138	155 Powell, R.W.	1953	+	279-1793	"High purity" iron; measured under vacuum; resistivity above 1623 K are smoothed values from graph.	

* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Ref. No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
139	155	Powell, R.W.	1953	+	1811		In molten liquid state; resistivity measured by immersing a specially constructed alumina tube in molten iron; current and potential contacts made by tungsten rods through separate holes, in the middle of the wall of the tube, which are open to the axial hole through small up-turned channels; reported value mean of 24 measurements with two heating rates of the specimen and with two different durations of the measuring current.
140*	108	Schimank, H.	1914	B	20-273	Fe I	High grade pure electrolytic iron; from Kalbaum; 1-2 mm long; drawn by Heraeus of Hanau.
141*	108	Schimank, H.	1914	B	20-273	Fe II	Same as the above except annealed in nitrogen atm.
142*	198	Holborn, L.	1919		80-784	Fe I ₁	Electrolytic iron, from vacuum melted iron supplied by Firma W.C. Heraeus; wire specimen 0.2 mm in diam; heated for several min at 773 K.
143*	198	Holborn, L.	1919		81-761	Fe I ₂	Same as the above except annealed at 573 K for 3 h.
144*	198	Holborn, L.	1919		80-372	Fe II	0.004 Co, Cu and Ni each, 0.001 Mn, traces of C, O and Si; "Nitrateisen" made from iron nitrate by Firma C.A.P. Kalbaum; drawn from 5 mm to 0.2 mm in diam; annealed at 653 K for 3 h.
145*	104	Meissner, M. and Voigt, B.	1930	+	1.4-273	Fe I	Specimen same as for Data Set 142; 0.2 mm in diam and 55 mm long; distance between potential contacts 50 mm; tempered; measured by compensation method; resistivity calculated from reported resistance ratio, i.e. point resistance (0.149 Ω) and sample dimensions.
146*	104	Meissner, M. and Voigt, B.	1930	+	1.4-273	Fe 2	Specimen same as for Data Set 144; 0.2 mm in diam and 59.7 mm long; distance between potential contacts 56.6 mm; tempered; measurement method and resistivity calculation same as above.
147	104	Meissner, M. and Voigt, B.	1930	+	1.4-273	Fe 2*	Same as the above specimen except 60 mm long and distance between potential contacts 56.3 mm.
148	104	Meissner, M. and Voigt, B.	1930	+	2.0-273	Fe 3	Specimen same as for Data Set 10; tempered; 1.0 mm in diam and 33.0 mm long; distance between potential contacts 30.0 mm; measurement method and resistivity calculation same as above.
149	104	Meissner, M. and Voigt, B.	1930	+	2.0-273	Fe 4	Electrolytic iron from Firma Heraeus; 1.0 mm in diam and 58.2 mm long; stretched; coarse grained; distance between potential contacts 53.4 mm; measurement method and resistivity calculation same as above.
150*	104	Meissner, M. and Voigt, B.	1930	+	1.4-273	Fe 5	Specimen obtained from Dr. Kreussler; 0.1 mm in diam and 58.6 mm long; distance between potential contacts 54.2 mm; measurement method and resistivity calculation same as above.

* Not shown on either figure.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
151*	104 Weissenber, M. and Voigt, B.	1930	+	1.4-273	Fe 6	Same as the above specimen except 58.4 mm long and annealed at 573 K for 3 h; distance between potential contact 54.4 mm.
152*	104 Weissenber, M. and Voigt, B.	1930	+	1.4-273	Fe 7	Electrolytic (5 times) iron from Firm Siemens and Halske; 0.3 mm in diam and 58.7 mm long; distance between potential contacts 56.0 mm; measurement method and resistivity calculation same as above.
153*	104 Weissenber, M. and Voigt, B.	1930	+	1.3-273	Fe 10	The above specimen annealed at red-hot, 15 h and etched; 57.5 mm long; distance between potential contacts 51.7 mm.
154*	104 Weissenber, M. and Voigt, B.	1930	+	1.4-273	Fe 8	Same as the above specimen except annealed at 573 K for 3 h; distance between potential contacts 54.4 mm.
155*	104 Weissenber, M. and Voigt, B.	1930	+	1.4-273	Fe 9	Same as the above specimen etched; 57.8 mm long; distance between potential contacts 55.1 mm.
156*	125 Russell, C.W., Christopher, J.E., and Coleson, R.V.	1970	A	0.3-1.2	<100> iron whisker; measured in a magnetic field of 570 Oe.	
157*	6 Matthiessen, A. and Voigt, C.	1864		273		Hard-drawn; resistivity value calculated from reported ratio of resistivities of silver and iron, with p(silver) assumed to be 1.468 $\times 10^{-9} \Omega \cdot m$.
158*	199 Potter, H.H.	1937		20-1130		99.96 pure; chief impurities are O and Si; from Messer. Adam Hilger; U-shape specimen 2 mm in diam and 8 cm long.
159*	200 Ribbeck, F.	1926	+	273-1273		0.07 Mn, 0.014 P, and traces of Si, Cu, S and Cr; electrolytic; 0.3-0.4 $\text{cm}^2 \times 10 \text{ cm}$; measured by compensation method with current 2-3 A.
160*	201 Bhagat, S.M., Anderson, J.R., and Wu, M.	1967		86-297		<111> iron whiskers; about 0.2-0.4 mm wide and 8 mm long; grown by hydrogen reduction of FeCl_2 either at room temperature using hydrogen saturated with water vapor or at 1023 K with a hydrogen flow rate of 300 ml/min; electropolished; measured in a longitudinal magnetic field of 2 kG.
161*	202 Massey-Tasey, G.	1950		194-1208		No details reported.
162*	203 Sudovtsov, A.I. and Semenenko, E.E.	1957	A	1.2-4.2		99.98 pure; polycrystalline specimen in the form of thin ribbons from Hilger; $R(4.2K)/R(273K) = 3.9328 \times 10^{-2}$; resistance at 273 K, 0.5091 Ω ; $R(T)/R(273K) = 3.9606 \times 10^{-2}$ with T extrapolated to 0 K; measured under condition where the earth's magnetic field is compensated by Helmholtz coils; specimen demagnetized with a 50 cps magnetic field of decreasing amplitude after each reversal in measuring current.
163	126 Semenenko, E.E. and Sudovtsov, A.I.	1962	A	1.3-20.3		* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
164 204	Semenenko, E.E., Sudortsov, A.I., and Shvetz, A.D.	1962	A	0.4-1.3		The above specimen measured at lower temperatures.
165* 116	Glaesser, W., Ingrund, H., and Never, H.	1967		4.2		0.008 total impurities; pure iron from Firma HEK, Lübeck.
166 116	Glaesser, W., et al.	1967		4.2		The above material 1 time zone-melted.
167 116	Glaesser, W., et al.	1967		4.2		The above material 5 times zone-melted.
168* 116	Glaesser, W., et al.	1967		4.2		The above material 10 times zone-melted.
169* 116	Glaesser, W., et al.	1967		4.2		The above material co-worked.
170 116	Glaesser, W., et al.	1967		4.2		The above material recrystallized at glowing.
171* 118	Schindler, A.I. and LaRoy, B.C.	1966	A	4.2	Fe-2	99.999 pure; from United Mineral and Chemical Co.; 0.5 mm in diam; distance between potential leads 3.5 cm; annealed at about 673 K under vacuum (7×10^{-5} Torr); measured under zero applied magnetic field.
172* 118	Schindler, A.I. and LaRoy, B.C.	1966	A	4.2	Fe-2	The above specimen; resistivity value obtained by extrapolating its magnetoresistance to zero magnetic induction.
173* 118	Schindler, A.I. and LaRoy, B.C.	1966	A	4.2	Fe-2	Same as Data Set 171 except with a different set of potential contacts.
174* 118	Schindler, A.I. and LaRoy, B.C.	1966	A	4.2	Fe-2	Same as above; resistivity value obtained by extrapolating the magneto-resistance to zero magnetic induction.
175* 118	Schindler, A.I. and LaRoy, B.C.	1966	A	4.2	Fe-1	Same specimen material as above; about 4 mm in diam; twice electron beam, float-zone-refined under 10^{-5} Torr; distance between potential leads 4 cm; measured in zero applied magnetic field.
176* 118	Schindler, A.I. and LaRoy, B.C.	1966	A	4.2	Fe-1	Same as above; resistivity value obtained by extrapolating the magneto-resistance to zero magnetic induction.
177 118	Schindler, A.I. and LaRoy, B.C.	1966	A	4.2	Fe-3	"High purity" single crystal from Materials Research Corp.; 2 mm in diam; distance between potential contacts 1.5 cm; measured under zero applied magnetic field.
178* 98	Schröder, K. and Giannuzzi, A.	1969			879-1126	Thermocouple grade; annealed in Ar at about 1190 K for 2 h.
179* 124	Beitchman, J.G., Trusel, C.W., and Coleman, R.V.	1970	A	0.3-1.2	T-7	Single crystal; specimen axis in a <111> direction; measured in a magnetic field of 950 Oe.

* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
180* 124	Beitchman, J.C., Trusel, C.W., and Coleman, R.V.	1970	A	0.4-1.2	T-7	The above specimen measured in a longitudinal magnetic field of 1230 Oe.
181* 124	Beitchman, J.C., et al.	1970	A	0.3-1.2	T-7	The above specimen measured in a longitudinal magnetic field of 1520 Oe.
182* 124	Beitchman, J.G., et al.	1970	A	1.0-4.1	T-7	The above specimen measured in a longitudinal magnetic field of 1150 Oe.
183* 124	Beitchman, J.G., et al.	1970	A	1.4-4.3	B-1	Single crystal; specimen axis in a <111> direction; measured in a longitudinal magnetic field of 1200 Oe.
184* 124	Beitchman, J.G., et al.	1970	A	4.7-21	B-1	The above specimen, measured at higher temperatures.
185* 205	Swartz, J.C. and Cuddy, L.J.	1970	V	4.2		Zone-refined iron; 0.13-0.40 mm in diam and 5-10 cm long; resistivity value calculated from reported $\rho(295K)/\rho(4.2K) = 180$, with $\rho(295K)$ taken to be $10.19 \times 10^{-8} \Omega \cdot m$.
186* 119	Arajs, S., Oliver, B.F., and Michalak, J.T.	1967	A	4.2	I	99.9966 pure; 0.0019 C, 0.0011 O and 0.0004 others (at.-%); interfacial grain area 7.0 mm^{-1} ; 1 mm in diam and about 80 mm long; produced by oxidation zone refining (oxygen activity γ_1).
187* 119	Arajs, S., et al.	1967	A	4.2	II	0.0019 C, 0.0018 O and 0.0042 others (at.-%); polycrystalline; interfacial grain area 14.3 mm^{-1} , 80 cm long.
188* 119	Arajs, S., et al.	1967	A	4.2	II	Same as the above except interfacial grain area 16.5 mm^{-1} .
189* 112	Fujii, T. and Morimoto, I.	1968	A	4.2	Fe I	0.0300 C (determined by vacuum combustion method), 0.0100 N and 0 each (determined by vacuum fusion method, and 0.0015 total metallic impurity; polycrystalline material obtained from Johnson and Matthey Co.; formed into a bar 5 mm in diam and 20 cm long; swaged into cylindrical rod 2.7 mm in diam and 50 cm long; annealed at 1163 K; chemically polished in a 500-1-500 solution of $H_2O-HF-C_2H_5OH$, removing a surface layer of 0.1 mm; resistivity value calculated from reported $\rho(295K)/\rho(4.2K)$, with $\rho(295K)$ taken to be $9.91 \times 10^{-8} \Omega \cdot m$.
190* 112	Fujii, T. and Morimoto, I.	1968	A	4.2	Fe I	Same specimen material as the above, prepared by a method similar to the above but exact treatment not given; resistivity calculated by same method as above.
191* 112	Fujii, T. and Morimoto, I.	1968	A	4.2	Fe II	0.0300 C, 0.0100 O, and 0.0015 N (determined by the same methods as for Data Set 189), and 0.0015 total metallic impurity; from the same specimen material as the above; zone-refined (1 pass at 3 mm min^{-1} in dry H ₂); other preparations same as the above except annealed at 1123 K for 20 h in a vacuum of $2 \times 10^{-6} \text{ mm Hg}$ before chemical polishing; resistivity calculated by same method as above.
192* 112	Fujii, T. and Morimoto, I.	1968	A	4.2	Fe III	0.0100 O, 0.0080 N, 0.0030 C (determined by same methods as for Data Set 189), and 0.0015 total metallic impurity; prepared from the same material and by a similar method as the above except decarbonized at 1023 K for 200 h in wet H ₂ ; resistivity calculated by same method as above.

* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
193* 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Prepared from the same specimen material and by a similar method as the above, but exact method not given; resistivity calculated by the same method as above.
194* 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Same as the above.
195* 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Same as the above.
196* 112	Fujii, T. and Morimoto, I.	1968	A	4.2	Fe IV	0.0030 C, <0.0005 N, 0.0004 C (determined by the same methods as for Data Set 189); and 0.0015 total metallic impurity; zone-refined (1 pass at 0.3 mm min ⁻¹ in dry H ₂); other preparations same as above; resistivity calculated by same method as above.
197* 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Prepared from the same specimen material and by a similar method as the above; but exact method not given; resistivity calculated by the same method as above.
198 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Same as the above.
199* 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Same as the above.
200* 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Same as the above.
201 112	Fujii, T. and Morimoto, I.	1968	A	4.2		0.0020 C, 0.0001 O, 0.015 total metallic impurity and trace N (determined by same method as for Data Set 189); zone-refined (1 pass at 0.3 mm min ⁻¹ and 5 passes at 1 mm min ⁻¹ in dry H ₂); other preparations and resistivity calculation same as the above.
202* 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Prepared from the same specimen material and by a similar method as the above, but exact method not given; resistivity calculated by same method as above.
203 112	Fujii, T. and Morimoto, I.	1968	A	4.2		Same as the above.
204 112	Fujii, T. and Morimoto, I.	1968	A	4.2		<0.0010 C, 0.015 total metallic impurity and traces N and O (determined by the same method as for Data Set 189); zone-refined (2 passes at 0.3 mm min ⁻¹ in wet H ₂ , 5 passes at 1 mm min ⁻¹ in vacuum and 2 passes at 1 mm min ⁻¹ in dry H ₂); other preparations same as the above; resistivity calculated by same method as above.
205 87	Seydel, U. and Fucke, W.	1977	+	1007-2997		99.99 pure; 0.0003 Ca and Si each, 0.0002 Al, Cu, and Mg each, and 0.0001 Ag, Cr, Mn, and Ni each (chemical analysis); measured by an exploding wire technique; measurement error 4%; smoothed values from curve; values corrected for thermal expansion.

* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
206	92	Güntherdt, H.J. Bausier, E., Künzli, H.U., and Müller, R.	1975	+	1726-1915		99.999 pure from Johnson and Matthey Co.; measured with potential method in which the sample material was enclosed within an alumina tube with four protrusions serving as current and potential contacts.
207*	206	Hölder, T.K.	1977	A	90-400		99.99 pure, 0.0025 C and N each, 0.0007 O and 0.0001 H; Material Research Corp. MARZ grade 3 pass zone refined iron; smoothed values from table; $\rho(273.15K)/\rho(4K) = 189$.
208	207	Ereshov, G.S., Kasatkina, A.A., and Gavrilin, I.V.	1974		1828-2065		99.997+ pure; measured by a contact method in a helium atm with specimen inside a vertical alumina crucible; liquid metal column 40-50 mm long.
209	113	Volkenshtein, N.V. and Yakina, V.P.	1971	A	4.2-46	Fe-4	Polyocrystalline specimen from Johnson and Matthey Co.; 0.1 mm thick, 3.0 mm wide and 15 mm long; vacuum (10^{-6} mmHg) annealed at 1273 K for 1 h, demagnetized; measuring current density 3.3 A/mm^2 .
210*	113	Volkenshtein, N.V. and Yakina, V.P.	1971	A	4.5-494		The above measured in an applied longitudinal magnetic field of 1.1 kOe.
211*	113	Volkenshtein, N.V. and Yakina, V.P.	1971	A	4.4-46.1		The above measured in an applied transverse magnetic field of 1.1 kOe.
212	93	Kita, Y., Ohguchi, S., and Morita, Z.	1978	+	1695-1895		0.008 Ni, 0.006 Si, 0.005 Cu and Cr each, 0.003 Mn and P each, and 0.002 C; measured with a four probe method in which the electrodes are made of the same material as the specimen, in a vacuum of 10 ⁻⁶ Torr; data points are taken at temperatures in the sequence: 1833, 1854, 1864, 1880, 1895, 1895, 1872, 1855, 1835, 1816, 1799, 1786, 1759, 1735, 1713, 1695 K; values from table supplied by authors; values corrected for thermal expansion.
213*	93	Kita, Y., et al.	1978	+	1676-1919		Same as the above; a second melt; temperature sequence: 1823, 1842, 1857, 1874, 1893, 1905, 1919, 1900, 1875, 1858, 1836, 1817, 1803, 1793, 1776, 1760, 1741, 1720, 1699 and 1676 K.
214*	93	Kita, Y., et al.	1978	+	1673-1973		Same as the above; a third melt; temperature sequence: 1823, 1843, 1866, 1876, 1889, 1905, 1915, 1937, 1915, 1896, 1889, 1850, 1833, 1814, 1829, 1845, 1863, 1878, 1893, 1910, 1894, 1879, 1864, 1850, 1841, 1817, 1802, 1777, 1764, 1748, 1726, 1708, and 1673 K.
215*	157	Arsentiev, P.P., Filipov, S.I., and Litsitskii, B.S.	1970	+	1693-1874		Specimen produced from electrolytic powder of composition: 0.23 C, 0.015 O, 0.012 S, 0.005 P and Si each, and trace Mn; melted in a hydrogen atm; electrical resistivity reported is the same as that reported for a 0.005 C specimen; measured with a potential method with tungsten electrodes; experimental chamber evacuated before heating and then filled with pure Fe; measured while heating.

* Not shown on either figure.

TABLE 8. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
216*	157 Arseniev, P.P., Phillipov, S.I., and Litsitskii, B.S.	1970	+	1683-1874	The above; measured while cooling.	
217	147 Lauchbury, M.D. and Saunders, N.H.	1976	A	373-1128	<0.03 Mn and <0.01 Cu, Si, Ca, and Mg each; cylindrical specimens 1.5 mm or 2 mm in diam and ~20 mm long, machined from 5 mm diam polycrystalline rods from Johnson and Matthey Co.; annealed at 1250 K for several hours in an argon atm; random measurement error 1%.	
218	128 Janes, S., Kovac, L., and Mlynec, R.	1972		9.9-28	Only temperature dependent part of resistivity reported; values from graph.	
219	115 Isshiki, M. and Igaki, K.	1978	A	1.7-271	High purity, prepared by floating zone refining and heated treated at 1073 K for 24 h in wet hydrogen described by authors in Trans. Jpn. Inst. Metals, 18, 413, 1977; specimen then electropolished in 95% acetic acid and 5% perchloric acid from a diam of 500 μm to 150 μm; about 10 cm in length; measured in a longitudinal applied magnetic field of 60 KA/m; values from graph.	
220	115 Isshiki, M. and Igaki, K.	1978	A	1.7-301	Similar to the above except specimen diam reduction from 500 μm to 180 μm.	
221	115 Isshiki, M. and Igaki, K.	1978	A	1.7-268	Similar to the above except specimen diam reduction from 500 μm to 190 μm.	
222	115 Isshiki, M. and Igaki, K.	1978	A	1.6-164	Similar to the above.	
223	115 Isshiki, M. and Igaki, K.	1978	A	1.6-292	Similar to the above except specimen diam reduction from 500 μm to 350 μm.	

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe
[Temperature, T; K; Electrical Resistivity, ρ , $10^{-8} \Omega \cdot m$]

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 1</u>																			
2.1	1.46*	77.78	0.925	4.2	0.092	873	71.0	194.1	5.31	380	14.77								
2.6	1.46*	194.8	5.26	15.2	0.097	973	87.5	273	9.04	400	16.09								
3.0	1.46*	273.3	8.91*	20.8	0.100	1013	107.2	323	11.72										
3.7	1.46*	298.8	10.33*	26.1	0.106			373	14.70										
4.3	1.46*			32.5	0.120			423	18.06										
4.9	1.46*			54.4	0.269			473	21.84*	1.63	0.0859								
5.5	1.46*			61.2	0.368	73	1.037*	523	26.10	3.14	0.0899								
6.2	1.46*	323	11.5	74.2	0.631	189	5.17	573	30.72	4.33	0.0875								
7.1	1.46*	373	14.5	79.1	0.744	273	9.04	623	35.90	6.30	0.0955								
8.3	1.46*	423	17.8	90.2	1.06	296	10.29*	673	41.51	9.02	0.0935								
10.4	1.46			293.0	10.3	297	10.35*	723	47.53	80.7	0.659								
12.3	1.46					310	11.06	773	54.12										
15.0	1.47					313	14.74*	823	61.22										
17.0	1.47					422	18.05*	873	68.89										
18.6	1.44	273	9.61	323	11.7	473	21.92*	923	77.10	293	10.4								
21.4	1.44			373	14.7	524	26.14*	973	86.22	373	14.4*								
23.7	1.44			423	17.9	573	30.67*	1023	96.46	473	22.0								
25.4	1.47			473	21.6	625	35.94*	1073	105.53	573	31.4								
27.7	1.48			523	25.6	671	41.07	1123	109.58	673	42.2								
30.0	1.51					723	47.38	1173	112.56*	773	54.8								
33.1	1.51					774	53.98*	1183	113.09	873	69.4								
36.4	1.51					824	61.18*	1193	112.54	973	86.1								
38.9	1.50			323	11.9	871	68.33	1223	113.66	1073	106.0								
41.5	1.51			373	14.9	924	77.02	1273	115.49										
44.0	1.51	273	10.7	423	18.2	973	85.85			1273	117.3	111.8							
49.5	1.59			473	21.8	995	90.25			1373	115.0*	118.0							
51.9	1.61			523	25.8	1023	96.16												
53.9	1.68			573	30.3	1033	96.18*												
56.8	1.80			673	41.0	1047	102.06	90	0.97										
58.9	1.84	83.2	0.929	773	53.3	1074	105.48*	100	1.27*										
61.2	1.89	273.2	9.11	873	67.9	1123	109.45*	120	1.95	196.5	5.0								
62.9	1.92			973	85.2	1113	112.35*	140	2.67	223.2	6.1*								
66.7	2.02			1073	104.2	1177	112.55*	160	3.47	245.3	7.1*								
69.2	2.08					1186	112.93	180	4.31	301.1									
72.6	2.14					1190	112.21*	200	5.20	349.7	13.2								
90.2	1.09			83.2	1.917	1191	112.20	220	6.11	406.6	16.6								
194.7	5.78	273.2	9.95	323	15.8	1198	112.47	240	7.04										
273.2	9.06*			373	18.7	1237	113.92	260	8.00										
373.2	14.73			423	22.0	1273	115.30	273	8.61	298.2	10.37								
						300	10.01*	300	10.01*	323.2	11.86*								
						320	11.09	423.2	14.69*	320	11.09								
						340	12.25	473.2	18.08*	340	12.25								
						77.5	1.01	523.2	21.89*	360	13.48								
								523	26.20*										

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 21(cont.)</u>															
<u>DATA SET 22(cont.)</u>															
573.2	30.97	1273	115.8	973.2	87.44*	293.2	9.72	293.2	10.00*	983.4	86.5	973.2	11.82*	994.0	88.6
623.2	36.16	1323	117.5	983.2	89.76*	373.2	14.85*	373.2	14.85*	1001.1	90.2	1005.1	91.0	1011.0	92.0
673.2	41.82	1373	119.0	993.2	92.00	<u>DATA SET 30*</u>		423.2	18.16*	1011.0	92.0	1014.1	92.9	1016.0	93.3
723.2	47.87	1423	120.4	1003.2	93.96*	293.2	9.71	473.2	21.97	1014.1	92.9	1016.0	93.3	1018.7	93.8
773.2	54.39	1473	121.8	1013.2	95.15	523.2	26.20	523.2	30.89	1018.7	93.8	1019.8	94.2	1020.8	94.3
823.2	61.39	1523	123.1	1023.2	97.17*	<u>DATA SET 31</u>		573.2	35.97*	1019.8	94.2	1021.8	94.5	1023.5	95.0
873.2	68.87*			1033.2	98.50*	623.2	41.55	673.2	41.55	1021.8	94.5	1023.5	95.0	1025.1	95.4
923.2	76.96			1043.2	99.67	<u>DATA SET 23*</u>		1053.2	100.70*	1025.1	95.4	1026.3	95.6	1027.6	95.9
973.2	85.85			1063.2	101.60	1063.2	101.60	1063.2	101.60	1027.6	95.9	1028.9	96.3	1031.6	96.9
1003.2	91.71	90	1.08	1073.2	102.36*	1073.2	102.36*	1073.2	102.36*	1031.6	96.9	1032.8	97.2	1034.2	97.6
1023.2	96.03	195	5.15	1083.2	103.03	1083.2	103.03	1083.2	103.03	1034.2	97.6	1036.7	98.1	1038.1	98.6
1033.2	98.57	290	9.95	1093.2	103.66*	1093.2	103.66*	1093.2	103.66*	1036.7	98.1	1042.9	99.7	1045.9	100.5
1036.2	99.41			1103.2	104.25	<u>DATA SET 24</u>		1103.2	104.25	1045.9	100.5	1047.7	100.8	1050.8	101.2
1043.2	100.84			1113.2	104.83*	1113.2	104.83*	1113.2	104.83*	1045.9	100.5	1047.7	100.8	1050.8	101.2
1053.2	102.23			1123.2	105.40*	1123.2	105.40*	1123.2	105.40*	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
1073.2	104.33*	293	2	1133.2	105.92	1133.2	105.92	1133.2	105.92	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
1123.2	108.10*	323	2	1143.2	106.41*	1143.2	106.41*	1143.2	106.41*	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
1173.2	110.78	373	2	1153.2	106.85	1153.2	106.85	1153.2	106.85	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
1223.2	112.79	393	2	1163.2	107.23*	1163.2	107.23*	1163.2	107.23*	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
1273.2	114.49	413	2	1173.2	107.55	1173.2	107.55	1173.2	107.55	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
1323.2	116.04	423	2	1183.2	107.83*	1183.2	107.83*	1183.2	107.83*	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
<u>DATA SET 22</u>															
443.2	18.83*			1193.2	108.07	1193.2	108.07	1193.2	108.07	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
453.2	19.66			1203.2	108.26	1203.2	108.26	1203.2	108.26	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
463.2	20.49*			1213.2	108.43*	1213.2	108.43*	1213.2	108.43*	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
473.2	21.31*			1223.2	108.57	1223.2	108.57	1223.2	108.57	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
483.2	22.14			1233.2	108.70*	1233.2	108.70*	1233.2	108.70*	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
493.2	22.98*			1243.2	108.83	1243.2	108.83	1243.2	108.83	1050.8	101.2	1053.2	106.31*	1053.2	106.31*
513.2	24.69*			523.2	25.58*	<u>DATA SET 25*</u>		523.2	25.58*	<u>DATA SET 32</u>		<u>DATA SET 34</u>		<u>DATA SET 36*</u>	
473	21.55*			573.2	30.30*	293.2	9.69	0.452	0.339	90	1.30	974.6	85.4		
523	25.65*			623.2	35.50*	623.2	41.19	0.643	0.346	133	2.48	984.2	88.0		
573	30.2*			673.2	47.39*	723.2	54.04	0.752	0.339*	152	3.19	994.3	89.9		
623	35.3			773.2	61.25*	823.2	75.74	0.788	0.350	172	4.06	1007.3	92.6		
673	40.95*			873.2	69.05	883.2	70.68	0.849	0.350	192	5.15	1012.3	93.6		
723	47.0			933.2	79.32	933.2	81.21	0.860	0.339	211	6.01	1018.9	95.0		
773	53.7			943.2	81.21	943.2	83.18*	0.860	0.349	231	6.95	1022.2	95.7		
823	60.9*			953.2	83.18*	953.2	85.26	0.892	0.338	251	7.95	1025.6	96.6		
873	68.7*			963.2	85.26	963.2	87.31	0.936	0.350	271	8.92	1028.0	97.3		
923	76.85*			973	85.9*	973	90.71	0.944	0.353	291	10.00	1031.1	98.2		
973	85.9*			973	90.71	973	97.70	0.952	0.338	1035.1	99.1				
1023	96.0*			1023	91.74	1023	96.04	1.001	0.333	1039.2	100.1				
1073	98.5*			1073	97.54	1073	101.49	1.031	0.328	1044.9	101.4				
1123	108.7*			1123	111.6	1123	113.9*	1.102	0.326	1059.8	103.4				
1173	111.6			1173	113.9*	1173	122.3	977.6	83.5	1078.8	105.3				

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

T	p	T	p	T	p	T	p	T	p	T	p	T	p	
1165.5	110.311	1183.6	110.589	1103	105.8	253	7.9	16	0.390	53.8	1.820			
1167.3	110.345	1184.4	110.503	1123	107.3	273	8.8	18	0.390	76.1	2.341			
1169.1	110.387	1186.2	110.624	1143	108.7	293	9.87	20	0.392					
1171.9	110.437	1187.0	110.638	1163	109.8	323	11.6	25	0.399					
1172.9	110.463	1187.9	110.652	1183	110.7	373	14.7	30	0.410					
1173.9	110.481	1189.7	110.676	1203	111.4	423	18.1	35	0.426	76.1	1.220			
1174.6	110.594	1190.6	110.691	1223	112.0	473	21.4	40	0.450	191.3	5.318			
1176.2	110.520	1191.4	110.701	1243	112.7	523	26.0	45	0.484	234.0	7.168			
1177.3	110.544	1192.5	110.715	1263	113.3	573	30.1	50	0.528	273	9.065*			
1178.2	110.567	1194.9	110.741	1283	114.0	623	35.0	55	0.585	273.85	9.115			
1179.0	110.589					673	40.3	60	0.654	291.40	10.014			
1179.8	110.604					723	46.8	65	0.737	333.40	12.359			
1180.8	110.624					773	53.3	70	0.832	371.25	14.631			
1181.7	110.640	73	2	1.0	1553	121.11	823	60.1	75	0.938	418.6	17.793		
1183.5	110.666	123.2	2.5	1573	121.52*	873	68.0	80	1.0	469.3	21.499			
1183.5	110.680	173.2	4.3	1593	121.92	923	76.0	85	1.186					
1185.3	110.697	223.2	6.6	1613	122.34	973	84.8	90	1.327					
1186.1	110.696	273.2	9.0	1633	122.76	1023	94.2	95	1.476					
1187.0	110.696	323.2	11.8	1653	123.17	1073	102.1	100	1.632	51.0	0.660			
1188.0	110.689	373.2	14.4	1659	123.31	1123	106.3	110	1.969	54.0	0.725			
1188.9	110.689	423.2	17.9	1663	123.49	1173	109.0	120	2.330	76.1	1.220			
1192.3	110.687	473.2	21.5	1673	123.74	1223	111.1	130	2.707	273.2	9.065			
1193.2	110.698	523.2	25.5	1693	124.22	1273	113.1	140	3.10					
1194.0	110.709	573.2	30.6	1713	124.73									
1195.0	110.719	623.2	35.8											
1197.6	110.745	673.2	40.9											
1163.9	110.485	723.2	46.4	83	1.22	291	11.96	180	4.75	50.5	0.644			
1165.5	110.519	823.2	60.2	203	5.60	373	16.81	190	5.18	50.8	0.649			
1167.4	110.553	923.2	67.2	223	6.50			200	5.61	76.1	1.220			
1168.3	110.578	973.2	84.2	248	7.65			220	6.52					
1169.2	110.595	1023.2	93.8	273	8.96	273	9.64	260	8.42	76	0.608			
1171.8	110.603	1073.2	103.3	293	10.0	373	15.09	280	9.43	91	1.067*			
1171.9	110.598	1123.2	108.1	313	11.3					173	4.010*			
		1173.2	110.4	333	12.5									
		1173.2	110.4	353	13.6									
1172.7	110.582	1223.2	112.5	312.07	11.99	76.1	2.341	191.3	6.647					
1173.7	110.552	1273.2	114.0											
1174.6	110.522	1323.2	115.3											
1175.4	110.480	1373.2	116.6	93	1.1									
1176.4	110.476	1423.2	117.9	113	1.7	6	0.387	274.55	10.592	303	15.3			
1177.3	110.491	1473.2	119.2	133	2.4	7	0.387	291.65	11.498	367	20.0			
1178.2	110.514	1523.2	120.6	153	3.1	8	0.385	325.25	13.399	413	23.1			
1180.1	110.531	1573.2	121.6	173	4.0	9	0.385	363.7	15.729	460	26.3			
1180.9	110.546	1623.2	122.8	193	5.0	10	0.385	412.0	18.902	527	32.0			
1181.8	110.566	1673.2	124.0	213	5.9	12	0.387	470.5	23.251	575	36.4			
		1715.2	125.2	233	6.9	14	0.389	648	43.6					

* Not shown on either figure.

TABLE 2. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON (continued)

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON (continued)

EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
DATA SET 95(cont.)															
942	83.2	1040	103.8	1174.7	117.711	1175.6	117.682	483.5	27.68	959.5	81.30				
947	84.1	1046	104.8	1175.6	117.735	1176.5	117.663	486	27.88	1009	89.00				
952	85.0	1092	110.2	1176.5	117.771	1177.4	117.663	527.5	41.30	1189	112.80				
956	85.9	1155	114.8	1177.4	117.802	1178.3	117.632	646	43.45	1158.5	110.60				
960	86.8	1158	115.0	1178.3	117.843	1179.2	117.651	803.5	61.55						
965	87.6	1164	115.2	1179.2	117.869	1180.0	117.655	808.5	61.55						
970	88.6	1168	114.8	1180.0	117.920	1181.0	117.655	916	77.40	273	10.50				
975	89.5	1172	114.9	1181.0	117.963	1181.9	117.665	947	83.40						
980	90.3	1176	115.0	1181.9	118.002	1182.8	117.690	1025	96.70	284.1	11.10				
984	91.4	1191	115.1	1182.8	118.036	1183.6	118.061	1184.5	117.741	325	13.21				
989	92.3	1186	115.1	1183.6	118.061	1184.5	118.077	1185.5	117.773	374	11.41				
999	93.2	1190	115.2	1184.5	118.077	1185.5	118.098	1186.4	117.800	401.5	18.44				
998	94.3	1194	115.3	1185.5	118.12	1186.4	118.12	463.5	23.28						
1008	96.2	1198	115.5	1186.4	118.12	1187.2	118.105	273	12.500	525.5	28.66				
1012	97.2	1203	115.6	1187.2	118.082	1188.2	118.082	289	13.58	587.5	34.92				
1016	98.3	1207	115.8	1188.2	118.082	1189.0	118.070	325	12.43	631.5	39.80				
1026	100.5	1211	115.9	1189.0	118.070	1190.0	118.070	444.5	23.48	686.5	45.90				
1031	101.6	1217	116.1	1189.6	118.056	1190.7	118.045	375	14.88	474.5	25.13				
1036	102.7	1221	116.2	1190.7	118.045	1191.5	118.047	425	18.33	594	36.28				
1050	105.8			1191.5	118.047	475	22.78	600	36.76	790	59.25				
1054	106.4			1192.4	118.052	525	26.23	603.5	37.00	828	64.40				
1059	106.9			1193.2	118.092	575	30.68	777.5	55.50	834	65.40				
1063	107.6	1003	95.4	1194.0	118.108	625	36.13	779	55.70	878.5	71.95				
1068	108.1	1021	99.6	1194.8	118.125	675	41.58	893	71.35	922	78.90				
1073	108.6	1040	104.4	1195.5	118.142	725	48.03	926	75.60	952	83.75				
1077	109.0	1045	105.4	1196.4	118.158	775	54.48	979	84.40	1012.5	94.20				
1082	109.5	1091	110.5	1197.0	118.198	825	61.93	997.5	86.60	1024.0	96.20				
1085	110.0	1155	114.2	1197.7	118.230	875	69.38	1034	92.60	1037.0	98.60				
1095	110.6	1159	114.4	1198.5	118.258	925	77.83	1059	97.20	1095	100.00				
1100	111.0	1166	116.7	975	86.28	1078	101.10	1059.5	103.00						
1104	111.3	1167	115.4	1025	94.73	1081.5	101.10	1073	106.10						
1109	111.6	1172	115.4	1075	102.18	1154	110.00	1099	108.30						
1114	111.8	1177	115.6	1125	107.63	1143	109.40								
1118	112.2	1181	115.7	1175	111.08	1209	110.10								
1123	112.5	1185	115.6	1164.8	117.381	1225	113.53	1223.5	114.20						
1127	112.8	1190	115.8	1165.7	117.429	1275	114.98	1273	115.00	273	10.50				
1131	113.1	1195	115.9	1166.6	117.473	1325	116.43	1299.5	115.80	291	11.14				
1137	113.2	1198	116.0	1167.5	117.540	1375	117.88	1323	115.80	357	15.39				
1141	113.5	1203	116.2	1168.5	117.600	1425	120.33			413.5	19.41				
1146	113.9	1207	116.4	1169.4	117.661	1425		469.5	24.02						
1150	114.2	1211	116.4	1170.1	117.704	1425		525.5	29.00						
		1216	116.7	1171.1	117.721	1425		568.5	34.02						
		1220	116.8	1172.0	117.718	1425		634	40.58						
1004	96.9			1173.0	117.712	1425		659	43.40						
1022	99.1			1173.9	117.689	400	22.15	679	45.72						
				1174.7	117.690	462	26.30	954	79.75	727.5	51.77				
DATA SET 99*															
DATA SET 101*															
								289.8	13.510						
								293	13.94						
								903	72.90						
								905.5	72.40						
								954	79.75						
DATA SET 103 (cont.)*															

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

T	p	T	p	T	p	T	p	T	p	T	p	T	p	T	p	T	p	T	p																		
<u>DATA SET 105(cont.)</u>		<u>DATA SET 107(cont.)</u>		<u>DATA SET 108(cont.)</u>		<u>DATA SET 109(cont.)</u>		<u>DATA SET 110(cont.)</u>		<u>DATA SET 111</u>		<u>DATA SET 112</u>		<u>DATA SET 113(cont.)</u>		<u>DATA SET 114</u>		<u>DATA SET 115</u>																			
776.5	57.85	5.4	0.084	1044	91.6	873	79.55	477	20.6	1397	116.8*	776.5	57.85	5.4	0.084	1044	91.6	873	79.55																		
826.5	64.85	6.2	0.084	1053	97.5	923	89.70	499	22.7	1617	115.8	827	64.80	6.7	0.086	1063	100.2	973	103.3	524	24.6																
867	70.05	7.3	0.086	1073	101.5	1023	113.2	545	26.8*	1445	116.4*	903.5	76.40	8.1	0.089	1093	103.6	1073	118.6	574	29.0																
910	77.40	9.1	0.086	1123	106.0	1123	120.4	597	31.2*	1524	118.3*	931	80.85	10.1	0.086	1173	121.2	623	33.9	1544	119.0																
970	87.20	11.2	0.086	1223	122.0	1223	122.0	647	36.6*	1573	119.6*	998.5	92.05	12.1	0.088	1273	122.4	671	38.9	1597	120.4*																
1017	95.65	13.1	0.090	273	8.53	699	41.9*	1618	121.1	1037.5	99.85	16.1	0.087	293	19.91	721	44.2	1645	121.6*																		
1038.5	100.00	15.1	0.093	323	11.64	750	47.4	1636	121.7	1043	100.90	16.2	0.091	373	15.53	775	50.9*	1668	122.8*																		
1054	103.40	17.1	0.094	423	20.21	293	10.95	802	53.8	1676	122.2	1060	104.60	19.3	0.095	473	25.00	323	11.92*	1686	123.5*																
1065.5	105.60	21.4	0.097	523	29.87	373	15.49	845	60.7	1697	123.8	1086.5	108.40	22.2	0.098	573	35.41	423	18.81	869	64.1*																
1097.5	109.60	26.1	0.103	623	40.75	473	22.76*	897	68.0	1718	125.0	1117	111.40	25.2	0.098	673	46.80	523	26.79	925	71.4*																
1131	112.50	26.1	0.105	723	53.50	573	31.93	953	75.2	1144	113.40	28.2	0.110	773	59.85	625	37.07	976	79.8*	1164.5	114.50	30.2	0.114	823	67.55	673	43.20	995	83.6								
1189.5	116.20	33.9	0.125	873	76.35	723	50.30	1016	89.0*	1262.5	118.55	100	1.28	1123	109.9	973	92.9	1044	94.4	1273.0	118.80	150	3.14	1173	111.1	1023	105.1	1046	95.8*								
1219.5	117.20	40.4	0.157	973	96.65	823	63.95	1031	92.3*	1245	118.20	40.9	0.163	1023	104.8	873	71.05	1031	93.2*	1256	118.35	49.0	0.217	1073	107.8	923	79.40	1031	94.4								
1287.5	119.10	53.8	0.200	1223	112.8	1073	111.0	1049	96.6	1309	119.65	250	7.74	1273	113.6	1123	114.5	1073	100.2	129	129	1331.5	120.05	300	10.33	1033	103.0	1173	117.8	1096	102.8*						
1344.5	120.35	56.8	0.200	1300	120.60	<u>DATA SET 108</u>	<u>DATA SET 110</u>	<u>DATA SET 112</u>	<u>DATA SET 114</u>	1348.5	120.85	78	2.07	323	12.06	1923	9.57	1165	107.0*	1817	137	1415	121.00	1423	120.60	173	10.1*	423	19.09	<u>DATA SET 113</u>	<u>DATA SET 115</u>	113	10.9*	1225	109.9*	1886	136
4.2	0.23	57.0	30.6	573	36.15	327	11.5	1253	110.7	4.2	0.23	57.0	30.6	373	15.39*	1182	108.3	1833	134	681	41.6	683	53.9	423	19.09	<u>DATA SET 113</u>	<u>DATA SET 115</u>	1195	108.0*	1274	111.1*	1852	135				
4.2	0.080	982	82.7	773	62.35	425	17.2*	1347	113.5*	4.5	0.083	1033	92.9	823	70.30	451	19.0	1373	114.3*	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

<u>T</u>	<u>ρ</u>	<u>T</u>	<u>ρ</u>	<u>T</u>	<u>ρ</u>	<u>T</u>	<u>ρ</u>	<u>$\rho - \rho_0$</u>	<u>T</u>	<u>ρ</u>	<u>T</u>	<u>ρ</u>	<u>T</u>	<u>ρ</u>	
<u>DATA SET 115</u>															
		<u>DATA SET 116 (cont.)</u>			<u>DATA SET 116 (cont.)</u>			<u>DATA SET 119*</u>			<u>DATA SET 124*</u>			<u>DATA SET 134 (cont.)</u>	
1773	129.9	1023.4	98.389*	1054.4	106.326*	2.438	0.0009942	77	0.700	25.4	0.3583				
1797	131.0	1024.7	98.281*	1055.4	106.433*	3.062	0.0001621	298	9.80	26.2	0.3549*				
1822	138.1	1026.0	99.409*	1056.3	106.504*	4.159	0.0002509			26.5	0.3553*				
1832	140.0	1027.1	100.015*	1057.4	106.611*	5.000	0.0003850			30.9	0.37608				
1842	138.4	1027.2	99.694*	1059.0	106.822*	7.674	0.0007771			33.6	0.3802				
1847	139.2	1028.5	100.122*	1059.6	106.896*	10.00	0.001326			37.2	0.4146				
1852	141.3	1029.6	100.443*	1060.5	106.896	11.32	0.001720			40.7	0.4484				
1862	139.3	1030.4	100.764*	1061.2	106.922*	15.92	0.004041			46.8	0.4977				
1872	140.8	1031.0	100.978*	1062.1	106.968*	18.84	0.0060988			51.6	0.5521				
1882	140.2	1032.1	100.263*	1063.3	107.003*	29.31	0.02007			59.0	0.6562				
1892	142.1	1032.6	100.512*	1064.0	107.039*	38.90	0.04770			64.6	0.7590				
1898	141.1	1033.4	101.833*	1065.2	107.075*	49.77	0.1184			70.6	0.8995				
		<u>DATA SET 116</u>			<u>DATA SET 120*</u>			<u>DATA SET 127*</u>			<u>DATA SET 127*</u>			<u>DATA SET 134</u>	
993.8	91.101	1035.7	102.618*	1069.1	107.396*	2.366	0.0001022			82.2	1.218				
995.4	91.422*	1036.0	102.760*	1069.9	107.431*	2.951	0.0001554			86.3	1.359*				
996.4	91.636*	1036.7	102.974*	1070.3	107.503*	4.130	0.0002732			90.6	1.509*				
996.7	91.707*	1037.4	103.295*	1071.4	107.574*	4.989	0.0004004			95.1	1.690				
997.7	91.885*	1038.2	103.519*	1072.3	107.610*	7.379	0.0008138			102.1	1.920*				
998.2	91.921*	1038.8	103.587*	1073.0	107.645*	11.02	0.001700			108.9	2.173*				
998.8	92.171*	1039.2	103.830*	1073.6	107.681*	19.01	0.005909			117.5	2.461				
1001.4	92.812	1039.7	103.973*	1074.7	107.752*	30.90	0.01993			126.8	2.915*				
1003.4	93.347*	1040.0	104.187	1076.0	107.824*	39.45	0.04041			137.4	3.34				
1003.5	93.419*	1040.3	104.294*	1077.0	107.895*	47.64	0.07789			150.0	3.85				
1004.4	93.561*	1040.8	104.308*	1077.9	107.930*	77.62	0.5514			166.3	4.66*				
1005.5	92.527*	1041.3	104.650*	1078.7	108.037*					175.4	5.067				
1005.7	93.704	1041.9	104.828*	1079.7	108.144*					181.6	5.548*				
1006.2	93.918*	1042.4	104.864*	1080.4	108.251					195.9	6.321				
1007.1	94.239*	1042.8	105.007*	1081.4	108.323*					218.3	7.336				
1008.2	94.417*	1043.2	105.042*	1082.4	108.394*					239.3	8.581				
1008.8	94.666*	1043.7	105.114*	1083.2	108.430*					252.3	9.253				
1010.4	94.916*	1044.3	105.185*	1084.3	108.501*					259.4	9.482				
1011.4	95.130*	1045.2	105.399*	1085.5	108.572*	1573	133.8			276.1	10.136				
1012.2	95.415*	1045.7	105.542*	1086.5	108.608*	1873	136.4			300.0	10.33				
1013.4	95.665*	1046.0	105.613*	1088.1	108.751					<u>DATA SET 134</u>					
1014.0	95.914*	1046.7	105.684*	1089.8	108.805*					373	16.1				
1015.7	96.271*	1047.3	105.791*	1090.4	108.901*					473	22.8				
1016.5	96.521*	1048.2	105.862*	1091.2	109.002*					573	30.8				
1017.1	96.628*	1049.2	105.969*	1092.1	109.103*					673	42.6				
1017.8	96.877*	1049.8	106.005*	1093.1	109.204*					773	55.4				
1019.3	97.412*	1050.4	106.041	1094.7	109.309*										
1020.5	97.697	1051.0	106.112*	1096.3	109.417*										
1021.1	97.911*	1052.2	106.148*	1097.9	109.525*										
1021.9	98.268*	1052.9	106.183*	1100.5	109.635*										
1022.4	98.339*	1053.7	106.291*	1102.1	109.742*										

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	
<u>DATA SET 136</u>			<u>DATA SET 138 (cont.)</u>		<u>DATA SET 143 (cont.)*</u>		<u>DATA SET 148</u>		<u>DATA SET 153 (cont.)*</u>		<u>DATA SET 158 (cont.)*</u>		
4.2	0.04	1511	120.5	273.0	8.57	1.98	0.0556	77.79	1.288	719.5	45.434		
100	1.3	1532	121.1	293.0	9.6100	4.21	0.0565	85.19	1.520	830.6	60.230		
200	5.4	1546	121.8	373.0	14.296	20.40	0.0692	273.16	11.04	837.8	61.261		
300	9.7	1572	122.1	373.0	14.296	78.20	0.6751			955.9	80.392		
400	15.6	1595	122.5	373.0	14.296	273.16	9.11			989.1	86.787		
500	23.1	1623	124.0	472.6	21.432					1012.2	91.467		
600	32.4	1673	125.0	580.8	31.015					1012.25	92.762		
700	43.7	1723	126.1	671.4	36.259					1023.8	96.296		
800	56.6	1773	127.1	760.7	51.759	1.98	0.0723	4.21	0.6712	1026.1	94.828		
900	71.6	1793	127.9			4.21	0.0723	20.40	0.6967	1028.9	95.539		
1000	90.3									1031.0	96.233		
1043	99.7		<u>DATA SET 140*</u>		<u>DATA SET 144*</u>		<u>DATA SET 150*</u>		<u>DATA SET 155*</u>		<u>DATA SET 159*</u>		
1100	106.5				80.3	0.962	78.24	0.6751	90.46	2.391	1033.4	96.709	
1185	111.6		20.4	-0.64286	194.9	4.5928	273.16	8.93	273.16	15.98	1034.3	96.887	
1200	110.3		80.6	0.97180	273.0	8.57					1035.3	97.086	
118	110.3		198.3	5.1537	373	14.296					1036.6	97.345	
120	110.3		273.1	8.57	373	14.296					1037.1	97.444	
<u>DATA SET 137*</u>			<u>DATA SET 141*</u>		<u>DATA SET 145*</u>		<u>DATA SET 151*</u>		<u>DATA SET 156*</u>		<u>DATA SET 159*</u>		
1611	142.7		20.4	-0.64286	572.4	30.215	20.40	0.1781	4.21	0.1614	3.71	0.6696	
1900	152.3		80.6	0.97180	1.38	0.2020	77.74	0.8610	20.40	0.9348	1040.6	98.143	
2000	164.9		198.3	5.1337	4.21	0.2022	273.16	9.84	81.73	2.755	1041.6	98.344	
<u>DATA SET 138</u>			273.1	8.57	20.40	0.2136			273.16	22.58	1043.0	98.625	
219	9.7		<u>DATA SET 142*</u>		<u>DATA SET 152*</u>		<u>DATA SET 157*</u>		<u>DATA SET 159*</u>		<u>DATA SET 159*</u>		
432	19.4				87.42	1.094	1.38	0.1631	3.71	0.1641	0.302	0.006210	
565	31.3		80.3	0.963	273.16	9.36	4.21	0.1674	4.21	0.1674	0.400	0.006211	
668	42.3		80.5	0.969			20.40	0.1772	5.00	0.1772	0.500	0.006212	
766	54.5		194.6	4.980			77.74	0.8935	0.600	0.006215	1057.5	101.56	
983	69.7		273	8.57	1.38	0.1252	273.16	10.87	0.700	0.006217	1061.6	102.40	
1050	101.5		293	9.6100	3.71	0.1252			0.805	0.006221	1078.4	105.90	
1075	104.3		373	14.296	4.21	0.1252			0.908	0.006225	1080.4	106.32	
1107	106.8		373	14.296	20.40	0.1341	1.38	0.6166	1.004	0.006229	1093.9	101.28	
1123	109.0		373	14.296	83.90	0.8898	3.71	0.6166			1095.2	109.47	
1131	109.1		373	14.296	273.16	8.88	4.21	0.6176			1129.6	117.03	
1149	109.4		472.1	21.393			20.40	0.6425	273	8.73	<u>DATA SET 159*</u>		
1170	111.3		58.6	31.094			81.73	1.421			273	8.57	
1200	111.6		682.5	41.954			90.46	1.66			293	9.61	
1213	112.1		784.2	54.956	1.38	0.0896	273.16	9.59			373	14.296	
1260	112.9				4.21	0.0887							
1352	115.4		<u>DATA SET 143*</u>		<u>DATA SET 147</u>		<u>DATA SET 153*</u>		<u>DATA SET 159*</u>		<u>DATA SET 159*</u>		
1410	117.2				20.40	0.0974	90	0.180			473	21.5	
1442	118.3		81.0	0.9836	83.90	0.828	273	1.046			573	30.3	
1458	119.0		196.9	4.9928	273.16	8.70	1.29	0.5123	373	1.421	673	40.6	
1479	119.8		195.0	4.9969			4.21	0.5167	566	29.129	773	53.4	
							20.40	0.5235	578.3	30.265	873	68.1	

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 159 (cont.)*</u>															
973	85.2	193.8	5.06	4.17	0.03370	4.2	0.0599	879	70.79	0.310	0.005887				
1073	105	292.8	9.6	4.19	0.03370	901	73.82	0.338	0.005890						
1173	127	398.0	15.9	4.19	0.03371	903	74.84	0.423	0.005894						
1273	152	491.8	23.0			DATA SET 167		927	78.98	0.504	0.005896				
						DATA SET 163		4.2	0.0381	928	77.97	0.601	0.005900		
								686.6	31.6	81.51	0.699	0.005905			
								684.6	42.2	81.51	0.807	0.005911			
								784.6	55.0	1.26	0.03399*	DATA SET 168*			
								887.8	70.5	1.46	0.03400	976	87.58	0.909	0.005915
								988.9	88.1	1.64	0.03401	979	86.57	1.01	0.005912
								1085.8	107.5	1.84	0.03403	1000	91.02	1.10	0.005918
								1207.7	135.4	2.01	0.03404	1000	92.03	1.20	0.005918
										2.21	0.03405	1022	95.67		
											4.2	0.0390	1022	97.39	DATA SET 182*
											2.44	0.03406	1045	101.13	
											2.85	0.03408	1050	102.65	1.02
												DATA SET 170	1072	103.25	0.005216
													1072	103.25	1.17
															0.005220
															1.29
															1.38
															1.49
															1.59
															1.68
															1.78
															1.89
															2.00
															2.08
															2.20
															2.29
															2.40
															2.50
															2.60
															2.70
															2.79
															2.90
															3.00
															3.10
															3.20
															3.30
															3.40
															3.51
															3.60
															3.70
															3.79
															3.89
															4.11
															4.20

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 183*</u>		<u>DATA SET 184*(cont.)*</u>		<u>DATA SET 196*</u>		<u>DATA SET 205(cont.)</u>		<u>DATA SET 207(cont.)</u>		<u>DATA SET 209(cont.)</u>		<u>DATA SET 209(cont.)</u>	
1.41	0.012080	17.6	0.02097	4.2	0.0615	1677	123.5*	360	13.446	40.1	0.0941		
1.51	0.012093	19.05	0.02248			1736	124.3*	380	14.499	41.3	0.0996		
1.61	0.012093	20.7	0.02454	<u>DATA SET 197</u>		1816	125.3	400	16.009	42.3	0.1047		
1.72	0.012099					1816	131.3			43.0	0.1083		
1.82	0.012098	<u>DATA SET 185*</u>		4.2	0.0516	2001	133.2	<u>DATA SET 208</u>		43.7	0.1134		
1.89	0.012119					2198	134.9			44.9	0.1216		
2.05	0.012124	4.2	0.0566	<u>DATA SET 198*</u>		2375	136.6	1828	137.5	45.7	0.1253		
2.22	0.012148					2505	137.8	1854	138.4			<u>DATA SET 210*</u>	
2.32	0.012165	<u>DATA SET 186</u>		4.2	0.0429	2699	139.4	1877	138.4				
2.39	0.012166					2825	140.3	1894	139.1				
2.50	0.012183	4.2	0.0246	<u>DATA SET 199*</u>		2964	141.5*	1915	139.7	4.5	0.027		
2.52	0.012193					2997	142.0	1953	141.9	5.8	0.027		
2.63	0.012215	<u>DATA SET 187*</u>		4.2	0.0384			1980	142.6	6.7	0.027		
2.78	0.012238							2010	143.2*	8.0	0.028		
2.99	0.012266	4.2	0.0402	<u>DATA SET 200</u>				2033	143.9*	8.9	0.028		
3.09	0.012296					1726	126.7	2065	144.4*	9.6	0.028		
3.26	0.012329	<u>DATA SET 188*</u>		4.2	0.0358	1748	126.7			10.5	0.028		
3.41	0.012364					1772	127.6			11.4	0.029		
3.62	0.012405	4.2	0.0491	<u>DATA SET 201*</u>		1775	127.6			12.3	0.029		
3.86	0.012458					1797	128.5			14.3	0.030		
4.08	0.012516	<u>DATA SET 189*</u>		4.2	0.0336	1813	131.5			16.1	0.032		
4.31	0.012571					1822	135.2*			7.2	0.0419		
<u>DATA SET 184*</u>						1832	135.1*			8.2	0.0423		
		<u>DATA SET 190*</u>				1838	135.5			9.1	0.0423		
						1852	135.9			10.0	0.0429		
4.7	0.01271	4.2	0.283	<u>DATA SET 202*</u>		1873	136.1			17.1	0.0458		
5.0	0.01283					1884	136.9			10.8	0.0425		
5.3	0.01288	4.2	0.134	<u>DATA SET 203</u>		1901	136.3*			11.6	0.0429		
5.8	0.01304			<u>DATA SET 191*</u>		1915	137.0			12.6	0.0433		
6.1	0.01315									15.0	0.0449		
6.2	0.01329	4.2	0.109	<u>DATA SET 204</u>		1915	137.0			17.1	0.0458		
6.6	0.01329									20.7	0.0482		
7.0	0.01346	<u>DATA SET 192*</u>		4.2	0.0248					21.8	0.0499		
7.5	0.01373					90	0.907			23.1	0.0507		
8.1	0.01395	4.2	0.0926	<u>DATA SET 205</u>		100	1.218			24.6	0.0520		
8.6	0.01421					1182	1.907			26.2	0.0544		
9.2	0.01448	<u>DATA SET 193*</u>				140	2.654			27.5	0.0561		
9.6	0.01479					160	3.452			28.6	0.0579		
10.3	0.01514	4.2	0.0884	<u>DATA SET 206</u>		1044	102.8*			30.0	0.0603		
11.1	0.01565					1098	107.6*			31.2	0.0632		
11.95	0.01622	<u>DATA SET 194*</u>				1182	112.6*			31.7	0.0650		
12.81	0.01678	4.2	0.1448			1182	113.6*			32.0	0.0679		
13.96	0.01765					1295	116.4			34.3	0.0708		
15.0	0.01850	4.2	0.0799			1421	119.1*			35.4	0.0746		
15.6	0.01892			<u>DATA SET 195*</u>		1501	120.4*			36.7	0.0788		
16.4	0.01973	4.2	0.0635			1627	122.5*			37.7	0.0834		
						1677	123.0*			39.3	0.0893		

* Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
DATA SET 211*		DATA SET 213(cont.)*		DATA SET 214(cont.)*		DATA SET 216*		DATA SET 217(cont.)		DATA SET 217(cont.)		DATA SET 217	
4.4	0.057	1801	135.9	1915	137.6	453.2	20.18*	923.2	77.04*	1046.95	102.33*		
6.6	0.057	1817	136.1	1915	137.7	473.2	21.82*	933.2	78.77*	1048.2	102.58*		
8.2	0.057	1821	136.2	1937	138.05	483.2	22.69*	943.2	80.56*	1049.45	102.79*		
10.0	0.058	1836	136.4	1842	136.45	493.2	23.58*	948.2	81.44*	1050.7	103.40*		
11.1	0.059	1857	136.65	1858	136.75	503.2	24.51*	953.2	82.40	1053.2	103.40*		
12.4	0.058	1874	136.9	1876	136.9	513.2	25.46*	958.2	83.30*	1055.7	103.77*		
14.4	0.059	1893	137.2	1894	137.35	523.2	26.41*	963.2	84.21*	1058.2	104.13*		
16.3	0.059	1895	137.35	1895	137.6	533.2	27.38*	968.2	85.12*	1063.2	104.98		
18.7	0.060	1875	137.0	1875	137.1	543.2	28.33*	973.2	85.52*	1068.2	105.63*		
23.2	0.064	1891	137.2	1892	137.2	553.2	29.29	978.2	86.87*	1073.2	106.37*		
26.6	0.067	1909	137.35	1874	137.6	563.2	30.22*	983.2	87.85*	1078.2	106.89		
29.9	0.071	1905	137.4	1919	137.6	573.2	31.18*	988.2	88.84	1083.2	107.38*		
33.0	0.076	1919	137.6			583.2	32.16*	993.2	89.56*	1088.2	107.85		
35.7	0.084					593.2	33.16*	995.2	90.07*	1093.2	108.31*		
38.2	0.090					603.2	34.18*	998.2	90.00*	1098.2	108.73*		
40.5	0.100					613.2	35.22*	1000.2	91.12*	1103.2	109.14		
42.8	0.112	1673	127.05	1703	127.65	623.2	36.28*	1003.2	91.64*	1108.2	109.53*		
46.1	0.130	1708	127.95	1713	127.95	633.2	37.37*	1005.7	92.17*	1113.2	109.93*		
		1728	127.95	1723	127.95	643.2	38.46*	1008.2	92.72	1118.2	110.29*		
		1748	128.2	1732	128.2	653.2	39.56	1010.7	93.27*	1123.2	110.63*		
		1764	128.55	1743	129.35	663.2	40.67*	1013.2	93.53*	1128.2	110.96		
		1777	133.45	1752	124.332	673.2	41.80*	1015.7	94.38*				
		1713	126.65	1802	136.2	1762	123.960	683.2	42.96*	1018.2	94.93*		
		1735	127.0	1814	136.2	1783	126.678	693.2	44.14*	1020.7	95.52*		
		1759	127.35	1817	136.4	1793	126.306	703.2	45.35*	1023.2	96.11*		
		1786	129.9	1822	136.15	1808	126.709	713.2	46.62*	1025.7	96.70*		
		1799	134.1	1829	136.4	1808	134.402	723.2	47.86*	1028.2	97.31*		
		1816	135.65	1833	136.45	1812	134.792	733.2	49.11*	1030.7	97.93		
		1833	135.85	1841	136.45	1823	135.960	743.2	50.38*	1033.2	98.57*		
		1835	135.9*	1843	136.45	1833	134.819	753.2	51.63	1034.45	98.90*		
		1854	136.2	1845	136.65	1843	131.369	763.2	52.93*	1035.7	99.24		
		1855	136.2*	1850	136.7	1849	138.685	773.2	54.26*	1036.95	99.58*		
		1864	136.35	1850	136.95	1853	131.382	783.2	55.61*	1038.2	99.92*		
		1872	136.5*	1863	136.95	1853	139.075	793.2	57.90*	1039.45	100.28		
		1880	136.55	1865	137.1	1858	138.697	803.2	58.39*	1039.7	100.33*		
		1895	136.8	1866	136.8	1864	133.704	813.2	59.83*	1040.2	100.41*		
						1864	139.088	823.2	61.27*	1040.7	100.62*		
						1866	138.326	833.2	62.70*	1041.2	100.79*		
						1876	137.0	833.2	63.82	1041.7	100.95*		
						1878	137.2	843.2	64.17*	1041.7	101.39*		
						1879	137.35	853.2	65.67	1043.2	101.59*		
						1889	137.2	863.2	67.20*	1043.7	101.56		
						1893	137.45	873.2	68.76*	1044.2	101.70*		
						1894	137.55	883.2	70.35*	1044.7	101.81*		
						1895	137.35	893.2	71.99*	1045.2	101.95*		
						1896	137.35	903.2	73.64	1045.7	102.09*		
						1905	137.45	913.2	74.23*	1046.2	102.21*		
						1910	137.75	913.2	75.33*				

Not shown on either figure.

TABLE 9. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF IRON Fe (continued)

T	$\rho_{T=0}$	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 218(cont.)*</u>											
21.78	6.64	48.7	15.0×10^{-2}	1.72	0.233×10^{-2}	2.20	0.158×10^{-2}	5.41	0.122×10^{-2}		
22.46	7.12	52.8	19.2	1.85	0.235	2.40	0.159	7.61	0.190		
22.91	7.44	58.8	26.6	2.12	0.237	2.59	0.162	10.4	0.300		
23.23	7.80	68.5	37.7	2.24	0.239	2.88	0.168	13.3	0.458		
23.45	8.07	73.7	51.5	2.41	0.241	3.13	0.171	14.7	0.545		
23.95	8.74	89.8	90.0	2.49	0.241	3.36	0.176	18.2	0.839		
24.40	9.06	137	249	2.70	0.243	3.68	0.177	22.2	1.28		
24.90	9.64	172	391	2.86	0.248	4.06	0.184	25.0	1.75		
25.26	9.87	213	567	3.07	0.248	4.45	0.189	29.1	2.41		
25.81	10.32	271	840×10^{-2}	3.30	0.252	5.68	0.223	35.1	4.38		
26.26	10.90			3.48	0.257	6.39	0.251	39.5	6.15		
26.76	11.58			3.68	0.259	6.93	0.265	43.6	7.88		
27.35	12.30			3.92	0.264	8.23	0.309	52.3	16.4		
27.89	13.07	1.70	0.645×10^{-2}	4.32	0.271	9.69	0.375	60.4	24.8		
		1.88	0.645	4.73	0.276	12.6	0.512	70.4	46.8		
		2.02	0.651	5.77	0.300	14.6	0.632	80.6	68.9		
		2.21	0.657	7.17	0.337	18.6	0.928	84.3	82.7		
		2.48	0.656	8.28	0.370	24.5	1.45	92.2	102		
		2.77	0.662	9.23	0.401	32.5	2.84	98.2	118		
		2.97	0.662	10.8	0.469	39.7	5.30	115	168		
		3.22	0.668	13.1	0.590	47.5	10.9	124	203		
		3.40	0.674	14.9	0.696	60.0	21.2	147	291		
		3.66	0.674	16.0	0.770	70.0	33.8	173	413		
		3.83	0.673	21.3	1.20	82.6	60.8	200	529		
		4.23	0.686	24.6	1.55	88.9	77.9	237	709		
		4.79	0.685	27.2	2.00	114	151	276	934		
		5.54	0.710	33.5	3.23	134	214	292	1020×10^{-2}		
		7.13	0.757	37.4	4.80	164	335×10^{-2}				
		8.85	0.829	47.4	9.92						
		10.5	0.867	52.4	13.6						
		14.2	1.06	60.1	22.7						
		14.7	1.06	73.5	42.0						
		2.75	18.9	1.36							
		6.38	20.9	1.54	106	123					
		7.43	33.5	3.79	119	180					
		8.35	49.2	11.8	127	192					
		10.0	56.9	17.3	172	258					
		11.0	67.1	30.0	200	517					
		11.9	79.1	56.5	240	645					
		14.2	99.4	116	268	782×10^{-2}					
		16.3	107	133							
		17.5	138	237							
		3.33									
		3.69	165	345							
		4.85	191	446							
		7.60	258	718							
		8.96	981×10^{-2}	301							
		11.0	11.0×10^{-2}								
				2.06	0.158×10^{-2}						
					4.52	0.103×10^{-2}					

* Not shown on either figure.

3.4. Nickel

There are more than 100 data sets available for the electrical resistivity of nickel. The information on specimen characterization and measurement condition for each of the data sets is given in table 11. The data are tabulated in table 12 and shown partially in figures 7 and 8.

Since nickel belongs to the same group in the periodic table as iron and is also ferromagnetic, the electrical resistivity of nickel is expected to resemble that of iron. For example, the solute resistivities of dilute nickel alloys are similar to those of dilute iron alloys in magnitude and in temperature dependence (Schwerer and Cuddy [148]). However, since nickel is not as strongly magnetic as iron (with a spontaneous magnetization of 6.4 kG as compared to 21.8 kG for iron), the magnetic effect on the electrical resistivity is not as strong in nickel as it is in iron. While the minimum in the longitudinal magnetoresistance at 4 K of a pure iron specimen occurs at ≥ 750 Oe ($\sim 60 \times 10^3$ A m $^{-1}$) (for example, see Fujii and Morimoto [112]), it occurs at ~ 250 Oe for pure nickel (Wycisk and Feller-Kniepmeier [209] and Fujii [210]). Furthermore, for iron the resistivity at the minimum can be as low as one third of the value at zero applied magnetic field. For nickel, it was only about 18% lower [209, 210].

The electrical resistivity of nickel has not been investigated as widely as that of iron, and there has been apparently lesser effort spent in its purification. In fact, among the data sources reporting the electrical resistivity of nickel, less effort was made to analyze the impurity content of the specimen than those reporting the electrical resistivity of iron. Nonetheless, there are a few data sets which show very good agreement on the residual resistivity of pure nickel: $\sim 0.0033 \times 10^{-8}$ Ωm at 2.32 K from White and Tainsh [210] (data set 31), $\sim 0.0031 \times 10^{-8}$ Ωm at 1.85 K from Ehrlich et al. [212] (data set 73), and 0.0033×10^{-8} Ωm from Wycisk and Feller-Kniepmeier [209] (data set 96). The recommended values for the residual resistivity (at 1 K) is based on these data sets. The specimens of the first two sources were described as "high purity" and "pure", respectively. The specimen of the last source was 99.999% pure and was five-time electron beam zone-refined.

The temperature-dependent part of the electrical resistivity has been reported to contain mostly of a T^2 component at low temperatures (≤ 10 K): see,

for example, White and Woods [21] (data sets 33-34), Ehrlich and Rivier [213] (data set 10), Greig and Harrison [214] (data set 4), Fert and Campbell [215] (data set 48), Price and Williams [80] (data set 55), and Sudovtsov and Semenenko [203] (data sets 77,78). An analysis similar to that applied in treating the low-temperature data on the electrical resistivity of iron, i.e., plotting the quantity

$$\rho - \rho_0 = A \left(\frac{T}{\theta_R} \right)^5 \int_0^{\theta_R/T} \frac{x^5 e^x}{(e^x - 1)^2} dx$$

with values of A and θ_R equal to $39.1 \times 10^{-8} \Omega m$ and $456 K$, respectively, gives very similar results. It increases as T^2 at temperatures below $\sim 50 K$. It then varies much less rapidly with temperature: with some data sets (e.g., data sets 55,57) there is a plateau at $\sim 110 K$, and with some (e.g., data sets 3,43) there is a minimum at around the same temperature. At temperatures above $150 K$, it increases more rapidly and approaches a T^3 dependence. The coefficient of the T^2 term (for temperatures below about $50 K$) varies between $\sim 1.5 \times 10^{-5} \Omega m K^{-2}$ (data set 48) and $\sim 3.5 \times 10^{-5} \Omega m K^{-2}$ (data set 57), and furthermore there is no discernible correlation between these coefficients and the residual resistivities of the specimens. However, the agreement between data sets with the lowest reported residual resistivities are good. The data set of White and Tainsh [211] (data set 31) yields a coefficient of $2.7 \times 10^{-5} \Omega m K^{-2}$ and a residual resistivity of $\sim 0.0033 \times 10^{-8} \Omega m$, that of Ehrlich and Rivier [213] (data set 10) yields $2.4 \times 10^{-5} \Omega m K^{-2}$ and $0.0031 \times 10^{-8} \Omega m$, respectively. The data set of Farrell and Greig [216] (data set 11) yields $2.6 \times 10^{-5} \Omega m K^{-2}$ and $0.0095 \times 10^{-8} \Omega m$, and that of Ehrlich et al. [212] (data set 73) yields $2.3 \times 10^{-5} \Omega m K^{-2}$ and $0.0031 \times 10^{-8} \Omega m$. The recommended values below $60 K$ are based on the above four data sets, with the values of the coefficient, $2.6 \times 10^{-5} \Omega m K^{-2}$ is also the mean of the above four values. It should be mentioned that the plateau or the minimum region in the quantity

$$\rho - \rho_0 = A \left(\frac{T}{\theta_R} \right)^5 \int_0^{\theta_R/T} \frac{x^5 e^x}{(e^x - 1)^2} dx$$

at around $110 K$ could not be eliminated by an effort in adjusting the values of A and θ_R . As a consequence, the value of θ_R was taken to be $456 K$ and the value of A was chosen so that the range of applicability of the T^2 term could be extended to as high a temperature as practicable. As an illustration, the

data of Farrell and Greig [216] (data set 11) deviate from the T^2 line by $+0.005 \times 10^{-8} \Omega m$ at 50 K; this deviation increases to $-0.02 \times 10^{-8} \Omega m$ at 60 K.

In the temperature range from about 60 K to room temperature, a number of authors reported data sets which agree well with each other: White and Woods [21] (data sets 33,34), Farrell and Greig [216] (data set 11), Laubitz et al. [217] (data set 52). In particular, the last two data sets merge very well at 90 K. The recommended values in this temperature range is based on the above four data sets, with more weight given to the last two.

For temperatures from the ice point up to the Curie point, a number of data sets agree to within $\sim \pm 4\%$: Pallister [218] (data set 14), Powell et al. [219] (data sets 17,20), Kierspe et al. [78] (data set 37), Schroeder and Giannuzzi [98] (data set 51), Laubitz et al. [217] (data set 52), Potter [199] (data set 53), Schwerer and Cuddy [148] (data set 65), and Ahmad and Greig [220] (data sets 89,90). Of these, the data of Laubitz et al. and of Potter show particularly good agreement ($\pm 2\%$). The recommended values in this temperature range are based on these results, with more weight given to those of Laubitz et al. [13] (data set 52) and of Potter [199] (data set 53).

The Curie temperature of nickel has been reported to be 631 K by Zumsteg and Parks [221] (data set 91), 631 K by Standley and Reich [222] (data set 2), 630 K by Dutta-Roy and Subrahmanyam [223] (data set 3), ~ 630 K by Laubitz et al. [13] (data set 52), 632.7 K by Jackson and Saunders [224] (data set 103), and from 629.3 to 629.8 K, depending on specimen, by Potter [199] (data set 53). Judging from the resistivity data of Pallister [218] (data set 14), the Curie temperature is ~ 627 K, of Kirichenko and Mikryukov [225] (data set 27), ~ 631 K, of Schwerer and Cuddy [148] (data set 65), ~ 628 K, of Kaul [226] (data set 67), 620–640 K, of Shirakawa [141] (data set 76), ~ 633 K, and of Schroeder and Giannuzzi [98] (data set 51), ~ 638 K. Among these sources, only two, Potter [199] (data set 53) and Zumsteg and Parks [221] (data set 91), give in detail the change of electrical resistivity at around the Curie temperature. The agreement between these are very good: $\pm 0.5\%$ below and $\pm 1\%$ above the Curie temperature. The recommended values in the vicinity (± 25 K) of the Curie temperature are based on this reference, with more weight given to the result of Zumsteg and Parks at temperatures above the transition. The resultant values are within 0.3% of those calculated on the basis of the dp/dT values reported by Jackson and Saunders [224].

At temperatures from the Curie point to about 1300 K, the following data sets fall into a band of width $\sim 2 \times 10^{-8} \Omega\text{m}$: Pallister [218] (data set 14), Bode [227] (data set 16), Powell et al. [219] (data set 20), Davis et al. [228] (data set 32), Laubitz et al. [217] (data set 52), and Potter [199] (data set 53). The recommended values in this temperature range are based on these data sets, with more weight given to the data of Laubitz et al. [217] (data set 52). Data set 52 is also used as basis for recommendation for lower temperatures.

Unfortunately, most of the data sets mentioned in the previous paragraph are for temperatures below 1300 K. For higher temperatures, the available data sets show large discrepancies. In addition, the resistivity values for lower temperature given in these sets are quite different from the recommended values (for example, data sets 37, 72). However, for temperatures slightly below the melting point, the data of Güntherodt et al. [92] (data set 93) and of Kita et al. [93] (data sets 100-101) are within $\sim 0.5 \times 10^{-8} \Omega\text{m}$ of each other. Extrapolations, either graphically or numerically using a cubic expression, from recommended values for lower temperatures give values that are also within $0.5 \times 10^{-8} \Omega\text{m}$ of the values reported by these authors. The recommended values are, therefore, obtained from the numerical extrapolation.

At temperatures immediately above the melting point, the available data sets show a spread of about $6 \times 10^{-8} \Omega\text{m}$. Between the data of Güntherodt et al. [92] (data set 93) and of Kita et al. [93] (data sets 100-102), which well agree below the melting point, the difference is about $4 \times 10^{-8} \Omega\text{m}$. The recommended value for the liquid phase at the melting point is based on the results of Güntherodt et al. [92] (data set 93), Seydel and Fucke [87] (data set 92), and Mokrovskii and Regel [158] (data set 56), which agree to within $0.2 \times 10^{-8} \Omega\text{m}$. The temperature dependence of the electrical resistivity in the molten state has been generally reported to be linear, e.g., Kita et al. [93] (data sets 100, 101), Güntherodt et al. [92] (data set 93), Seydel and Fucke [87] (data set 92), Samarin [94] (data set 87), Mokrovskii and Regel [158] (data set 56), Eliutin et al. [88] (data set 49), and Ono and Yagi [89] (data set 61). The recommended values are generated with a temperature coefficient of $0.011 \times 10^{-8} \Omega\text{m K}^{-1}$, which is slightly (6%) lower than that given by Kita et al. [93], and slightly higher ($\sim 1\%$) than that determined from the data of Güntherodt et al. [92] (data set 93).

The recommended values for the solid state both uncorrected and corrected for thermal expansion of the material and those for the liquid state corrected

for thermal expansion are presented in table 10, and the values except those corrected for thermal expansion of the solid are also shown in figures 7 and 8 along with the experimental data. These values at temperatures above 100 K are for nickel of purity 99.99% or higher, while those below 100 K are applicable only to highly purified zone-refined nickel having a residual resistivity of $0.00320 \times 10^{-8} \Omega \text{m}$. The estimated uncertainty in the recommended values is $\pm 5\%$ below 150 K, $\pm 3\%$ from 150 to 1300 K, $\pm 5\%$ from 1300 K to the melting point, and $\pm 10\%$ for the liquid state.

For slightly less pure nickel having different residual resistivity, its electrical resistivity values can be calculated from the recommended values using the Matthiessen's rule, which will not introduce serious errors. For example, the data of Ahmad and Greig [220] (data set 90) show that for a specimen with a residual resistivity less than $0.009 \times 10^{-8} \Omega \text{m}$, the application of Matthiessen's rule causes an error of about 2% at 40 K and about 1% at 260 K. Also the data of Greig and Harrison [214] (data set 4), Ahmad and Greig [220] (data set 89), Berger and Rivier [229] (data set 23), White and Woods [21] (data sets 33, 34), and of Kemp et al. [130] (data set 43), which are for specimens with residual resistivities of the order of a few tenths of a $\text{n}\Omega \text{m}$, show that the application of Matthiessen's rule causes errors generally of about 3% for temperatures below 300 K. The most interesting comparison is made with the data of Rowlands [230] (data set 57), since his data extend from liquid-helium temperatures up to above the Curie temperature. For this data set, the errors are less than 1% below 20 K, 10% at ~ 60 K, $\sim 6\%$ from ~ 100 to ~ 300 K, and drop to $\sim 3\%$ from ~ 500 K to above the Curie temperature. This behavior is consistent with the solute resistivities for dilute nickel alloys (see, for example, Schwerer and Cuddy [148]). Thus, when the Matthiessen's rule is used for calculating the electrical resistivity of less-pure nickel with a residual resistivity less than $0.05 \times 10^{-8} \Omega \text{m}$, the values are likely to be lower by $\sim 3\%$ than the true values from 40 K to room temperature, and are likely to lower by $< 1\%$ at temperatures below 40 K and above the Curie temperature. For specimens of even lower purity, with a residual resistivity of about $0.3 \times 10^{-8} \Omega \text{m}$, the probable errors are about 2% at high and at low temperatures, but may be as high as -10% at intermediate temperatures (40-300 K).

The recommended values for the solid state uncorrected for thermal expansion and those for the liquid state given in table 10 can be represented approximately by the following expressions to within $\pm 0.5\%$.

1-60 K:

$$\rho = 0.0032 + 2.5 \times 10^{-5} T^2 + 39.1 \left(\frac{T}{456} \right)^5 \int_0^{456/T} \frac{x^5 e^x}{(e^x - 1)^2} dx \quad (35)$$

60-150 K:

$$\rho = 0.4214558798 - 2.07384562 \times 10^{-2} T + 3.48017305 \times 10^{-4} T^2 - 8.609303313 \times 10^{-7} T^3 \quad (36)$$

150-500 K:

$$\rho = -1.355285714 + 2.103190475 \times 10^{-2} T + 1.141428571 \times 10^{-5} T^2 + 4.523809524 \times 10^{-6} T^3 \quad (37)$$

500-600 K:

$$\rho = -50.1320558 + 2.978166536 \times 10^{-1} T - 5.156360117 \times 10^{-4} T^2 + 3.824418489 \times 10^{-7} T^3 \quad (38)$$

600-630 K:

$$\rho = 28.71 - 1.2315000 \times 10^{-1} (T_C - T) + 5.749999984 \times 10^{-4} (T_C - T)^2 \quad (39)$$

631-670 K:

$$\rho = 28.71 + 9.060833333 \times 10^{-2} (T - T_C) - 1.809583333 \times 10^{-3} (T - T_C)^2 + 3.941666667 \times 10^{-5} (T - T_C)^2 - 3.541666667 \times 10^{-7} (T - T_C)^4 \quad (40)$$

670-1400 K:

$$\rho = -6.329325957 + 8.023011038 \times 10^{-2} T - 4.451156858 \times 10^{-5} T^2 + 1.201757591 \times 10^{-8} T^3 \quad (41)$$

1400-1728 K:

$$\rho = -9.255955877 + 7.140577598 \times 10^{-2} T - 2.771379283 \times 10^{-5} T^2 + 5.589224949 \times 10^{-9} T^3 \quad (42)$$

1728-3000 K:

$$\rho = 63.22 + 1.10 \times 10^{-2} T \quad (43)$$

It should be emphasized that these expressions do not necessarily suggest any theoretical justification, and should be treated, most appropriately, as numerical aids only. It should also be understood that giving these expressions does not imply a recommendation for the temperature derivative of the electrical resistivity.

TABLE 10. RECOMMENDED VALUES FOR THE ELECTRICAL RESISTIVITY OF NICKEL^a[Temperature, T, K; Electrical Resistivity, ρ , $10^{-8} \Omega \text{m}$]

T	ρ		T	ρ	
	uncorrected	corrected		uncorrected	corrected
1	0.00320	0.00320	630	28.71	28.86
4	0.00360	0.00359	670	31.06	31.24
7	0.00443	0.00442	700	32.14	32.34
10	0.00573	0.00572	800	35.52	35.80
15	0.00901	0.00899	900	38.58	38.95
20	0.0140	0.00140	1000	41.41	41.88
25	0.0212	0.0212	1100	44.06	44.65
30	0.0317	0.0316	1200	46.62	47.33
40	0.0678	0.0676	1300	49.15	50.00
50	0.135	0.134	1400	51.73	52.73
60	0.242	0.242	1500	54.36	55.54
70	0.377	0.376	1600	56.94	58.31
80	0.545	0.544	1700	59.50	61.07
90	0.741	0.739	1728	60.22(s)	61.85(s)
100	0.959	0.957	1728		82.23 ^b (l)
150	2.21	2.20	1800		83.02 ^b
200	3.67	3.67	1900		84.12 ^b
250	5.32	5.32	2000		85.22 ^b
273	6.16	6.16	2500		87.72 ^b
293	6.93	6.93	3000		90.22
300	7.20	7.20			
350	9.34	9.35			
400	11.78	11.80			
500	17.67	17.72			
600	25.54	25.66			

^a The values are for nickel of purity 99.99% or higher, but those below 100 K are applicable only to nickel having a residual resistivity of $0.00320 \times 10^{-8} \Omega \text{m}$. The columns headed uncorrected and corrected refer to values uncorrected and corrected for thermal expansion, respectively. Solid line separating tabular values indicates solid to liquid state transformation.

^b Provisional value.

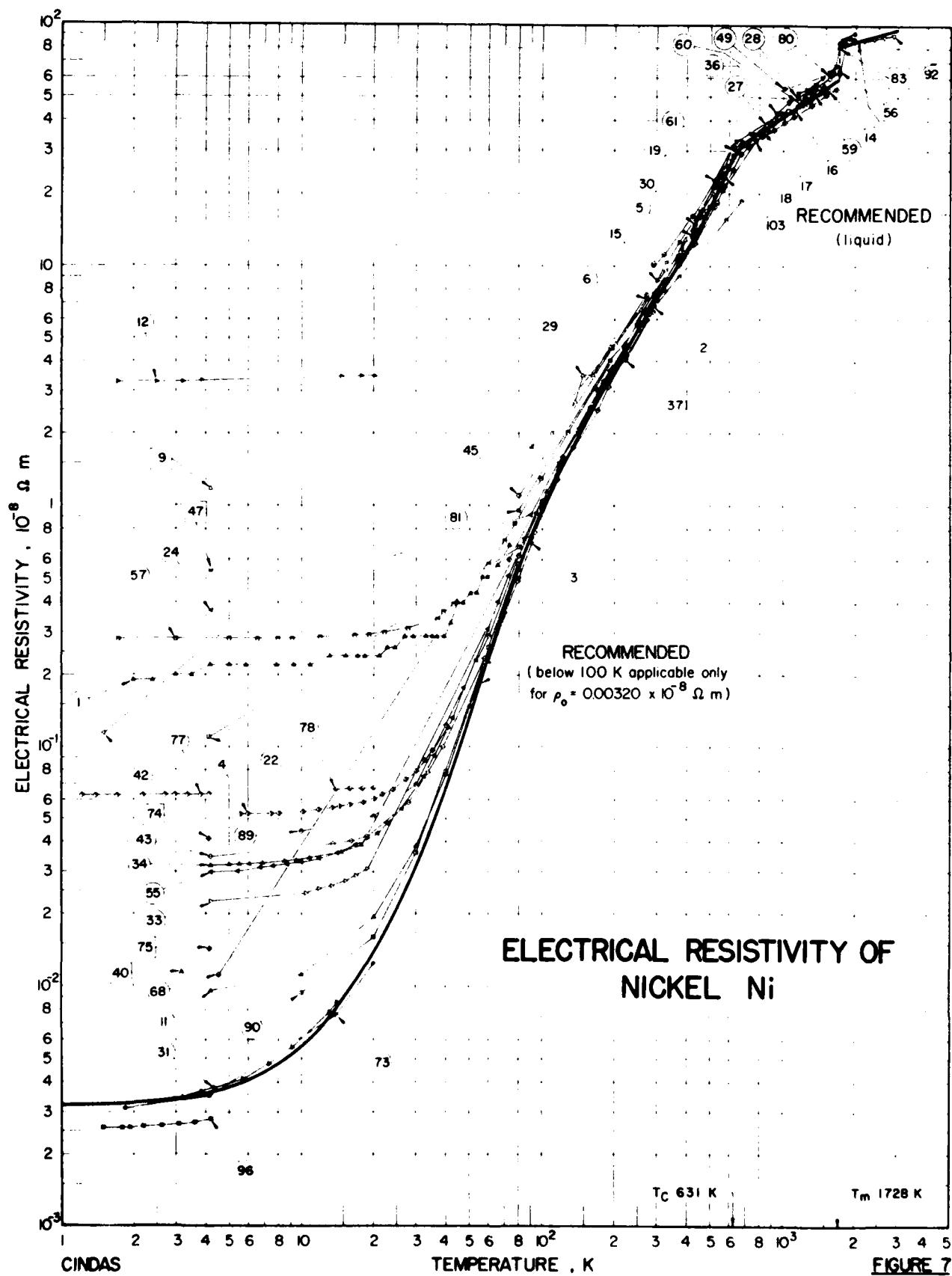


FIGURE 7

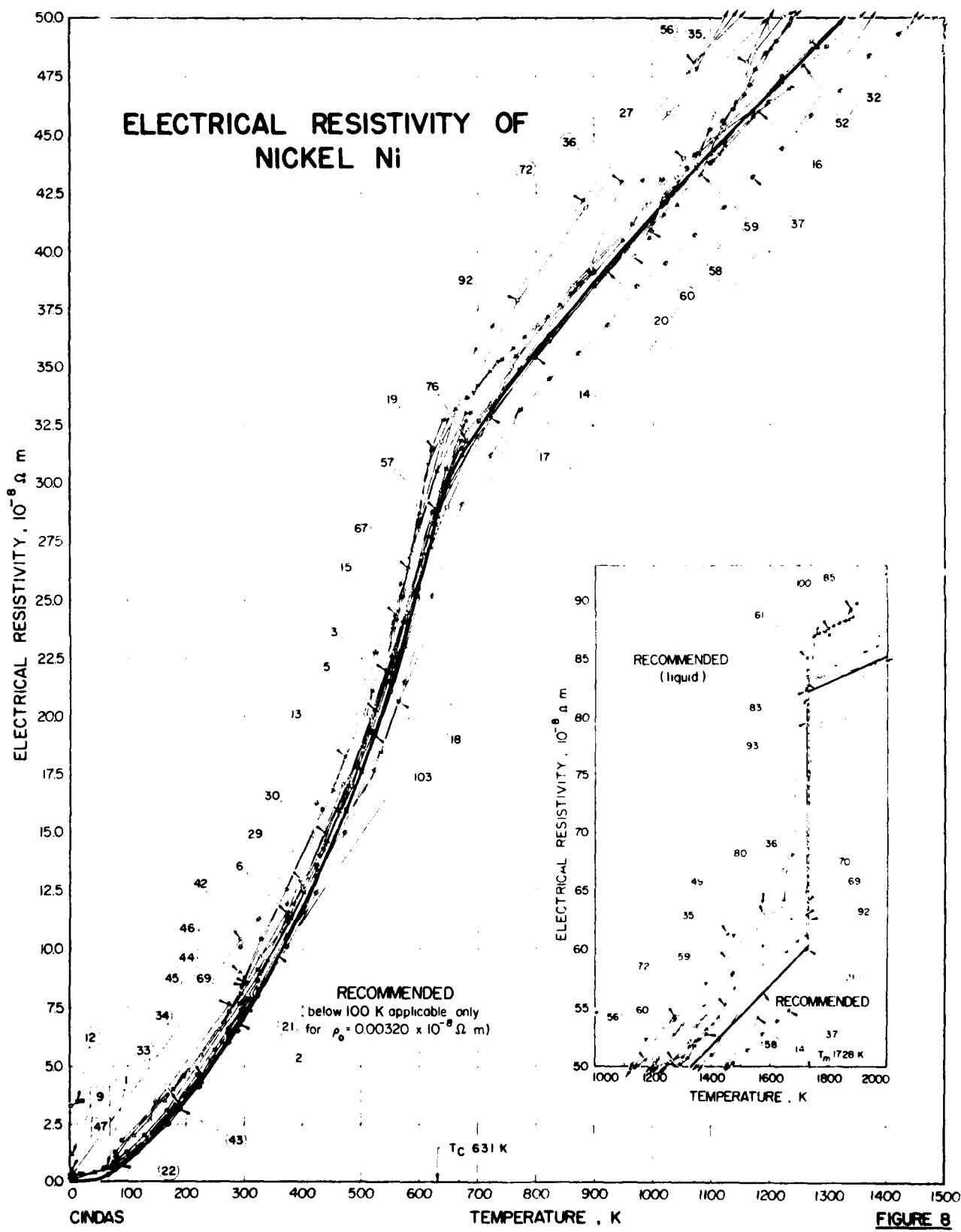


TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL Ni

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
1 129	Kondorskii, E.I., Galkina, O.S., and Chernikova, L.A.	1938	A	2-73	Ni	Chemically pure; wire specimen 0.1 to 0.2 mm in diam and 150 to 160 mm long; annealed in vacuum at 1173 K for 1 h; slowly cooled at 100 K/h; residual resistivity $0.20 \times 10^{-8} \Omega \text{ m}$.	
2 222	Standley, K.J. and Reich, K.H.	1955		293,473	Ni	Ingot heated in argon to about 1273 K for 12 h; slowly cooled; rolled to a sheet about 0.5 mm thick; discs of the required diameter punched out; polished on fine emery, annealed in vacuo and electrolytically polished, then annealed in vacuum; $T_C = 631 \text{ K}$.	
3 223	Dutta-Roy, S.K. and Subrahmanyam, A.V.	1969	V	80-735	"Spectrographically pure," from Johnson Matthey Co.; 6 x 0.3 x 30 mm; annealed for 24 h at 1073 K in a vacuum furnace; cleaned in aqua regia; $T_C = 630 \text{ K}$.		
4 214	Greig, D. and Harrison, J.P.	1965	C	5.6-41	JM 893; A	Pure; 0.0016 total impurity (mostly Fe and Si); polycrystalline; grain size ~0.1 mm; from Johnson Matthey Co. (JM 893); annealed at 1023 K for 12 h; resistivity values calculated from reported ideal resistivity and ρ_0/L_0 ratio ($2.11 \pm 0.01 \text{ } \mu\text{ohm cm}^2/\text{K}^2$).	
5 231	Svensson, B.	1936	B	323-623	0.102 Fe, 0.036 Al and Si each; from Hilger of London; 1 mm in diam and 1 cm long; annealed at 1173 K; resistivity values calculated from measured resistance ratios and a $\rho(273 \text{ K})$ value of $6.58 \times 10^{-8} \Omega \text{ m}$ from Landolt-Bornstein: Physik-Chem. Tabellen 5 Auft. 5, 1050 (1923).		
6 161	Broom, T.	1952	B	90-373	0.12 Mg, <0.05 Cr, Cu and Mn each, 0.03 C, and 0.01 Co; wire specimen 0.056 cm in diam; annealed at 873 K for 2 h, furnace cooled.		
7* 232	Lavine, J.M.	1961	A	73-633	499 alloy		
8* 176	Kondorskii, E.I. and Sedov, V.L.	1960	A	4.2	Electrolytically pure; 5.9 mm in diam and 112 mm long.		
9 176	Kondorskii, E.I. and Sedov, V.L.	1960	A	4.2	Technically pure; cylindrical specimen 5.9 mm in diam and 112 mm long; vacuum annealed at 1273 K for 8 h; furnace cooled.		
10* 213	Ehrlich, A.C. and Rivier, D.	1968		1.6-19	"High purity"; polycrystalline plate, electropolished to a thickness of 0.19 mm; $\rho(293 \text{ K})/\rho(4.15 \text{ K}) = 2200$; only $\rho(T) - \rho(0)$ reported where $\rho(0)$ is the resistivity extrapolated to 0 K from data in the 1.75 to 4.15 K range, in which the resistivity is reported to be proportional to T^2 .		
11 216	Farrell, T. and Greig, D.	1968	A	4.2-273	Pure; 3 mm in diam and 9 cm long; annealed for 15 h at 1123 K; resistivity values calculated from reported $\rho(0)$ and tabular values of $\rho(T)$.		
12 233	Kondorskii, E.I., Galkina, O.S., and Chernikova, L.A.	1957	A	1.7-20	Ni	99.9 pure; wire specimen 0.1 to 0.2 mm in diam; supplied by Central Scientific Research Institute of Ferrous Metallurgy; cold drawn; annealed in neutral gas at 1173 K for 1 to 12 h; residual resistivity $1.54 \times 10^{-8} \Omega \text{ m}$.	

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL Ni (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp Range, K	Name and Specimen Designation	Composition (weight percent). Specifications and Remarks
13 234	Kurbaniyazov, N., Chereauzhkina, A.V., and Akmaradov, B.A.	1973	A	373-773		Pure; specimen of dimensions $3 \times 6 \times 100$ mm; homogenize annealed in vacuum at 1273 K for 24 h, slow cooled in furnace; values from graph.	
14 218	Pallister, P.R.	1965	A	273-1550	E	99.84 Ni, <0.03 Fe, <0.01 Al, Co, Cr, Cu, Mg, Mn, Mo, Si, Sn, Ti, Zn, and Zr each, <0.005 Pb and <0.002 Bi; supplied by International Nickel Co. (Mond) Ltd.; annealed; measurements made in vacuum; smooth values from table; reported electrical resistivities based upon room temperature dimensions.	
15 235	Sager, G.F.	1930	B	327-1016		Pure; wire specimen about 0.2 cm in diam and 35 cm long; electrolyzed from Mond anodes; vacuum melted under a pressure of 0.3 mmHg, chilled cast, forged, hot rolled and cold drawn through a steel die plate; flash annealed, held at 1023 K for "considerable periods" and "later more thoroughly annealed"; current and potential leads of nickel silver soldered to specimen; density 8.74 g/cm ³ .	
16 227	Bode, K.H.	1961	+	1098-1241		99.95 pure; wire specimen 1 mm in diam; vacuum melted, cast, polished, annealed for 12 h at about 1273 K; measured by compensation method.	
17 219	Powell, R.W., Tye, R.P., and Hickman, M.J.	1965	A	293-1123	Sample 1	<0.03 Fe, <0.01 Al, Cr, Co, Cu, Mg, Mn, Mo, Si, Sn, Ti, Zn, and Zr each, <0.005 Pb, and <0.002 Bi; spectroanalyzed by International Nickel Co.; tubular specimen of 1.272 cm I.D., 1.908 cm O.D. and 20 cm long; supplied by the Castner Keilner Alkali Co.; density 8.61 g/cm ³ .	
18 219	Powell, R.W., et al.	1965	A	373-773	Sample 2	"Very high purity"; electrolytic; tubular specimen of 0.634 cm I.D., 2.801 cm O.D., and 19 cm long; supplied by National Engineering Lab.; density 8.90 g/cm ³ .	
19 219	Powell, R.W., et al.	1965	A	293-623	Sample 4	Commercial Ni; rod specimen 2.56 cm in diam and about 20 cm long; supplied by Explosives Research and Development Establishment.	
20 219	Powell, R.W., et al.	1965	A	293-1323	Sample 5 J.M.Lab. No. 4497	"High spectrographic purity"; trace amounts of Al, Ca, Cu, Li, Mg, Si, Ag, and Na; rod 0.5 cm in diam and 15 cm long; supplied by Johnson, Matthey and Co.; density 8.91 g/cm ³ .	
21 236	Martynuk, M.M. and Tsapkov, V.I.	1973	+	298,1726		99.93 pure; specimen 0.3-1 mm in diam and 50 cm long; specimen heated in air by a 400 usec pulse of 1-4 kamp; voltage and current measured by double beam pulse oscilloscope; resistivity at melting point determined from break points corresponding to the onset and end of fusion on the relative resistance curve; data not corrected at higher temperature.	
22 229	Berger, L. and Rivier, D.	1962	B	4.2-292	Ni 5011 (1)	Specimen 0.15 cm in diam and 5.2 cm long; supplied by Johnson, Matthey and Co.; annealed for 4 h at 1273 K in a vacuum of 10^{-5} mmHg; furnace-cooled at a rate of 150 K/h; $\rho(273\text{ K})/\rho(4.2\text{ K}) = 60$.	
23* 229	Berger, L. and Rivier, D.	1962	B	4.2-273	Ni 5011 (11)	Specimen 0.19 cm in diam and 5.0 cm long; from the same stock as the above specimen; annealed for 10 h at 1573 K in hydrogen at 1573 K in a vacuum of 10 ⁻³ mmHg for 2 h; $\rho(273\text{ K})/\rho(4.2\text{ K}) = 298$.	

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL Ni (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
24 237	Kronmeller, H. and Buck, O.	1964	A	4-273		99.99 pure; from Johnson, Matthey and Co.; single crystal with one axis parallel to <111>; specimen 3.2 mm in diam and 120 mm long.	
25* 238	Neimark, B.E. and Bykova, T.I.	1965		793-773	No. 1	99.87 (Ni + Co); tube 8.51 mm O.D. and 8.025 mm I.D.; smoothed values from table.	
26* 238	Neimark, B.E. and Bykova, T.I.	1965		373-748	No. 2	Tube 12.96 mm O.D. and 11.025 mm I.D.; smoothed values from table.	
27 225	Kirichenko, P.I. and Mikryukov, V.E.	1964		313-1172		99.999 ⁺ pure; 0.3 cm in diam and 30 cm long; forged from sheet; annealed in vacuum for 48 h at 1173 K; furnace cooled.	
28 239	Jain, S.C., Goel, T.C., and Chandra, I.	1967	+	1152-1320		99.95 pure; filaments 0.05 cm thick, 1 cm wide, and 14 cm long; obtained from Johnson, Matthey and Co.; data from figure; experimental method same as Jain and Krishnan, Proc. R. Soc. London, <u>A225</u> , 7, 1954.	
29 240	Watson, T.W. and Robinson, H.E.	1964	V	110-803		99.85 Ni, 0.11 Co, 0.026 Cu, 0.006 Fe, 0.001 Al, <0.004 Si, <0.002 Ti, <0.001 Cr and Mg each, and <0.0005 Mn; electroformed nickel from International Nickel Co.; 2.54 cm in diam and 37 cm long; smoothed values from table.	
30 240	Watson, T.W. and Robinson, H.E.	1964	V	184-680		The above specimen measured with decreasing temperature.	
31 211	White, G.K. and Tainsch, R.J.	1967		2.3-14		"High purity"; specimen 0.1 cm x 0.1 cm x 7 cm; prepared by Bell Telephone Laboratories; annealed in vacuum of 10 ⁻³ Torr at 773 K; $\rho(273 K)/\rho(4 K) = 2500$.	
32 228	Davis, M., Densem, C.E., and Rendall, J.H.	1955		293-1273		0.01-0.2 O, 0.07 C, 0.016 Si, 0.013 Fe, 0.003 S, 0.0005 Mn, and 0.0003 Mg; Grade A carbonyl nickel powder; supplied by Mond Nickel Co.; sintered and annealed; density 8.9 g/cm ³ ; Curie point 626 K.	
33 21	White, G.K. and Woods, S.B.	1959	G	4.2-298	Ni 2	99.997 pure, 0.0010 Fe, 0.0003 Cr and Mg each, 0.0002 Ca, Cu, and Mn each, and 0.0001 Ag, from Johnson, Matthey and Co. (JM 10369); rod specimen 2 mm in diam and 6 to 8 cm long; vacuum annealed at 1073 K; resistivity values calculated from reported ρ_1 , $\rho(4.2 K)/\rho(295 K) = 3.23 \times 10^{-3}$, and $\rho(295 K) = 7.04 \times 10^{-8} \Omega \text{ m}$.	
34 21	White, G.K. and Woods, S.B.	1959	G	4.2-252	Ni 3	Similar to the above specimen except (1) specimen 0.63 mm in diam, (2) resistivity ratio $\rho(4.2 K)/\rho(295 K) = 4.51 \times 10^{-3}$, (3) $\rho_1(295 K) = 7.33 \times 10^{-8} \Omega \text{ m}$; because of slight uncertainty in ρ_1/A , ρ_1 was normalized to the value for the above specimen for which χ and A are more accurately known.	
35 241	Reddy, B.K. and Goel, T.C.	1975	V	1163-1644		99.95 pure; tubular specimen 0.75 cm I.D., 0.3 mm wall thickness, and 18 cm long; obtained from Johnson, Matthey and Co.; specimen heated for about 1 h at ~1630 K and cooled to room temperature repeatedly for 6 or 7 times.	

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

Data Ref. Set No.	Author(s) No.	Year	Method Used	Temp Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
36 97	Kovenskii, I.I. and Samsonov, G.V.	1963	+	891-1673	99.86 Ni, 0.10 C, 0.01 Co, 0.008 Cu, 0.004 Fe, and 0.002 Si and S each; wire specimen; measured in argon atmosphere, specimen heated by passing an electric current through; smoothed values from figure.	
37 78	Kierspe, W., Kohlhaas, R., and Conska, H.	1967	B	73-1668	<0.0003 Si, 0.0002 Fe and Mg each, <0.0001 Al, Cu and Ag each; obtained from Koch-Light Laboratories Ltd.; smoothed values from figure.	
38* 242	Birss, R.R. and Dey, S.K.	1961		78-1306	Smoothed values from graph of ρ vs. T/θ , with θ apparently equal to 370 K.	
39* 243	Franklin Institute, Laboratories for Research and Development	1953		73-830	No details reported.	
40 244	Coltman, R.R., Klabunde, C.E., and Redman, J.K.	1967		3.2	99.99 ⁺ nominal purity; 0.025 cm in diam and 5 cm long; annealed at 1223 K in air at a pressure of 8×10^{-6} Torr; furnace-cooled.	
41* 179	Niccolai, G.	1908	B	84-673	Wire specimen 0.5 mm in diam and 8 m long wound on an insulating spool.	
42 245	Sharma, J.K.N.	1967	D	1.5-293	99.995 pure; polycrystalline; wire specimen obtained from Johnson, Matthey and Co.; P/A ratio 2.88×10^3 cm ⁻¹ .	
43 130	Kemp, W.R.G., Clemens, P.G., and White, G.K.	1956	G	4.2-293	99.99 ⁺ pure, traces of Al, Ca, Cu, Si and Ag, and very faint traces of Li, Mg, and Na; 2 mm in diam; obtained from Johnson, Matthey and Co.; annealed in vacuum at 1023 K for 4 h; ideal electrical resistivity, ρ_i , from figure; ρ_0 taken as $0.0347 \times 10^{-8} \Omega \text{ m}$, $\rho = \rho_i + \rho_0$.	
44 246	Masumoto, H.	1927		303	0.10 Fe, 0.037 C, 0.019 S, 0.013 Cu, 0.006 Si, and trace of Al, Co, Mn, and P; 5 mm in diam and 20 cm long; obtained from Mond & Co.; cast and machined; annealed at 1073 K for 40 min.	
45 163	Eucken, A. and Dittrich, K.	1927	V	80,273	Electrolytic.	
46 247	Rubanenko, I.R. and Grossman, M.I.	1969		293	7 x 7 x 28 mm; measuring temperature assumed 293 K.	
47 248	Mitchell, H.A., Clemens, P.G., and Reynolds, C.A.	1971	A	4.2	99.9 pure; single crystal, grown by a variation of the Bridgeman method; specimen axis along <111> direction; annealed in vacuum at 1203 K for 48 h.	
48* 215	Fert, A. and Campbell, I.A.	1968		4-79	Ideal resistivity reported only.	

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

Date Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
49	88	Elutin, V.P., Turov, V.D., and Maurakh, M.A.	1965	R	1013-1997	Nickel 270	98.5-99.0 pure; electrolytic; liquid state obtained by melting in graphite crucible either in an atmosphere of helium or in vacuum.
50*	249	Starr, C.D.	1969				100 nominal purity; temperature coefficient of resistivity $\alpha(298,378) = 0.00555$ and $\alpha(218,298) = 0.00461/\text{deg}$; data from table at 811 K only.
51*	98	Schroeder, K. and Giannuzzi, A.J.	1969		375-825		99.999 pure; wire specimen; annealed in an inert gas atmosphere (92 He, 8 Ar) for 2 h at ~150 K above the Curie temperature; resistivity values calculated from reported $\rho(T)/\rho(T_C)$, with $\rho(T_C) = 29.288 \times 10^{-8} \Omega \text{ m}$, taken from data set 52.
52	217	Laubitz, H.J., Matsumura, T., and Kelly, P.J.	1976	A	90-1250		99.999 pure (nominal); 0.0016 C, 0.0014 Si, 0.0007 Fe, 0.0006 Cu, 0.0005 Al and O ₂ , 0.0003 F, 0.0002 K, Na, and S each, 0.0001 Ta, 0.00007 Cl, 0.00005 Ca, 0.00003 Ti and N ₂ each, 0.00002 Cr and Mn each, 0.00001 Pb, Mg and Ag each, 0.00004 V and 0.00002 B by mass spectrographic analysis; from Metals Research Ltd.; polycrystalline; specimen 2 cm in diam and 20 cm long; annealed in vacuum of 5×10^{-6} Torr at 1400 K for 2 h; slow cooled for measurements between 300 and 1250 K; machined to 1 cm in diam and 10 cm long, unannealed for measurements between 90 and 370 K; density $8.908 \pm 0.001 \text{ g cm}^{-3}$ at 293 K; T _C about 630 K; residual resistivity ratio 220 ± 10 ; smoothed values from table.
53*	199	Potter, H.H.	1937	V	77-1153		99.971 pure; 0.018 Fe and 0.010 C; obtained from Adam Hilger; specimen 2 mm in diam and 8 cm long, bent into U shape; resistance ratio R/R _{273K} reported; reference value of $\rho(273 \text{ K}) = 6.16 \times 10^{-8} \Omega \text{ m}$ assumed; T _C reported to be 629.3 or 629.8 K, depending on specimen.
54*	250	Arai, S.	1961	V	0-1000		Pure; 0.01 Fe and Cu each, and traces of C, Co, S, and Si; wire specimen 1.5 mm in diam; enclosed in silica tubes evacuated to 10^{-5} mmHg ; annealed for 68 h at 1400 K; quenched in saline solution at room temperature; original data reported graphically; extracted from the reported smooth curve.
55	80	Price, D.C. and Williams, G.	1973	A	4-300		99.998 pure; specimen 0.15 x 0.2 x 10 cm; supplied by Johnson, Matthey and Co.; cold rolled between Melinex sheets, etched and annealed for 24 h in vacuo at 873 K; ideal resistivity reported graphically; total resistivity obtained by adding the reported residual resistivity $\rho(4.2 \text{ K}) = 0.0299 \times 10^{-8} \Omega \text{ m}$ to the reported ideal resistivity.
56	158	Mokrovskii, N.P. and Regel, A.R.	1953	R	1073-1964		99.7 pure; specimen contained in corundum crucible ~12 mm in diam and 25 mm high; smoothed values from graph.
57	230	Rowlands, J.A.	1973	A	1.7-672		Pure; from Sherritt Gordon Mines, annealed; $\rho_0 = 0.28195 \times 10^{-8} \Omega \text{ m}$; data in tabular form supplied by author.

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
58	251	Wong, H.Y.	1966	+	998-1381		99.92 pure; wire specimen 0.081 cm in diam and 61 cm long; supplied by British-Driver-Harris Co. Ltd.; electrically heated in air at 1173 K for 5 min, oxide formed had olive-green color; measured in vacuum of about 2×10^{-6} torr; data extracted from figure.
59	251	Wong, H.Y.	1966	+	993-1479		Similar to the above specimen except electrically heated in air at 1173 K for 15 min.
60	251	Wong, H.Y.	1966	+	970-1498		Similar to the above specimen except electrically heated in air at 1173 K for 25 min.
61	89	Ono, Y. and Yagi, T.	1972	R	1728-1898		99.9 ⁺ pure; in liquid state; contained in a 10 mm I.D. recrystallized alumina crucible; density data of Saito et al. (Bull. Res. Inst. Min. Dress. Metall., Tohoku Univ., 25, 67, 109, 1969) used to calculate specimen volume; data given as the formula $\rho(10, \Omega\text{m}) = 0.0280 \text{ T}(\text{C}) + 44.32$.
62*	252	Schindler, A.I., Smith, R.J., and Salkovitz, E.I.	1956	B	6-292		99.99 pure; material obtained from International Nickel Co.; specimen 2.0 mm in diam and 16.3 cm long; fabricated from spectrographic rod; vacuum annealed at 1073 K for 2 h then gradually cooled for 24 h.
63*	138	Dewar, J. and Fleming, J.A.	1893	B	76-469		Pure; prepared by Mr. Mond, nickel tubes formed by passing vapor of nickel carbonyl through heated glass tube, portion of nickel tube cut into a very fine spiral on lathe; resistance ratio reported; data uncorrected for thermal expansion; data extracted from table; $\rho(273 \text{ K}) = 12.323 \times 10^{-8} \Omega\text{m}$, Matthiessen's value as given in Everett's "Physical Units" used to convert resistance ratio to resistivity; temperatures at 76.1, 191.3, and 229.6 K measured by platinum resistance thermometer.
64*	253	Dewar, J. and Fleming, J.A.	1892	B	91-368		Pure, carbonyl nickel; wire specimen had probable dimensions of 0.0076 cm in diam and 50 to 100 cm long; from Johnson, Matthey and Co.; measurement of resistance repeated several times, mean observed resistivity reported; data uncorrected for thermal expansion; data extracted from table.
65*	148	Schwerer, F.C. and Cuddy, L.J.	1970	V	4-940		"High purity"; rod specimen 1.8 mm in diam; $\rho(4.2 \text{ K}) = 0.024 \times 10^{-8} \Omega\text{m}$; measurement made "quasi-statically" with temperature decreasing at 1 C min ⁻¹ .
66	254	Kalinovich, D.F., Kovenskii, I.I., Smolin, M.D., and Statsenko, V.M.	1972		657-1291		Pure; original data reported graphically.
67	226	Kaul, S.N.	1974	C	84-900		Values from table supplied by author.

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

Date Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
68 103	Norak, J.A. and Blewitt, T.H.	1972	A	4.5-295	Polycrystalline; wire 0.025 cm in diam and 5 cm long; data from table.	
69 255	Borodovskaya, L.N. and Lebedev, S.V.	1955	+	293, 1726	Wire specimen 0.015 cm in diam; measured by pulse heating of the wire with current density 6×10^4 to 5×10^6 Amp/cm ² ; voltage and current measured by pulse oscilloscope.	
70 255	Borodovskaya, L.N. and Lebedev, S.V.	1955	+	293, 1726	Similar to the above except measured by heating the wire slowly in vacuum.	
71 256	Köster, W. and Gähling, W.	1951	+	293	99.9 pure; Mond Nickel; vacuum melted in a high frequency oven; out-gassed; measured by compensation method.	
72 257	Vedernikov, M.V. and Kolomets, N.Y.	1961	A	295-1473	N-00	99.8 pure; electrolytic.
73 212	Ehrlich, A.C., Huguenin, R., and Rivier, D.	1967		1.9-20	NI III	"Pure", polycrystal in the form of flat plates; from Johnson, Matthey and Co.; annealed at 1273 K; cooled at a rate of 3 K min ⁻¹ ; resistivity value calculated from reported $\rho(293\text{ K})/\rho(T)$ ratio; $\rho(293\text{ K}) = 6.93 \times 10^{-9} \Omega\text{ m}$.
74 212	Ehrlich, A.C., et al.	1967		4.2	NI I	Similar to the above specimen except annealed at 1473 K and coded at a rate of 5 K min ⁻¹ .
75 212	Ehrlich, A.C., et al.	1967		4.2	NI I	A different specimen cut from the same stock as the above; annealed at 1273 K and cooled at a rate of 5 K min ⁻¹ .
76 141	Shirakawa, Y.	1939	V	78-1123	0.02 Fe, 0.01 C, 0.003 Si, 0.002 Mn, and 0.001 P and Mn each; electrolytic nickel from Monson and Co.; 0.0608 cm in diam and 3.95 cm long; annealed at 1273 K for 1 h in vacuum, with specimen in the east-west direction; slowly cooled; lead wire of nickel soldered by pure silver; reannealed at 1123 K for 1 h in vacuum; slow cooled; measurement done with specimen in the east-west direction.	
77 203	Sudovtsov, A.I. and Semeneko, E.E.	1956	A	1.2-4	Polycrystalline specimen in the form of this ribbon; from Hilger; $R(4.2\text{ K})/R(273\text{ K})$ reported to be 1.0148×10^{-2} ; resistivity value calculated from reported resistance ratio, with resistivity at 273 K taken to be $6.16 \times 10^{-9} \Omega\text{ m}$.	
78 203	Sudovtsov, A.I. and Semeneko, E.E.	1962	A	14-20	The above specimen measured at hydrogen temperatures; specimen described at 99.9% pure; sealed in glass tube with helium gas; values calculated from reported $R(T)/R(273\text{ K}) = 1.00986 \times 10^{-2} + 2.88 \times 10^{-6} T^2 + 4.85 \times 10^{-11} T^5$; with $\rho(273\text{ K})$ taken to be $6.16 \times 10^{-9} \Omega\text{ m}$.	
79* 258	Panakhov, T.M., Peninov, R.I., Muradov, T.I., and Ibragimov, A.I.	1974		339-1042	99.99 pure; electrolytic; measured in a vacuum of $\sim 10^{-6}$ mmHg.	

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

Data Ref. Set No.	Author(s) No.	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
80 259	Tyagunov, G.V., Baum, B.A., and Kushniv, N.N.	1972	R	1573, 1973	99.98 pure.	
81 198	Holborn, L.	1919		80-672		Wire specimen 0.5 mm in diam; resistivity values calculated from reported $R(T)/R(273 K)$, with $\rho(273 K)$ taken to be $6.16 \times 10^{-8} \Omega m$.
82* 108	Schilmank, H.	1914	A	20-273		Wire specimen 1-2 mm long; from Hartmann and Braun; resistivity value calculated from reported $R(T)/R(273 K)$, with $\rho(273 K)$ taken to be $6.16 \times 10^{-8} \Omega m$.
83 187	Güntherodt, H.J. and Künzi, H.U.	1973	C	1726		99.998 pure; from Johnson, Matthey and Co.; in liquid state; temperature = 1726 K assumed.
84* 260	Busch, G., Güntherodt, H.J., Künzi, H.U., Meier, H.A., and Schlaepbach, L.	1970		1726		No details reported.
85 159	Baum, B.A., Tyagunov, G.V., Gel'd, P.Y., and Khasin, G.A.	1971	R	1573, 1873		99.99 pure; zone refined; specimen contained in either an alumina or zirconia crucible; measured in an atmosphere of helium.
86* 193	Dubini, E., Esin, O.A., and Vatolin, N.A.	1969		1873		"High purity"; measured in purified helium.
87* 94	Sazarin, A.M.	1962	R	1728-1900		Measured in an atmosphere of helium; rotating field apparatus calibrated against an iron specimen with resistivity value at melting taken from R.W. Powell, Philos. Mag. 44, 772, 1953; resistivity values calculated from reported conductivity $\sigma = (32.35 - 0.88 \times 10^{-3} T(C)) \times 10^8 (\text{ohm cm})^{-1}$; (this equation is apparently erroneous).
88* 261	Schwerer, F.C. and Silcox, J.	1968		16.4-56.3		No details reported; $\rho(273 K)/\rho(4.2 K) \sim 1400$; values of $\rho(T)-\rho(1.4 K)$ reported only.
89 220	Ahsad, H.M. and Grieg, D.	1974	A	10-873	Pure Ni(I)	"Spec-pure" nickel from Johnson, Matthey and Co.; 0.5 mm in diam and 10 cm long; annealed in vacuum at 1223 K for 24 h; $T_C = 631$ K; data below 260 K supplied by author; values from table.
90 220	Ahsad, H.M. and Grieg, D.	1974	A	10-260	Pure Ni(II)	Similar to the above; data supplied by author.
91* 221	Zumsteg, F.C. and Parks, R.D.	1970	V	623-650		99.999 pure; 0.005 cm thick, 0.05 cm wide and 50 cm long; swaged; annealed 1-30 days <i>in situ</i> before measurement; sample mounted on fiber-glass; resistivity values calculated from reported $R(T)/R(T_C)$ and $\rho(T_C)$ taken to be $28.70 \times 10^{-8} \Omega m$.

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
92 87	Seydel, U. and Focke, W.	1977	+	508-2989	99.99 pure; 0.0015 Fe, 0.0003 Cu, 0.0002 Si, 0.0001 Ag, Al and Ca each, and <0.0001 Cr, Mg, Mn, and Sn each (chemical analysis); measured by an exploding wire technique; measurement error 4%; smoothed values from curve.		
93 92	Güntherodt, H.J., Hauser, E., Kunzi, H.U., and Müller, R.	1975	+	1723-1843	99.999 pure, from Johnson, Matthey and Co.; measured with a potential method in which the sample material was enclosed in an alumina tube with four protrusions setting as current and potential contacts.		
110	Müller, R.	1976					
94*	Yao, Y.D., Arajs, S., and Anderson, E.E.	1975	A	4-300	0.0010 Fe, 0.0007 Al, 0.0005 Si, 0.0002 Ca, Cu, and Mg each, and <0.0001 Ag and Mn; from Johnson, Matthey and Co., R(4.2 K)/R(298 K) = 3.3×10^3 .		
95*	Wycisk, W. and Feller-Kniepmeier, M.	1976	A	295-1390	99.999 pure, <0.0005 Si, 0.0003 Fe, <0.0001 Mg and Ag each, 0.00001 Co, and 0.00005 Ca, Cd, Cu and Pb each; 5 mm diam and 150 mm long rod from Gallard-Schlesinger Chemical Corp.; zone-refined 5 times in electron beam; rolled and drawn to 60 μ m diam wire with diamond tools; electrolytically cleaned after each rolling and drawing with a 7% acetic acid and 23% perchloric acid solution; annealed 1/2 to 1 h at 573-673 K in a vacuum of <10 ⁻⁷ Torr; flushed with helium; then slowly lowered over a liquid helium bath, with copper guard roof for the ends of which are immersed in liquid helium; heated to 1073 K for 40 min; then 1273-1373 for 5 min and 1473 K for 1 min; potential leads knotted and sintered to wire specimen at the highest temperature; ρ (6.2 K) reported to be $0.0027 \times 10^{-6} \Omega \text{ m}$ is a longitudinal magnetic field of 250 Oe; resistivity values calculated from reported R(T)/R(296 K), with $\rho(296 \text{ K})$ calculated from reported R(696 K)/R(4.2 K) = 1923.		
96	Wycisk, W. and Feller-Kniepmeier, M.	1976	A	1.5-4.2	Similar to the above, except R(296 K)/R(4.2 K) = 1845; resistivity values calculated from reported $\Delta R/R(4.2 \text{ K})$; measured wire a current density of $\sim 3.5 \times 10^8 \text{ A cm}^{-2}$, and in a magnetic field of 250 Oe.		
97*	Wycisk, W. and Feller-Kniepmeier, M.	1976	A	4.2	Similar to the above, except measured without a longitudinal magnetic field, resistivity value calculated from reported R(296 K)/R(4.2 K), with $\rho(296 \text{ K}) = 5.191 \times 10^{-6} \Omega \text{ m}$ from data set 96.		
98*	Wycisk, W. and Feller-Kniepmeier, M.	1976	A	4.2	Similar to the above, except single crystal 5 mm in diam and 10 cm long.		
99*	Wycisk, W. and Feller-Kniepmeier, M.	1976	A	4.2	Similar to the above, except measured in a longitudinal magnetic field of 250 Oe.		
100	Kita, Y., Ohguchi, S., and Morita, Z.	1978	1654-1882	0.08 Co, 0.007 Fe, 0.005 Si, 0.0025 Cu, C, 2 Mg, 0.001 Al, and 0.0007 S; measured with a four probe method in which the electrodes are made of the same material as the specimen; measured in a vacuum of 10 ⁻⁶ Torr; data points taken at temperatures in the sequence: 1770, 1788, 1796, 1814, 1840, 1857, 1869, 1882, 1852, 1856, 1861, 1799, 1791, 1767, 1748, 1711, 1692, 1772, and 1654 K; values corrected for thermal expansion; values from table supplied by authors.			

* Not shown in figure.

TABLE II. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

Data Ref. Set No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications and Remarks
101* 93	Kita, Y., Ohguchi, S., and Morita, Z.	1978	+	1648-1872		Same as the above; a second melt; temperature sequence: 1755, 1780, 1798, 1818, 1838, 1856, 1872, 1855, 1836, 1821, 1805, 1793, 1769, 1756, 1740, 1693, 1667, and 1648 K.
102* 93	Kita, Y., et al.	1978	+	1720-1888		Same as the above; a third melt; temperature sequence: 1751, 1766, 1782, 1800, 1811, 1826, 1844, 1865, 1888, 1873, 1857, 1841, 1823, 1808, 1795, 1783, 1765, 1741, and 1720 K.
103 224	Jackson, P.J. and Saunders, N.H.	1968		293-673		99.999 pure (10 ppm metallic impurities); polycrystalline; annealed; data from table supplied by N.H. Saunders.
104* 263	Sherif, I.I., Ibrahim, A.F., Ghani Awad, A.A., Ammar, A.S., and Esmail, S.A.	1976	+	373-873		Polycrystalline spectroscopic nickel supplied by the National Research Center, Cairo; either dumbbell-shaped specimen with long ends about 3 cm long and 0.9 cm in diam or wire specimen of gauge length 2.5 cm; measured by a four probe method in an oven flushed with inert gas.
105* 210	Fujii, T.	1970	A	4.2		0.0050 C, 0.0007 O, 0.0004 H, 0.0003 N and Fe each, 0.0002 Si and Mg each, and <0.0001 Ag, Al, Ca and Cu each; supplied by Johnson, Matthey and Co.; carbon impurity determined by vacuum combustion method, nitrogen and oxygen impurities determined by vacuum fusion method with high purity silicon; metallic impurities determined by the supplier; 5 mm in diam and 20 mm long; annealed at 1273 K for 1 h; grain size reported to be 9 grains/cm ² ; resistivity value calculated from reported $\rho(295\text{ K})/\rho(4.2\text{ K})$ with $\rho(295\text{ K})$ taken to be $7.004 \times 10^{-8} \Omega \text{ m}$.
106* 210	Fujii, T.	1970	A	4.2		0.0040 C, 0.0010 O, <0.0002 H, and 0.0001 N; metallic impurities not determined; the above material after surface oxidation-a treatment to remove carbon in an air atmosphere for 2 h at 1173 K; "this treatment is aimed to remove carbon easily by volatilization in vacuum, with a chemical reaction to the forms of CO or CO ₂ from NiO in the process of molten containing excessive oxygen during zone melting"; 1 pass zone-refined in vacuum at 3 mm min ⁻¹ ; 1.5 mm in diam and 50 mm long, made by diameter controlled operation in zone refining process; gaseous impurities determined by the methods given above; grain size 4 grains/cm ² ; resistivity value calculated by the same method as above.
107* 210	Fujii, T.	1970	A	4.2		Similar to the above except containing 0.0020 C, <0.0002 O, <0.0001 H, and trace amount of N and 3 pass zone-refined in vacuum at 1 mm min ⁻¹ ; grain size 3-5 grain/cm ² .
108* 210	Fujii, T.	1970	A	4.2		Similar to the above except containing 0.0010 C, <0.0002 O and trace amounts of hydrogen and nitrogen and 5 pass zone-refined in vacuum at 1 mm min ⁻¹ ; grain size 4 grain/cm ² .
109* 210	Fujii, T.	1970	A	4.2		Similar to the above except oxygen content is reduced to 0.0001; 10 pass zone-refined in vacuum at 1 mm min ⁻¹ ; grain size 4 grain/cm ² .

* Not shown in figure.

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF NICKEL
[Temperature T in Electrical Resistivity ρ , $\times 10^{-6}$ ohm]

Not shown in figure.

TABLE 12. EXPERIMENTAL DATA IN THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 15 (cont.)</u>													
373	12.55	293	10.1	293	7.90	579	24.2	384	11.9	5.5	0.0322		
452	16.81	323	11.3	323	9.30	631	29.3	438	15.0	6.1	0.0323		
519	21.10	423	16.3	373	11.50	647	29.1	493	18.0	6.9	0.032		
558	24.39	523	22.8	423	14.16	555	35.3	551	22.6	7.7	0.0328		
568	25.13	623	31.5	473	17.24	794	36.4	615	27.7	8.5	0.033		
630	30.49			498	18.71	864	38.8	680	32.7	9.5	0.0335		
680	33.00			523	20.70	993	42.3			10.4	0.0338		
688	33.00			548	22.50	1053	44.4			10.8	0.0342		
766	35.46	293	7.1	573	24.70	1124	45.9			14.7	0.0363		
803	36.76	323	8.3	598	27.19	1172	46.1			17.9	0.0391		
803	36.50	423	13.1	623	28.88					2.32	0.00329		
900	39.06	523	19.4	648	30.51					2.97	0.00339	105.6	1.15
949	40.49	623	28.3	673	31.84					3.24	0.00346	115.1	1.36
1016	43.10	723	33.2	698	32.69					3.83	0.00366	123.8	1.60*
1018	43.10	823	36.4	723	33.63					4.36	0.00377	134.1	1.87
		923	39.2	748	34.57					5.72	0.00417	179.1	3.17
		1023	42.1	773	35.36					7.31	0.00476	199.5	3.78
		1123	44.7							9.12	0.00553	226.6	4.62
1098	43.8	1223	47.5							13.1	0.00780	252.2	5.41
1104	43.9	1323	49.8							14.1	0.00859		
				293	8.08								
				323	9.36								
				373	11.60								
				423	14.11								
				473	17.29								
				498	18.70								
				523	20.54								
				548	22.51								
				573	24.74								
				598	26.91								
				623	29.18								
				648	30.75								
				673	32.01								
				698	32.70								
				723	33.23								
				748	33.98								
				313	8.3								
				364	10.9								
				373	11.5								
				411	13.0								
				483	17.2								
				505	18.7								
				535	20.7								
				721	33.4								
				803	36.8								
						4.2	0.0319			7.06	1475.2	61.2	
						5.0	0.0321			7.24	1574.2	64.1	
											1673.2	68.1	

* Not shown in figure.

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF NICKEL (continued)

* Not shown in figure.

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF NICKEL NI (continued)

T	p	T	p	T	p	T	p	T	p	T	p	T	p
DATA SET 53(cont.)*		DATA SET 54(cont.)*		DATA SET 55(cont.)		DATA SET 55(cont.)		DATA SET 57(cont.)		DATA SET 59		DATA SET 62*	
551.5	21.25	600	27.0	100.2	1.052	27.85	0.3122	993	40.6	6	-0.08		
617.5	27.06	637	30.8	105.7	1.177*	37	0.3411	1020	41.6	65	0.41		
621.5	27.48	700	33.4	113.5	1.368*	39	0.3654	1042	42.0	77	0.63		
624	27.80	800	36.8	122.2	1.566	43	0.3918	1083	43.3	272	6.13		
626.9	28.15	900	40.1	133.4	1.835*	60	0.5753	1110	44.9	292	6.84		
627.8	28.27	1000	43.3	143.2	2.107	70	0.7175	1143	46.4				
628.6	28.39			150.3	2.339*	77	0.8404	1168	46.9				
628.9	28.43			174.2	3.019*	99.5	1.303	1204	48.7				
629.2	28.47			182.0	3.300	129	2.020	1239	50.0	76.1	1.908		
629.4	28.50			191.4	3.699	167	3.073	1281	50.8	191.3	7.242		
630.5	28.59			204.2	4.165*	292	7.700	1305	50.8	229.6	9.456		
631.1	28.61			227.0	5.094*	297	7.770	1325	51.7	273	12.323		
633.2	28.76			251.8	5.885	326	8.874	1348	52.2	274.30	12.402		
633.4	28.79			259.4	6.361*	379	11.31	1382	53.2	291.9	14.653		
635.2	28.89			267.9	6.509*	435	14.29	1406	53.6	324.9	16.185		
637.1	28.99			291.1	7.266*	493	17.78	1422	54.2	363.50	19.419		
638.7	29.09			300.0	7.34*	519	19.32	1448	55.3	406.9	23.250		
641.1	29.24			300.0	7.34*	546	21.54	1479	56.7	468.5	29.730		
642.3	29.32			300.0	7.34*	561	22.59						
643.8	29.41			300.0	7.34*	578	24.12						
651.8	29.80			300.0	7.34*	598	25.59						
675.3	30.83			311.0	0.0328	608	26.97	970	39.8	91	1.900		
701.2	31.82			311.0	0.0336*	1173	50.6	628	28.89	1001	41.3	173	6.110
724.8	32.66			311.8	0.0341	1273	52.8	646	30.63	1021	42.4	193	7.470
740.1	33.17			312.8	0.0346*	1373	55.2	672	31.80	1042	43.2	274.4	12.350
760.0	33.84			314.1	0.0357	1473	57.8			1076	43.7	293	13.494
785.8	34.66			315.6	0.0374*	1573	60.3			1106	45.9	367.7	18.913
815.3	35.57			316.9	0.0390	1673	62.7			1161	47.5		
839.5	36.33			318.8	0.0411*	1722	65.0			1178	48.6		
898.6	38.06			20.6	0.0437	1723	82.5	998	40.9				
939.7	39.22			22.9	0.0480	1728	83.5	1016	42.1	1225	50.1		
972.6	40.12			26.1	0.0551	1773	84.5	1040	42.7	1267	50.5	4.2	0.024
1016.0	41.29			28.8	0.0627*	1873	85.6	1059	43.6	1287	51.1	100	1.0
1044.0	42.04			32.2	0.0756	1968	86.1	1077	44.2	1327	52.1	200	3.6
1102.0	43.51			35.8	0.0923			1099	45.2	1360	53.8	300	7.3
1128.2	44.17			38.7	0.1109*	1121		1121	45.6	1385	54.5	400	11.9
1143.1	44.52			42.9	0.1339	1140		1140	46.1	1408	55.1	500	17.9
1153.1	44.75			47.9	0.1787	1158		1158	46.7	1265	50.2	600	25.6
100	1.1			53.1	0.2310	1177		1177	47.8	1294	50.2	628	29.3
200	4.0			53.1	0.6601*	1195		1195	48.5	1318	50.7	700	32.4
300	8.0			64.9	0.7338	1214		1214	49.0	1339	51.7	800	36.0
400	12.7			89.5	0.8178*	1250		1250	50.2	1357	52.3	900	38.8
500	18.7			94.8	0.9367	1265		1265	50.2	1367	52.7	940	40.1
						1294		1294	50.2	1398	52.7	968	35.4
						1318		1318	50.7	1381	52.7		

* Not shown in figure.

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF NICKEL N1 (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
<u>DATA SET 66 (cont.)</u>													
673	35.2*	160	2.50*	293	8.5*	373	11.35	18	0.0669	1726	85.1		
683	36.0	180	3.10	1726	63	482	17.1*	20	0.0673			<u>DATA SET 85</u>	
696	37.1*	200	3.70*			562	21.9						
704	37.4	220	4.38			596	25.6						
711	37.6*	240	5.10			621	27.3						
733	38.2	260	5.95	1726	64	633	28.6	339	9.5	1573	58.6		
742	38.5*	280	6.75*	1726	81.5	642	29.1*	381	10.7	1873	89.4		
749	38.9*	300	7.65*			654	30.5	450	14.2			<u>DATA SET 86*</u>	
764	39.5	320	8.50*			666	31.3*	503	18.3				
766	40.0*	340	9.45	293	7.61	680	31.8	536	21.5	1873	125		
777	39.5*	360	10.35*			702	32.7	583	24.0				
787	39.5*	380	11.35*			772	34.9	618	27.8			<u>DATA SET 87*</u>	
795	40.2	400	12.40			873	38.6	662	29.2				
806	40.4*	420	13.50			966	41.2	695	30.9				
817	41.6*	440	14.65	295	8.4	1073	44.1	731	32.0				
855	43.0	460	15.90	432	16.0	1123	45.5	776	33.4				
861	43.3*	480	17.15*	568	25.7			865	36.7				
873	43.5*	500	18.50	696	35.8			928	39.0				
902	44.5	520	20.25*	725	36.8			999	40.4				
945	45.2	540	22.00*	881	42.2	1.23	0.0628	1042	42.0				
952	45.6*	560	24.10	1063	47.7	1.23	0.0629*					<u>DATA SET 88*</u>	
962	45.6*	580	26.30*	1273	54.3	1.30	0.0628*					<u>DATA SET 80</u>	
997	47.5	600	28.75	1473	58.0	1.40	0.0629	1573	63				
1019	47.5*	620	31.25			1.58	0.0629*	1973	87				
1036	48.0*	640	32.75			1.62	0.0629*						
1078	49.1	660	33.25			1.73	0.0629						
1089	49.4*	680	33.75	1.85	0.06308	2.01	0.0629*						
1127	51.0	700	34.25	4.15	0.06346	2.20	0.0629						
1141	51.4*	720	34.75	14.1	0.00753	2.41	0.0629*	80.2	0.9510	16.4	0.00521		
1165	51.3	740	35.25	20.1	0.01237	2.52	0.0629*	80.9	0.9666	19.5	0.00801		
1173	52.0*	760	35.75			2.73	0.0630	194.7	4.0486	23.5	0.0123		
1187	52.6*	780	36.25			3.00	0.0630	313	9.1092	28.3	0.0214		
1200	52.8	800	36.75	4.15	0.0630*	3.18	0.0630*	581.4	15.7036	32.7	0.0325		
1211	53.0*	820	37.25			3.38	0.0630	671.8	18.7782	37.4	0.0497		
1222	53.4*	840	37.75			3.52	0.0630*						
1270	54.8	860	38.25			3.55	0.0630*						
1273	54.7*	880	38.75	4.15	0.0141	3.64	0.0631*						
1281	54.9*	900	39.25			3.81	0.0631	20.2	1.2726			<u>DATA SET 89</u>	
1291	55.2					3.84	0.0631*	195.4	4.1811	10	0.044		
<u>DATA SET 67</u>													
80	0.75	4.5	0.0116	78	1.28								
100	1.25*	295	7.51	178	4.02								
120	1.65*			273	7.36*								
140	2.05			294	8.13			14	0.0665	1726	82.3		
				323	9.16			16	0.0666	80	0.625		
										100	1.033		
<u>DATA SET 68*</u>													
<u>DATA SET 69</u>													
<u>DATA SET 70</u>													
<u>DATA SET 71</u>													
<u>DATA SET 72</u>													
<u>DATA SET 73</u>													
<u>DATA SET 74</u>													
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<u>DATA SET 106</u>													
<u>DATA SET 107</u>													
<u>DATA SET 108</u>													
<u>DATA SET 109</u>													
<u>DATA SET 110</u>													
<u>DATA SET 111</u>													
<u>DATA SET 112</u>													

EXPERIMENTAL. DATA ON THE ELECTRICAL RESISTIVITY OF NICKEL.

M. Compton

* Not shown in figure

TABLE 12. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF NICKEL Ni (continued)

T	p	T	p	1	ρ
<u>DATA SET 96(cont.)</u>		<u>DATA SET 101(cont.)*</u>		<u>DATA SET 103(cont.)</u>	
2.88	0.002653	1693	61.4	573	23.03
3.09	0.002615	1740	87.35	623	27.86
3.37	0.002705	1755	87.45	673	31.18
3.60	0.002735	1756	87.55		
3.80	0.002761	1769	87.65		
3.97	0.002782	1780	87.7		
4.21	0.002814	1793	87.95	373	8.54
		1798	87.95	422	10.67
		1805	88.05	471	13.60
		1818	88.2	522	17.19
4.2	0.003185	1821	88.25	571	20.56
		1836	88.45	617	24.27
		1838	88.45	666	26.74
		1855	88.7	718	28.76
4.2	0.003053	1856	88.65	770	31.01
		1872	88.85	821	33.26
				873	35.06
		<u>DATA SET 102*</u>		<u>DATA SET 105*</u>	
4.2	0.002588	1720	87.15	4.2	0.0233
		1741	87.4		
		1751	87.45		
		1765	87.7		
		1766	87.65		
		1781	87.85		
1711	61.2			4.2	0.0145
1748	87.05	1792	87.8		
1767	87.25	1795	88.05		
1770	87.25*	1800	88.05		
1772	60.3*	1808	88.2		
1788	87.4	1811	88.2		
1791	87.55*	1823	88.35		
1796	87.55*	1826	88.35		
1799	87.65	1841	88.6		
1814	87.8	1844	88.6		
1817	87.9*	1857	88.8		
1836	88.1	1865	88.85		
1840	88.1*	1873	89.1	4.2	0.00424
1852	88.3*	1888	89.3		
1857	88.3				
1867	88.45*				
1869	88.45				
1882	88.65	293	7.00		
		323	8.22		
		373	10.48		
		423	13.00*		
1648	60.35	473	15.86		
1667	60.8	523	19.16		

* Not shown in figure.

4. ACKNOWLEDGMENTS

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5. APPENDICES

5.1. Methods for the Measurement of Electrical Resistivity

At the Center for Information and Numerical Data Analysis and Synthesis (CINDAS) of Purdue University, the experimental methods for the measurement of electrical resistivity have been classified into various categories according to a similar scheme used by CINDAS for the classification of methods for the measurement of thermal conductivity [264, pp. 13a-25a]. This classification scheme of CINDAS is presented below. Note that the letters in parentheses following the respective methods are the code letter used in the "Method Used" column of the Table of Measurement Information for indicating the experimental methods used by the various authors.

Methods for the Measurement of Electrical Resistivity

A. Steady-State Methods

1. Voltmeter and ammeter direct reading method (V) [265, p. 159; 266, pp. 244-5]
2. Direct-current potentiometer method (A) [267, pp. 151-8]
 - a. 4-probe potentiometer method
3. Direct-current bridge methods (B) [267, pp. 144-51]
 - a. Kelvin double bridge method
 - b. Mueller bridge method
 - c. Wheatstone bridge method
4. Van der Pauw method (P) [268, 269]
5. Galvanometer amplifier method (G) [270, pp. 159-62]

B. Non-Steady-State Methods

1. Periodic current method
 - a. Direct connection to sample
 - (1) Alternating-current potentiometer method (C) [267, pp. 161-2]
 - (2) Alternating-current bridge method (D) [267, p. 162]
 - b. No connection to sample
 - (1) Mutual inductance method (M) [271]
 - (2) Self-inductance method (S) [272]
 - (3) Rotating field method (R) [273]

2. Non-periodic current method

a. Direct connection to sample

(1) Transient (subsecond) method (T) [154]

b. No connection to sample

(1) Eddy current decay method (E) [273; 267, p. 103]

5.2. Conversion Factors for the Units of Electrical Resistivity

The recommended values and experimental data for the electrical resistivity tabulated in this work are in the units: $10^{-8} \Omega \text{m}$. Conversion factors for the units of electrical resistivity, which may be used to convert the values given in ($10^{-8} \Omega \text{m}$) to values in other units, are given below.

Conversion Factors for the Units of Electrical Resistivity

Units to be Converted to	Multiply the Value Given in ($10^{-8} \Omega \text{m}$) by
ohm-meter ($\Omega \text{ m}$)	1×10^{-8}
ohm-centimeter ($\Omega \text{ cm}$)	1×10^{-6}
ohm-inch ($\Omega \text{ in.}$)	3.937×10^{-7}
ohm-foot ($\Omega \text{ ft}$)	3.281×10^{-8}
microohm-centimeter ($\mu\Omega \text{ cm}$)	1
abohm-centimeter (ab $\Omega \text{ cm}$)	1×10^3
statohm-centimeter (stat $\Omega \text{ cm}$)	1.113×10^{-18}
emu (= ab $\Omega \text{ cm}$)	1×10^3
esu (= stat $\Omega \text{ cm}$)	1.113×10^{-18}
ohm-circular mil per foot ($\Omega \text{ cmil ft}^{-1}$)	6.015

Example: $1.000 \times 10^{-8} \Omega \text{m} = 3.937 \times 10^{-7} \Omega \text{ in.}$

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