Electrical Resistivity of Copper, Gold, Palladium, and Silver

R. A. Matula

Center for Information and Numerical Data Analysis and Synthesis, Purdue University, West Lafayette, Indiana 47906

In this work, recommended values for the electrical resistivity as a function of temperature from the cryogenic region to well beyond the melting point are given for bulk pure copper, gold, palladium, and silver. In addition to the total electrical resistivity values for the solid state, intrinsic electrical resistivity values are presented from cryogenic temperatures to the melting point. The values are corrected for the change in geometry due to thermal expansion. The recommendations are based on theoretical considerations and on the experimental data found in the open literature. Those available experimental data together with information pertaining to the specimen characterization and measurement conditions are included in this work. The methods of data evaluation and other considerations used in arriving at the recommendations are described. For the solid state, an interpolation scheme is given to aid in the determination of values between those supplied in the tables; for the liquid state, equations are given.

Key words: Copper; critical evaluation; data analysis; data compilation; data evaluation; data extraction; data synthesis; electrical resistivity; elements; gold; metals; molten metals; palladium; precious metals; reference data; silver; solid state physics; transport properties.

Contents

List of Tables

List of Figures

Explanation of Symbols

A	Area; constant
A	Code for dc potentiometric method
B	Constant
B	Code for dc bridge method
c	Concentration
C	Constant
C	Code for ac potentiometric method
D	Constant
D	Code for ac bridge method
E	Code for eddy current decay method
$F(x)$	Grüneisen function
$G_1(T)$	A modified Bloch-Grüneisen function
$G_2(T)$	Another modified Bloch-Grüneisen function
I	Code for induction method
$J_5(x)$	A transport integral
ℓ	Length
L_F	Latent heat of fusion
M	Atomic weight; mass
M	Code for mutual inductance method
p	Power of a term in modified Bloch-Grüneisen function $G_2(T)$
P	Code for van der Pauw method
R	Radius; resistance
R	Code for rotating magnetic field method
S	Code for self-inductance method
T	Temperature
T	Code for transient (subsecond) method
T_m	Melting point
V	Code for voltmeter and ammeter direct reading method
x	Variable in Grüneisen function and transport integral $J_5(x=\theta/T)$
Δ	Deviation from Matthiessen's Rule
$\Delta\ell$	Change in length
θ	Constant; electrical resistivity Debye temperature
ρ	Electrical resistivity
ρ_0	Residual electrical resistivity
ρ_i	Intrinsic electrical resistivity
ρ_L	Electrical resistivity in the liquid state at the melting point
ρ_S	Electrical resistivity in the solid state at the melting point
$\Phi(x)$	Grüneisen function $F(x)$ divided by x

1. Introduction

The central purpose of this work is to present recommended values for the electrical resistivity of bulk pure copper, gold, palladium, and silver over the full range of temperatures to the melting point and beyond. It includes also a summary of all data found in an extended search of the open literature for these metals with less than 1/2 weight percent impurities as well as a complete characterization of the materials to which the data relates, so far as it can be determined. Some original data provided by authors of recent papers have been included. In all, 621 sets of original data from 188 references are provided. It is believed that essentially all important documents in the open literature on the pure metals have been located through 1976, and that the coverage is 75% complete for materials with less than 1/2 weight percent impurities. This information has been studied, correlated, and integrated with theoretical and empirical knowledge to arrive at the recommended values for the resistivity of the pure metals, corrected for the change in geometry of samples due to thermal expansion at normal pressures.

The organization of this work is as follows. Section 2 gives a brief discussion of some items from the theory of electrical resistivity in order to establish terminology and notation and to state equations of which use is to be made. It is not intended to provide a survey of the theory. Section 3 indicates some general ideas and procedures used in judging the experimental evidence and in arriving at the recommended values for the resistivity.

Section 4, Data and Numerical Results, is the heart of this work. It is divided into subsections relating to the four elements, preceded by a discussion of items common to the four subsections. Each subsection opens with a description of the element and some of its properties. The scope of the available information on its electrical resistivity is indicated, and the selection of the sets of data used in arriving at the recommended values for the resistivity of the pure bulk material is discussed. Any special methods used in arriving at the recommended values are described, and the uncertainty to be attributed to these values is indicated. The full data are then presented. The recommended values in tabular form are followed by a graphical display of the data along with the curve of the recommended values. Then the information pertaining to the specimen characterization and measurement conditions for each set of data is provided in tabular form. Finally, tables of the original experimental data, either as stated by the original authors or as extracted from their graphs, are presented.

Section 5, Summary, contains a statement characterizing the results of this work. In addition, a brief description of the methods used in arriving at the final smoothed values of resistivity is given. Also, a comparison of the ratio of the resistivity of the liquid to that of the solid at the melting point is made between a simple theory and the results of this work.

The last two sections are for Acknowledgments and References, respectively. The latter, section 7, contains references to sources of data, as well as to other publications referred to in the text. It is arranged to bring together references to sources of information on each of the metals: first copper, then in turn gold, palladium, and silver. To avoid multiplication of references to papers that deal with more than one of these metals, the references for each metal except copper are of two types. First, there are full references, arranged alphabetically by first author, to all papers for which full references are not given elsewhere; then, following the notation "See also," are listings (again alphabetically by first author) to preceding reference numbers under which one will find full references to other papers also dealing with this metal. Each listing ends with the numbers of the data sets for that metal derived from the listed paper. The references thus provide an index to the data tables and the associated measurement information tables for each metal. Section 7 concludes with references to publications not dealing directly with these particular metals.

2. Some Theoretical Background

This section contains a brief discussion of some points from the theory of the electrical resistivity of metals to which later reference will be made.

2.1. Matthiessen's Rule

The electrical resistivity of a chemically pure metallic element with no physical defects is called its intrinsic resistivity $\rho_i(T)$. It is the resistivity caused by the scattering of the charge carriers (electrons or holes) by quantized vibrations of the lattice (that is, phonons) and by their collisions with each other. The intrinsic resistivity of metals goes to zero at $T=0$ K, roughly as some power of T. When impurities are present they also scatter the carriers, and this increases the resistivity. To the extent that the scattering from different impurity atoms is independent, the different types of impurity will make independent, additive contributions to the resistivity, each proportional to the concentration c of that impurity. The contribution of the impurities to the resistivity is to the first approximation independent of temperature and remains as the residual resistivity ρ_0 at $T=0$ K. To the approximation that the contribution of the impurities to the resistivity is additive and independent of temperature, one can write the total resistivity as

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

This relation is commonly referred to as Matthiessen's Rule [219, pp. 7–8; 191, p. 433; 218][1], though this is not the form originally given by Matthiessen. The same name is often given to the more general idea of the additivity of resistivity contributions from different sources. In this form it applies to the effects of other sources of scattering, such as lattice imperfections that make contributions to the resistivity that vary with temperature, and it implies that the total added resistivity is a linear function of the concentration of each type of impurity and imperfection that may be present. Here the name Matthiessen's Rule will be applied to eq (1), supplemented by the idea that ρ_0 is proportional to c.

The qualitative behavior of the electrical resistivity of impure metals is illustrated in figures 1 and 2. In constructing these figures, $\rho_i(T)$ has been taken to be given by the Bloch-Grüneisen expression (section 2.2), and ρ has been computed using Matthiessen's Rule for several values of ρ_0. Figure 1 uses linear scales, and figure 2 uses logarithmic scales, as is much preferred with nearly pure metals. For T below about 10 K the residual resistivity is essentially the total resistivity, and the plots are all nearly straight horizontal lines from which ρ_0 can be read. In analyzing data on a metal containing various concentrations c of a single impurity or dopant, one can make such plots, read ρ_0 from them, and then test Matthiessen's Rule in two ways:

(a) by checking the proportionality of ρ_0 to c, and
(b) by checking that $\rho-\rho_0$ is the same for all samples.

In fact, deviations from Matthiessen's Rule do occur and in some materials are of major interest. When a single impurity is involved, the deviations can be brought out, even when the impurity concentrations are not well known, by constructing plots such as that in figure 3. Here $\rho-\rho_0$ for various samples at the same T is plotted against log ρ_0 as a (nonlinear) measure of the impurity concentration. If Matthiessen's Rule is strictly obeyed, such a plot will be a horizontal line corresponding to the value of $\rho_i(T)$; if it is not, the curve may deviate from a straight line as is indicated in the high-concentration range in figure 3 by the dotted line. In the latter case, $\rho_i(T)$ can be determined from the horizontal asymptote of the curve at the lowest

[1] Figures in brackets indicate literature references.

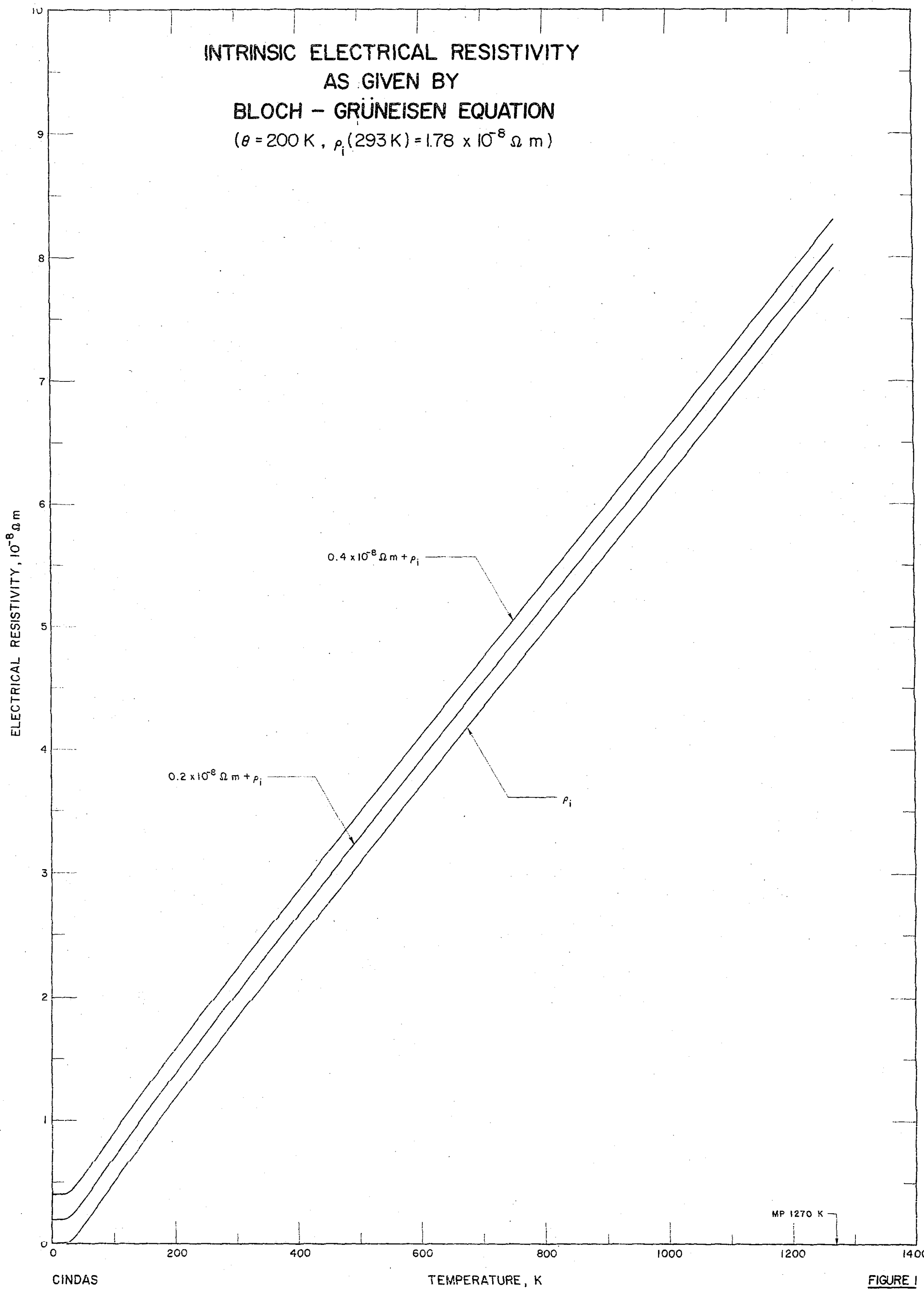

INTRINSIC ELECTRICAL RESISTIVITY
AS GIVEN BY
BLOCH – GRÜNEISEN EQUATION
(θ = 200 K , ρ_i(293 K) = 1.78 x 10^{-8} Ω m)
0.4 x 10^{-8} Ω m + ρ_i
0.2 x 10^{-8} Ω m + ρ_i
ρ_i
MP 1270 K
ELECTRICAL RESISTIVITY, 10^{-8} Ω m
TEMPERATURE, K
0
200
400
600
800
1000
1200
1400
1
2
3
4
5
6
7
8
9
10
CINDAS

FIGURE 1

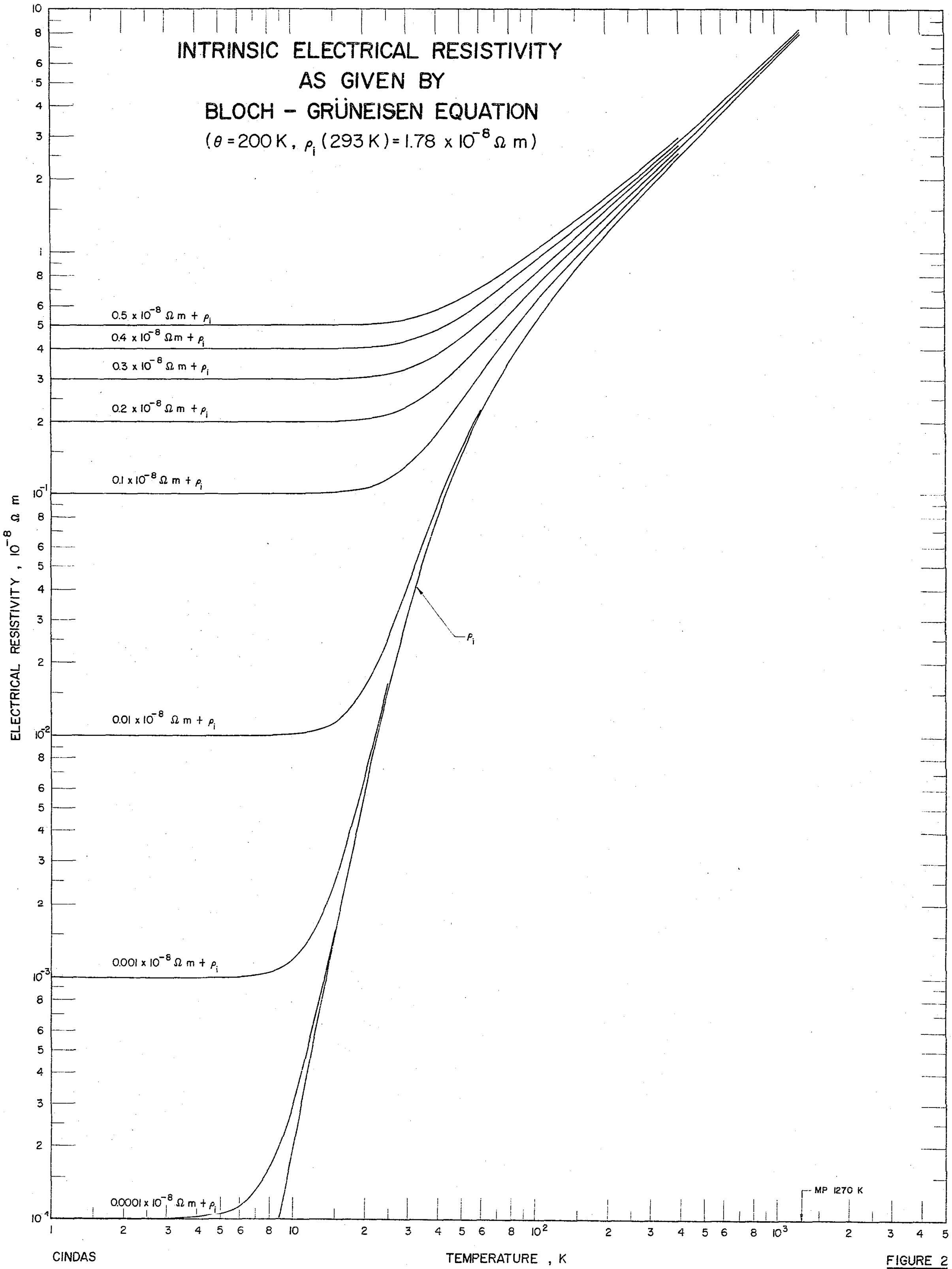

INTRINSIC ELECTRICAL RESISTIVITY
AS GIVEN BY
BLOCH – GRÜNEISEN EQUATION
(θ = 200 K, ρ_i (293 K) = 1.78 x 10^{-8} Ω m)
0.5 x 10^{-8} Ω m + ρ_i
0.4 x 10^{-8} Ω m + ρ_i
0.3 x 10^{-8} Ω m + ρ_i
0.2 x 10^{-8} Ω m + ρ_i
0.1 x 10^{-8} Ω m + ρ_i
0.01 x 10^{-8} Ω m + ρ_i
0.001 x 10^{-8} Ω m + ρ_i
0.0001 x 10^{-8} Ω m + ρ_i
ρ_i
MP 1270 K
ELECTRICAL RESISTIVITY, 10^{-8} Ω m
TEMPERATURE, K
CINDAS

FIGURE 2

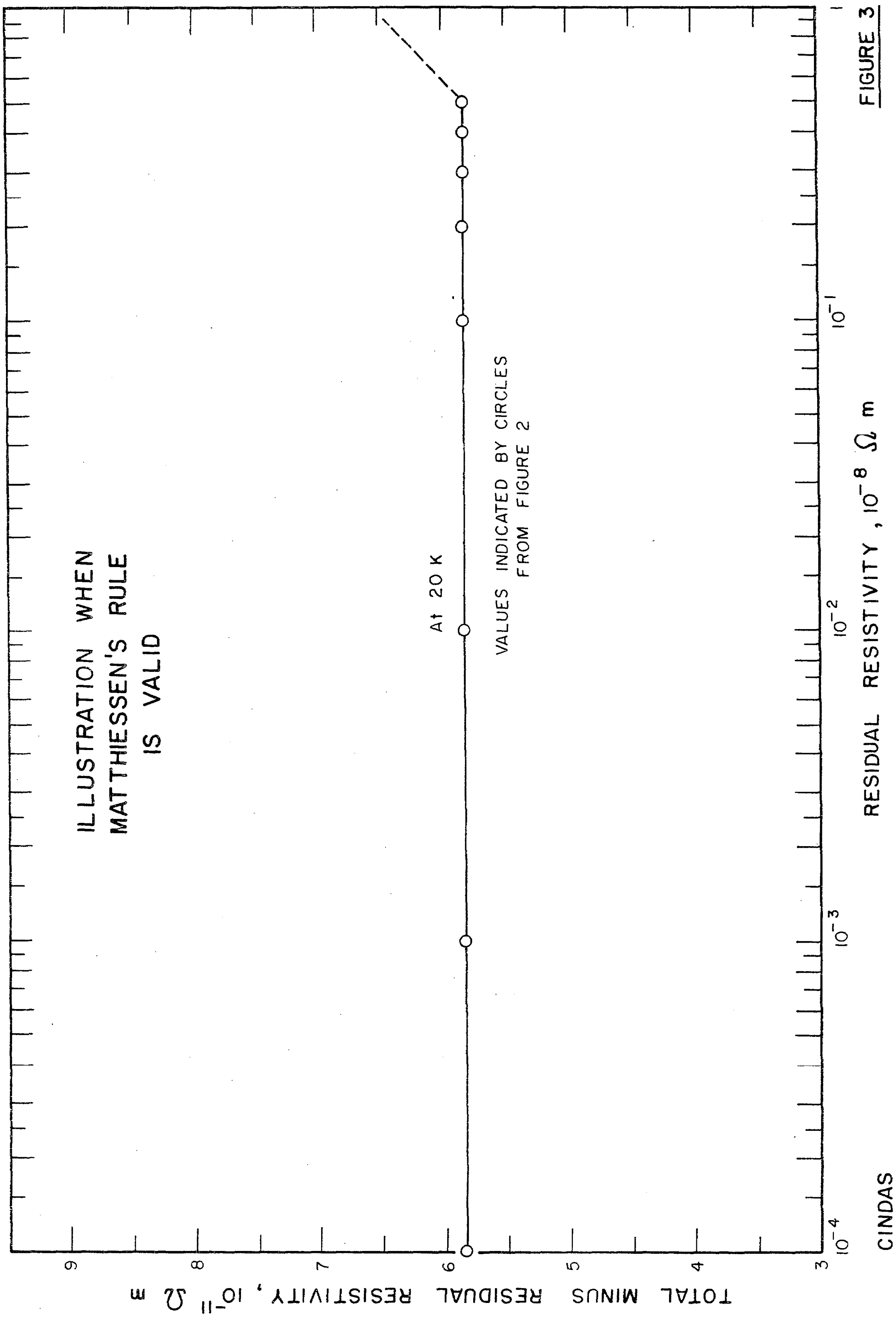


ILLUSTRATION WHEN
MATTHIESSEN'S RULE
IS VALID
At 20 K
VALUES INDICATED BY CIRCLES
FROM FIGURE 2
RESIDUAL RESISTIVITY , 10⁻⁸ Ω m
TOTAL MINUS RESIDUAL RESISTIVITY, 10⁻¹¹ Ω m
10⁻⁴
10⁻³
10⁻²
10⁻¹
1
3
4
5
6
7
8
9
CINDAS

FIGURE 3

concentrations, and the "deviation from Matthiessen's Rule," defined as

$$\Delta(c,\ T) = [\rho(c,\ T) - \rho_0] - \rho_i(T), \tag{2}$$

can be determined by comparing the curve with its asymptote.

Comprehensive reviews of deviations from Matthiessen's Rule have been given by Bass [191] and Cimberle et al. [199]. The latter authors include a presentation of experimental data that is available for copper alloys [199, pp. 647–9], gold alloys [199, pp. 649–51], and silver alloys [199, pp. 651–4]. They give figures similar to figure 3, thus allowing a determination of the validity of Matthiessen's Rule for a given combination of temperature, residual resistivity, and impurity species.

2.2. Bloch-Grüneisen Formula

An important theoretical expression for the intrinsic resistivity of a metal is the Bloch-Grüneisen equation,

$$\rho_i(T) = \frac{C}{M\,\theta}\left(\frac{T}{\theta}\right)^5 \int_0^{\theta/T} \frac{z^5 e^z}{(e^z-1)^2}\, dz, \tag{3}$$

which can also be written as

$$\rho_i(T) = \frac{C}{M\theta}\left(\frac{T}{\theta}\right)^5 J_5\left(\frac{\theta}{T}\right), \tag{4}$$

with T the temperature, θ a characteristic temperature of the metal known as the electrical resistivity Debye temperature, M the atomic weight, C a constant of the metal, and J_5 a transport integral [219, 223, 207, 208, 194, 195]. The Bloch-Grüneisen formula is derived for a quite special model: a monovalent metal with a spherical Fermi surface and a phonon spectrum derived from a Debye model. It is treated as having volume, Debye temperature θ, and carrier-phonon interaction parameters all independent of temperature, and the derivation is carried through with neglect to Umklapp processes [233, chapter IX].

Despite the special assumptions made in arriving at this equation, it is quite useful to compare experimental results with it as a basis for the further elaboration of ideas. Experimental results for real materials are sometimes stated in terms of it: for instance, treating θ as the only parameter variable with T, one can determine θ as a function of T so as to reproduce the observed $\rho_i(T)$, and then discuss the variation of this θ with T [219, section 4.3; 215; 216]. As will be seen later, its generally appropriate form can also be modified by elaborations that represent the effects of other factors acting in real metals in order to make it represent quite well the observed behaviors of real materials.

At limiting temperatures the Bloch-Grüneisen equation takes on simple forms:

$$\rho_i(T) \rightarrow 124.431\frac{C}{M\theta}\left(\frac{T}{\theta}\right)^5, \text{ as } T \rightarrow 0, \tag{5}$$

$$\rho_i(T) \rightarrow \frac{C}{4M\theta}\left(\frac{T}{\theta}\right), \text{ as } T \rightarrow \infty. \tag{6}$$

Figures 1 and 2 were constructed for illustrative purposes using a Bloch-Grüneisen form for $\rho_i(T)$, with values of the parameters generally appropriate for the metals treated in this report: θ was taken to be 200 K, the melting point 1270 K, and C was chosen to make the intrinsic resistivity 1.78×10^{-8} Ω m at 293 K. Figure 4 gives, for this same function, a plot of the logarithmic derivative of the intrinsic resistivity, $d \ln \rho_i/d \ln T$ or the "local power"; it shows clearly the rapid departure from the fifth-power law at low temperatures as well as the slower approach to the first-power law at higher temperatures, which is nearly complete at $T=\theta$.

2.3. Change of Resistivity on Melting

When a metal melts, the resistivity changes abruptly [202] and generally increases [203]. A theory of the ratio of the resistivity ρ_L of the liquid to the resistivity ρ_S of the solid, both at the melting point, has been given by Mott [220], who finds

$$\left(\frac{\rho_L}{\rho_S}\right)_{T_m} = \exp\left(\frac{80\ L_F}{T_m}\right). \tag{7}$$

Here T_m is the melting point in kelvins and L_F is the latent heat of fusion in kilojoules per mole. In deriving this equation, Mott adopts the Einstein model for the atomic motions in a solid and a corresponding model of the liquid in which the atoms vibrate about fixed but imperfectly ordered mean positions; he then assumes that the change in resistivity on melting is primarily due to the change of the frequencies of atomic vibrations or of θ. A comparison of the results of the present work with Mott's rough and simple theory will be found in section 5.

3. Evaluation and Synthesis of Data

3.1. Extraction of Data from the Literature

Extraction of data from the literature must, of course, precede its evaluation. It is important that one extract not merely the raw numerical data, reading it from graphs, if necessary, but also the fullest possible characterization of the measured samples, and an adequate characterization of the method of measurement. While the author's estimate of the accuracy of the results is essential, a comparison of the results and estimated accuracies of different authors will soon undermine any uncritical trust in their estimates. Data extraction has been carried out with the aim of minimizing the need for a second examination of a paper, but this cannot always be avoided. The results of data extraction are summarized in the Tables of Experimental Data and Tables of Measurement Information in section 4.

3.2. General Procedures in the Analysis and Synthesis of Data

In beginning the analysis, it is very useful to bring all data onto a single graph in order to make evident any gross discrepancies and to facilitate the recognition of subtler similarities and differences. In the present work, plots of ρ

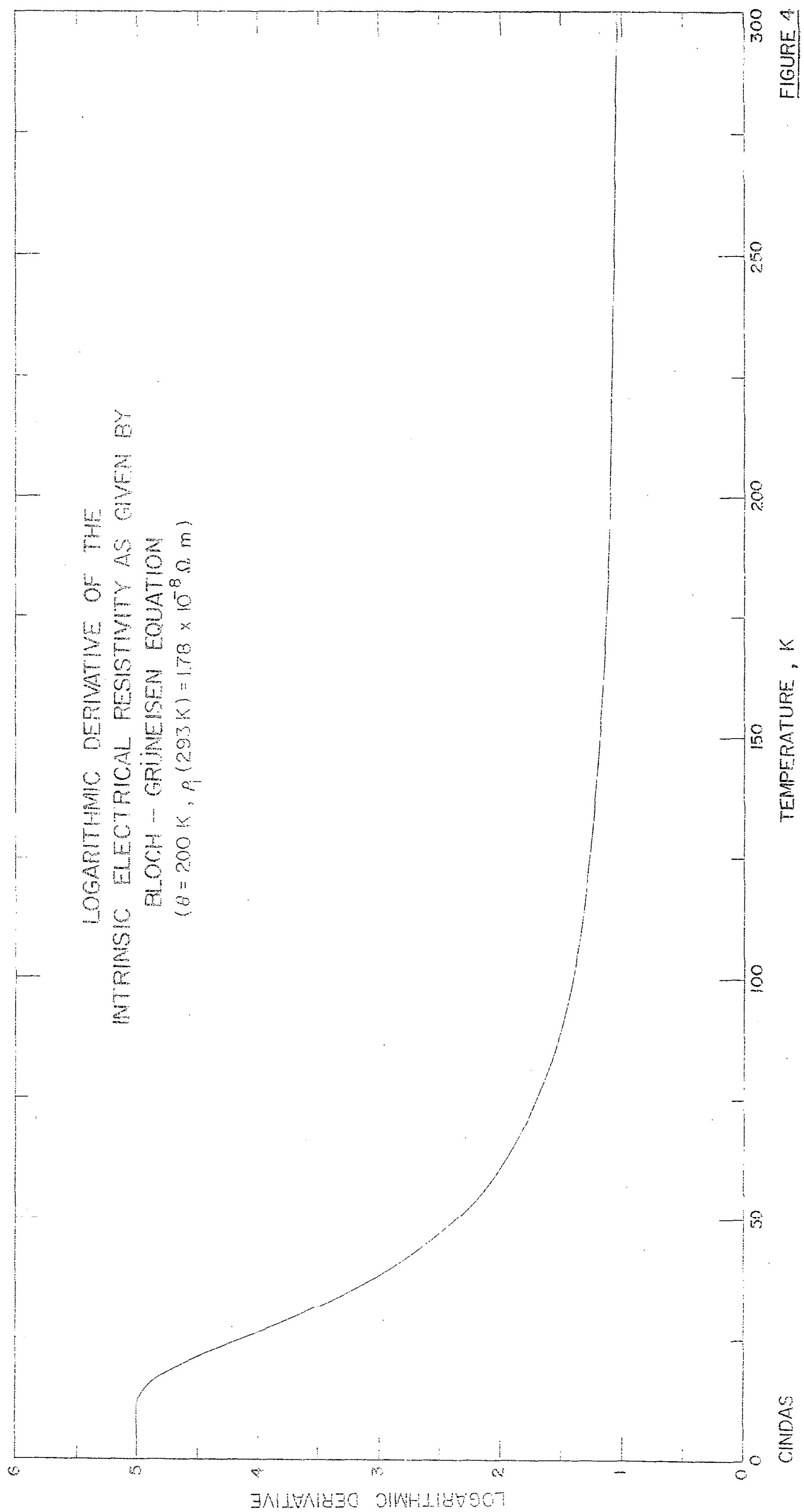

LOGARITHMIC DERIVATIVE OF THE
INTRINSIC ELECTRICAL RESISTIVITY AS GIVEN BY
BLOCH -- GRÜNEISEN EQUATION
(θ = 200 K , ρ_i (293 K) = 1.78 x 10^-8 Ω m)
TEMPERATURE , K
LOGARITHMIC DERIVATIVE
CINDAS
0
50
100
150
200
250
300
1
2
3
4
5
6

FIGURE 4

or ρ_i against T were not useful for this purpose, because ρ changes by orders of magnitude over the full range of T, while the percentage accuracy of the measurements is about constant; plots of log ρ against log T are required. These bring out large discrepancies that can lead to the exclusion of some work from consideration, and, in the low-temperature range, make very evident the differing purities of different samples. The general agreement or disagreement of results obtained by different observers using different methods and the fit of low-temperature to higher-temperature measurements may send one back to an examination of some of the original papers.

The preliminary selection of what data to include as the basis of the evaluated data depends on many factors including the central purpose of this work, the explicitness with which experimenters report their results, and how the data are reported. Since the central purpose of this work is to generate evaluated data for the pure bulk material, data for conditions not relevant to this central purpose were not considered in the evaluation. In addition, abnormal values were also excluded. The explicitness with which certain items are reported enhances the quality of the reported data. Such items include purity, method and procedure of fabrication, thermal history, specimen dimensions, method of measurement, and measurement environment. Data in tabular form are given higher weight than data reported in a figure, and data over an extended temperature range are given more importance than data over a limited range of temperatures. The final decision of the data to be included in the synthesis of information will include considerations such as the method of measurement and the evidence of care with which it was applied, the methodolology used in sample preparation (in which there are sometimes dramatic steps forward), and the consistency of the results of different workers.

Before the final synthesis of data from different sources, one must be sure that they are as closely comparable as possible. One matter to be considered is the correction for thermal expansion of the sample made by the original author. Electrical resistivity measurements are ordinarily made at constant pressure on samples with dimensions that change with temperature. In deriving the resistivity ρ from a measured resistance R using an equation such as

$$\rho = RA/\ell, \tag{8}$$

where ℓ is the length between the voltage probes on a specimen and A the cross-sectional area of the specimen, it is common to use for A and ℓ the values measured at room temperature. This is not inappropriate in reporting measurements of limited accuracy over not-too-large a temperature range, but the difference between

$$\rho(T, \text{nominal}) = R(T)\ A(293\text{ K})/\ell(293\text{ K}) \tag{9}$$

and

$$\rho(T) = R(T)\ A(T)/\ell(T) \tag{10}$$

ought not to be ignored in other cases. Unfortunately, there is not full uniformity in the reporting of $\rho(T$, nominal) as a substitute for $\rho(T)$. In the present work, it has been important to determine which quantity has been reported and to bring the results to a common basis by use of a relation such as

$$\rho(T, \text{nominal}) = \rho(T)\left[\frac{A(T)}{A(293\text{ K})}\frac{\ell(293\text{ K})}{\ell(T)}\right]^{-1} \cong \rho(T)\left[1+\frac{\ell(T)-\ell(293\text{ K})}{\ell(293\text{ K})}\right]^{-1} \tag{11}$$

before making comparisons. (It should be emphasized that not all methods of measuring ρ are equivalent to measuring R, A, and ℓ, and that the correction for dimensional changes with changing T may differ with the experimental set-up.) It has been most convenient to reduce data reported as $\rho(T)$ to terms of $\rho(T$, nominal) since most reported data are in terms of $\rho(T$, nominal) and to then carry out the synthesis of all data using $\rho(T$, nominal). The final results have, however, been converted to and reported as the true $\rho(T)$.

The values of $\rho(T$, nominal) were converted to $\rho_i(T$, nominal) by Matthiessen's Rule using values of ρ_0 provided by the authors or deduced from the low-temperature values of $\rho(T$, nominal). When measurements are made only above room temperature, authors commonly do not provide a value of ρ_0, and one cannot deduce it from the measurements of ρ. For the purer samples one can then appropriately neglect the difference between ρ and ρ_i, since the difference is smaller than other sources of error.

Reduction of the selected values of ρ_i(nominal) to a smoothed curve must ultimately depend on a draftsman's eye supplemented by a physical understanding of the behavior to be expected. To improve on the precision attainable by smoothing on a large-scale plot of log ρ_i(nominal) against log T, an intermediate numerical fitting to a suitable analytic function has been employed. In this connection a suitable function is one that can easily represent the general behavior of the data at high, low, and intermediate temperatures, that does not tend to misbehave seriously outside the range of the fitted data, and that involves only a small number of parameters that can be adjusted by a computer to achieve an optimum fit to the data, ordinarily in a least-squares-error sense. A plot of the fractional deviation of the data from the smooth fitted curve or of log [ρ_i(data, nominal)/ρ_i(fitted, nominal)] against log T then gives a conveniently enlarged presentation of any systematic deviations of the data from the fitted curve on which are superimposed the erratic deviations due to experimental errors. Using this, one can construct a smoothed curve from which to read fractional deviations of recommended values from the fitted curve at the T's that are to appear in the table. Values of ρ_i(nominal) as thus obtained were corrected to get values of ρ_i using eq (11) and the best available data on the thermal expansion of the material. Finally, values of $\rho(T)$ were constructed for a material with specified ρ_0 by using Matthiessen's Rule.

3.3. Fitting Functions

Two functions have been used in the present work in unifying high- and low-temperature data. Both are variants of the Bloch-Grüneisen form that preserve its generally suitable character for the representation of the intrinsic resistivity of pure metals, but which also permit representation of behaviors known to occur at high and low temperatures because of factors neglected in derivation of the Bloch-Grüneisen form.

The first of these forms is

$$G_1(T) = A\left(1 + \frac{BT}{\theta - CT}\right) \Phi\left(\frac{\theta - CT}{T}\right), \quad (12)$$

where A, B, C, and θ are constants, and

$$\Phi(x) = F(x)/x, \quad (13)$$

where $x = \theta/T$ and $F(x)$ is the Grüneisen function

$$F(x) = \frac{4}{x^4}\int_0^x \frac{z^5 e^z}{(e^z - 1)^2}\, dz. \quad (14)$$

Grüneisen [207] has given a good table of this function, with asymptotic approximations, and a less accurate table of its logarithmic derivative [208]. (A simple routine has provided the values needed by the computer in the present work: $F(x)$ to 0.02%, and its logarithmic derivative to about 0.1% with both percentages based on a comparison with Grüneisen's tabulated values.) Replacement of θ in the Bloch-Grüneisen form by $\theta - CT$ provides for representation of changes in the effective Debye temperature due to anharmonicity of the atomic vibrations and the thermal expansion of the material. The factor involving B helps to represent the effects of anharmonicity and thermal expansion on the effective coupling of electronic motions to lattice vibrations, as well as the difference between ρ_i(nominal) and ρ_i. At high T, this factor provides for a quadratic term in the dependence of G_1 on T, which corresponds to the upward and downward curvature observed in many plots of intrinsic resistivity. Preliminary smoothed plots of intrinsic resistivity for 15 metals have been fitted by this function from around 50 K to near their melting temperatures, with rms fractional deviations ranging from 0.015 for Fe to 0.0024 for Li, some of this deviation being due to roughness in the preliminary plots.

When it is desired to include data from very low T in the synthesis, the form of G_1 may not be sufficiently flexible, since it always gives proportionality to T^5 in the limit of low T, whereas some scattering processes (such as carrier-carrier collision) may tend to introduce terms varying with T^n for n as small as 2. In such cases use has been made of the form

$$G_2(T) = A\left[1 + \frac{BT}{\theta - CT} + D\left(\frac{\theta - CT}{T}\right)^p\right]\Phi\left(\frac{\theta - CT}{T}\right), \quad (15)$$

where p and D are new constant parameters. If p is positive, the added term is dominant at sufficiently low temperatures, and the form approaches proportionality to $T^{(5-p)}$. The search for a satisfactory choice of p when making a least-squares-error fit to data has been carried out by performing calculations for a series of fixed values of p, with the other parameters optimized by the computer. A fairly careful determination of the optimum p to within about 0.1 is required if the fit is to be kept good at the lowest temperatures.

For smoothing at the lowest temperatures it may be sufficient to fit the data to a simple power law. Extrapolations to extreme low temperatures using a power law depend on the availability of data at temperatures so low that the effective power has become essentially constant. Figure 4 suggests that such temperatures may be very low indeed.

The functions G_1 and G_2 are useful in extrapolating high-temperature data to still higher temperatures, but marked deviations due to the rapid increase of vacancy concentration may appear well below the melting point.

It should be emphasized that this smoothing procedure does not depend on getting an accurate fit between the analytic function and the data: the deviations are smoothed, not neglected. Nor should special physical significance be attributed to the values of the parameters that appear in the fitted function, the character of which is suggested by empirical fact and mathematical convenience rather than fundamental theory.

In analyzing resistivity data for the molten metals it was sufficient to fit the best data to a linear form,

$$\rho = A + BT, \quad (16)$$

using the least-squares-error criterion.

3.4. Estimation of Uncertainty

The estimates of the uncertainty in the smoothed, recommended values of ρ_i were made with attention to each author's estimate of uncertainty for the data sets employed, to the differences between the data sets employed, and even to the differences between the data sets employed and other sets of data for the same material obtained by the same measurement methods when these other data sets appeared to be of reasonable quality. Consideration also had to be given to the accuracy of the thermal expansion data used in correcting ρ_i(nominal).

When a chosen ρ_0 was added to $\rho_i(T)$ to obtain a value of $\rho(T)$ according to Matthiessen's Rule, the addition was regarded as a formal change, and no increase was made in the estimated uncertainty in the recommended values of the total resistivity, i.e., the residual resistivity is considered to be exactly specified.

3.5. Types of Evaluated Data

Two types of evaluated data are presented in this work. When the estimated uncertainty is 5% or less, the term "recommended value" is, by CINDAS usage, applicable to the results; when it is greater than 5%, the term "provisional value" is applicable. Both of these terms are applicable to a well-characterized material.

4. Data and Numerical Results

In this section, which is the heart of the work, the recommended values of the temperature dependence of electrical resistivity for bulk pure copper, gold, palladium, and silver are presented together with the reasoning and information on which these values are based. Four subsections, each relating to one of the four elements, are preceded by this summary of matters relevant to all subsections.

Each subsection starts with a description of the element and some of its properties. The scope of the available information is next indicated, and the selection of material for use in arriving at the recommended values is discussed. Any special methods used in arriving at the recommended values are described, and the uncertainty ascribed to these values is indicated. The recommended values are then presented in tabular form. This is followed by a presentation of the full data extracted from the open literature. First, the greater part of the data is graphically displayed, together with the curve of recommended values. Information on the specimen characterization and measurement conditions for each set of data is provided in the Tables of Measurement Information. Finally, tables of the original numerical data, either as stated by the original authors or as extracted from their published graphs, are presented in the Tables of Experimental Data.

The data collected as potentially useful in this study and reported here are for samples with weight percentage of total impurities less than 0.50 and weight percentage of any single impurity less than 0.20. It thus includes some data on materials that were deliberately doped or alloyed with small amounts of another metal. As is indicated in the Introduction, coverage of the literature on dilute alloys is less complete than that for the purer samples for which coverage is believed to be essentially complete through 1976.

The reported data may consist of values for the "nominal" total resistivity as discussed in section 3 or of values corrected for thermal expansion of sample dimensions; if it is the latter, it is indicated in the Tables of Measurement Information. In a few cases, intrinsic resistivities indicated by ρ_i instead of the usual ρ have been reported.

The Tables of Recommended Values contain two columns for the solids, one for the total resistivity and the second for the intrinsic resistivity, both corrected for the change in geometry due to thermal expansion. The tables also contain recommended values for the molten metals.

The figures presenting the data are of two kinds. One is a log-log plot, which gives a better display for the low-temperature region; the linear-linear plot is better for the high-temperature region. In both figures the recommended values for the total electrical resistivity are shown by heavy lines. Lighter straight lines connect data points in a single data set. Each data set is labeled with its number in the Tables of Measurement Information and Experimental Data. The data set numbers are enclosed in squares if the set consists of a single point; otherwise circles are used. When data points would be too close together on the figures to be distinguishable, some are omitted. Those entire data sets not shown on the figures are indicated by asterisks in the Table of Measurement Information and in the Table of Experimental Data. Other data points not plotted in both figures are indicated by asterisks to the right of the values in the Table of Experimental Data.

The Tables of Measurement Information contain for each data set the following information: the data set number, reference number, author's name (or names), year of publication, experimental method used for the measurement, temperature range covered by the data, name and specimen designation, and, finally, specimen characterization, measurement information, and pertinent remarks (column labeled "Composition, Specifications, and Remarks").

The experimental methods used are indicated by code letters as follows:

A dc Potentiometric Method
B dc Bridge Method
C ac Potentiometric Method
D ac Bridge Method
E Eddy Current Decay Method
I Induction Method
M Mutual Induction Method
P Van der Pauw Method
R Rotating Magnetic Field Method
S Self-Induction Method
T Transient (subsecond) Method
V Voltmeter and Ammeter Direct Reading Method

The symbol "→" used in the column headed "Method Used" means either that the method described by the author is not sufficient to assign a specific code letter or that the use of a code letter would not convey enough of the information reported in the document. For additional information and for references to the literature pertaining to methods of measuring electrical resistivity, refer to Appendix 1.

The column of the Tables of Measurement Information labeled "Composition, Specifications, and Remarks" contains the following information about the specimen and its measurement if it is available in the document containing the experimental data: purity or chemical composition, method of determining composition and associated inaccuracies, crystalline properties, specimen homogeneity, state, final shape and dimensions of the specimen, manufacturer and supplier of the material, method and procedure of fabrication of the material, heat and other treatments of the specimen before measurement (especially annealing), relevant physical properties such as density, concise description of a new experimental method, measuring environment, and special features of the apparatus or of the measuring technique. An additional remark includes an indication as to whether the data were corrected for the change in geometry due to thermal expansion; unless there was explicit evidence that this correction was carried out, it was assumed that, in accordance with standard practice, it was not. If the correction was carried out, it is noted what data on the thermal expansion were used, if that information is available in the document. If measurements on a sample were made for other than a monotonely increasing sequence of temperatures, this is noted.

When information on a specimen and its measurement has seemed inadequate, the data set has been given less weight in our analysis or omitted entirely.

The column labeled "Composition, Specifications, and Remarks" also includes a statement of whether the data as given were presented in numerical form in the paper or were extracted from a figure. In the latter case there is an indication of the error that may be introduced in this extraction, which involves computer digitization of settings on the figure that are reproducible to ±0.01 in. The estimated extraction error for data plotted on a linear scale is reported in the form $\pm(y)\times10^{-8}$ Ω m, while our data reported on a logarithmic scale the extraction error is reported as $\pm(z)\%$. The estimated extraction error is an important piece of information in making an evaluation of the data. In the few cases where no explicit statement is given as to the form in which the data appear in the original document, the data were extracted from a table.

Electrical resistivity is reported in different units in the literature. For uniformity, the reported data are converted to a standard unit, 10^{-8} Ω m. This unit is used in preference to the nΩ m of the International System of Units, because so much data in this field have been and are being reported in units of μΩ cm ($=10^{-8}$ Ω m). For a listing of the various conversion factors and their justification, see Appendix 2.

Abbreviations used in the Composition, Specifications, and Remarks Column of the Tables of Measurement Information come from the following List:

Abbreviation	Meaning
ac	alternating current
approx	approximately
at.%	atomic percent
Co.	company
coeff	coefficient
comp	composition
dc	direct current
diam	diameter
DPH	diamond pyramid hardness
emf	electromotive force
fcc	face-centered cubic
Inc.	Incorporated
lab.	laboratory
Ltd.	Limited
max	maximum
min	minimum
mp	melting point
no.	number
p.	page
pp.	pages
ppm	parts per million
wt%	weight percent
x	by
%	percent
5N	99.999%
6N	99.9999%

Some authors report the same data in different publications such as, first, in the proceedings of a conference and, later, in a journal. These data would be treated as the same data. If, however, there is doubt as to whether data in one document and data in another do in fact represent the same data, the data sets are presented as distinct.

This introduction to the data and numerical results concludes with table 1 that brings together values of some properties of the four metals considered in this work.

TABLE 1. Physical characteristics of copper, gold, palladium, and silver[a]

Element (chemical symbol)	Atomic number	Relative[b] atomic mass	Density,[c] Mg m^{-3}	Crystal structure	Debye[d] temperature, K at 0 K	Debye[d] temperature, K at 298 K	Melting point, K	Normal boiling point, K
Copper (Cu)	29	63.546	8.933	fcc	342±2	320	1357.6	2840
Gold (Au)	79	196.9665	18.88	fcc	165±1	178±8	1337.58	3135
Palladium (Pd)	46	106.4	12.02	fcc	283±16	275	1827	3243
Silver (Ag)	47	107.868	10.492	fcc	228±3	221	1235.08	2440

[a] Information taken from Touloukian, Kirby, Taylor, and Desai [228, pp. 39a, 41a. 42a] unless otherwise stated.
[b] Relative atomic masses are based on $^{12}C=12$ as adopted by the International Union of Pure and Appied Chemistry in 1971. Applies to material of terrestrial origin.
[c] Density values given for 293.2 K.
[d] From Gschneidner [209, table XV] as obtained from specific heat data.

4.1. Copper

Copper is a reddish metal. It has an atomic number of 29, a relative atomic mass of 63.546 (see table 1), and is the first element in subgroup IB of the periodic table. There are two stable naturally-occurring isotopes; one with mass number 63 has a natural abundance of 69.09%, and the other with mass number 65 has a natural abundance of 30.91% [232, p. B-286]. The crystal structure is face-centered cubic. Copper has a melting point of 1357.6 K and a normal boiling point of 2840 K [228, p. 39a]. It has a density of 8.933 Mg m^{-3} at 293.2 K [228, p. 39a]. At 300 K it has a thermal conductivity of 4.01×10^{2} W m^{-1} K^{-1} for well-annealed high-purity material [211, p. I-243]. At 293 K it has a coefficient of thermal linear expansion of 16.5×10^{-6} K^{-1} [228, p. 77]. Copper has a latent heat of fusion of 13.05 kJ mol^{-1} [214, p. 227]. High-purity copper, 99.999^{+}% pure, is available commercially.

There are 290 sets of experimental data reported in this work for the temperature dependence of the electrical resistivity of copper. Information pertaining to the specimen characterization, measurement conditions, and method of data extraction for each of the data sets is given in table 3. The data themselves are tabulated in table 4. The data are shown in figures 5 and 6; the former figure has logarithmic scales, which highlight the low-temperature region, and the latter figure has both scales linear, which emphasize the high-temperature region. Data for the electrical resistivity exist over the temperature range from 0.035 K to 2275 K.

Among the data sets for the electrical resistivity of solid copper there are many sets obtained before 1940. The earliest measurement found, reported in 1881, is the work of Lorenz [39] (data set 162) who took data at 273 K and 373 K. Other measurements up to 1940 include the 1900 report of Jaeger and Diesselhorst [27] (data sets 134–7) who made measurements at 291 K and 373 K, the 1908 report of Niccolai [52] (data set 188) who made measurements on pure material from 84 K to 673 K, the 1914 report of Northrup [53] (data sets 62–4) whose data went from room temperature to well above the melting point, the 1918 report of Tsutsumi [83] (data sets 194,195) who also took measurements well above the melting point, and the 1927 report of Grüneisen and Goens [21] (data sets 6–20) who performed measurements on numerous copper specimens from 21.2 K to 273.2 K.

There are several noteworthy measurements at intermediate or high temperatures in the solid state. Laubitz [34, 35] (data sets 36–8) in 1966 and 1967 reported measurements on annealed 99.999^{+}% pure copper from 273 K to 1272 K. Also in 1967, Moore et al. [48] (data set 35) reported measurements on 99.999% pure copper from 85 K to 375 K, with the data reported as smoothed values in tabular form. The sample was from the same batch as that measured by Laubitz. In 1970 Ascoli et al. [2] (data set 140) reported measurements on well-annealed 99.999^{+}% pure copper from 575 K to 1328 K. The data were corrected for thermal expansion, and data for a typical sample were extracted from a figure.

There is a good deal of disagreement as to the behavior of ρ_i at very low temperatures. In 1959 White and Woods [91] (data set 124) reported measurements on vacuum-annealed 99.999% pure copper from 15 K to 295 K. They reported smoothed data of intrinsic resistivity in tabular form and found a $T^{5.1}$ dependence for the intrinsic resistivity for $T>10$ K [91, p. 286]. In 1968 Schriempf [72] (data sets 80–2) reported measurements on 99.999% pure material from a low of 6.7 K to 297 K. He pointed out, "The observed temperature dependence of the electrical resistivity is approximately $T^{4.6}$ for all three specimens at temperatures from about 5° to 20 °K." [72, p. 251]. Lengeler et al. [37] (data set 266) in 1970 reported measurements on high-purity copper in the range 1.7 K to 324 K. They found that the intrinsic resistivity of pure copper between 10 K and 35 K followed a $T^{4.9\pm0.2}$ relation [37, p. 67]. In 1976 Rumbo [66] (data sets 184–7) reported measurements on very pure copper below 8.5 K. He indicated a "...change in the slope of $\rho_i(T)$ ... near 4 K for Cu, ... from approximately $T^{3.5}$ at higher temperatures to $T^{2.8}$ (Cu) ... at lower temperatures." [66, p. 90]. In 1974 Teixeira [82] (data sets 268–70) reported measurements on 99.999% pure copper from 1.3 to 299 K. He indicated that for all cases at low temperatures there was a temperature dependence slightly stronger than T^{5} [82, p. 20]. In a 1976 paper discussing that work, Haen et al. stated, "Below 20 K and down to 8 K our data fit a T^{5} law." [23, p. 197]. In 1977 Moussouros and Kos [49] (data sets 280, 282–4, 286, 287) reported measurements on several pure copper specimens and found that between temperatures of 4.2 K and 6.8 K the temperature dependent resistivity followed T^{k} with k from 3.3 to 3.75, between temperatures of 6.8 K and 11.7 K, k was from 3.86 to 4.12, and between temperatures of 11.7 K to 34 K, k was from 4.40 to 4.84. These disagreements probably arise from problems in sample control, the formal difficulty of separating out the residual resistivity, and the general applicability of Matthiessen's Rule for all impurities.

Our evaluated data for the electrical resistivity of pure bulk copper in the solid state were primarily based on the data of Laubitz [34, 35] (data set 36), Moore et al. [48] (data set 35), and White and Woods [91] (data set 124). One reason for selecting these data sets is the fact that the measurements are for pure specimens of comparable purity with specimen characterization and conditions of the measurements well stated. Data for specimens that were not pure were excluded from being the basis of the evaluated data. Abnormal values were also excluded, an example of this being the unusually high values of Hudson [25] (data sets 87–93).

In order to match and smooth the data sets, a preliminary fit to the data, reduced to nominal intrinsic resistivity, was made using eq (12). The error in the fit began to increase below 80 K, indicating the inadequacy of that form. A fit to the form of eq (15) was quite successful, an rms fractional deviation of 0.0023 being found with $p=1.84$, $A=1.8089\times10^{-8}$ Ω m, $B=-5.9991\times10^{-3}$, $C=0.04563$, $D=-6.4760\times10^{-4}$, and $\theta=310.8$ K. A plot of the fractional deviations against temperature was smoothed, and the result added to eq (15) to obtain smoothed data from 50 K to 1200 K. Below 50 K, a plot of ρ_i(nominal)/$T^{5.1}$ was utilized to check and improve smoothness. Above 1200 K, values of

ρ_i(nominal) were determined by graphical extrapolation using a plot of ρ_i(nominal)/T against T. Finally, the thermal expansion correction was applied to ρ_i(nominal) using eq (11) together with the CINDAS recommended values for $\Delta\ell(T)/\ell(293 \text{ K})$ [228, p. 77]. Values of the thermal linear expansion from 1300 K to the melting point were found by graphically extrapolating the CINDAS values. A residual resistivity of 0.00200×10^{-8} Ω m was added to ρ_i to obtain the reported total resistivity. This value of residual resistivity is representative of the residual resistivities of the data used in developing the recommended values.

An estimate of the uncertainty in our recommendations was arrived at by applying the general ideas mentioned in subsection 3.4. In particular, estimates of the experimental uncertainties made by Laubitz, by Moore et al., and by White and Woods were supplemented by comparison of the results with the high-temperature data of Ascoli et al. [2] (data set 140) and the low-temperature data of Lengeler et al. [37] (data set 266) and of Teixeira et al. [82] (data set 268). A check was made to determine whether deviations from Matthiessen's Rule could be expected to be important in copper. For the residual resistivity of 0.00200×10^{-8} Ω m used here, the plots in Cimberle et al. [199, p. 647, figure 3.1] indicate no deviation from Matthiessen's Rule down to 15.7 K. Over the whole temperature range in the solid state, the analyzed values of total resistivity qualify as recommended values, according to CINDAS usage.

Sixteen of the data sets reported here contain data on copper in the liquid state. Most of the data agree reasonably well, falling into an essentially linear band of width about 1×10^{-8} Ω m. Two other data sets lie considerably higher, and two are definitely lower; three of these four sets suggest a marked nonlinearity in the dependence of ρ on T. As the best estimate for pure copper we have chosen values that vary linearly with T and lie toward the bottom of the band in which most data lie. The data points of Roll and Motz [64] (data set 178) were fitted by a straight line using a least squares criterion to get

$$\rho = 21.01 + 0.009929\ (T - 1357.6) \qquad (17)$$

(T in K, ρ in 10^{-8} Ω m). Reasons for selecting the data of Roll and Motz include the fact that more modern measurements are expected to have better sample control, an explicit statement was made that the thermal expansion correction was carried out, and error estimates were given. In view of the spread in the values reported by different authors, we have estimated the uncertainty in the tabulated values to be in the range of 5 to 6%, which is considerably higher than the experimental uncertainties estimated by individual workers. These values should be regarded as provisional.

The recommended values for the temperature dependence of the electrical resistivity of copper are tabulated in table 2. The values for the solid and liquid states are corrected for thermal expansion. The values tabulated are for the total resistivity. In addition, intrinsic resistivity values are given for the solid state. The recommended values for the total resistivity are shown in figures 5 and 6. The values for the total resistivity of the solid apply to annealed 99.999% pure or purer bulk copper and the values below 55 K are applicable to a sample obeying Matthiessen's Rule with a residual resistivity of 0.00200×10^{-8} Ω m. (The criterion for the selection of 55 K is that, at this temperature or above, the percentage error in using the intrinsic resistivity instead of the total resistivity, or vice versa, is within the uncertainty in the total resistivity given below.) The values for the intrinsic resistivity apply to pure copper with various impurity concentrations and residual resistivities. Values for the total resistivity of samples other than one with a residual resistivity of 0.00200×10^{-8} Ω m can be obtained by adding the residual resistivity of the particular sample to the intrinsic resistivity. For the liquid state, the values apply to 99.99% pure or purer copper. The uncertainty in the recommended values for the total electrical resistivity is negligible below 10 K, 3% above 10 K to 100 K, 1% above 100 K to 250 K, 0.5% above 250 K to 350 K, 1% above 350 K to 500 K, and 4% above 500 K to the melting point. There is negligible uncertainty below 10 K, because, in determining the uncertainty in the total resistivity, the residual resistivity is considered to be exactly specified. The percentage uncertainty in the intrinsic resistivity is the same as that for the total resistivity down to 40 K. It increases to 4% at 30 K, 5% at 25 K, and 10% at 20 K. Values for the intrinsic resistivity below 20 K are not given in table 2 because of the large uncertainty. For the liquid state, the uncertainty is 5 to 6% from the melting point to 1700 K. The values in the table have been given beyond the physically significant figures and for values in the solid state permit linear interpolation of log ρ_i versus log T and log ρ versus log T. The maximum error introduced solely by linear interpolation of log ρ_i versus log T compared to the correct values is less than 0.1% from 200 K to the melting point of 1357.6 K, but increases at lower temperatures; it is less than 0.25% from 175 K to just below 200 K, less than 0.5% from 125 K to just below 175 K, less than 0.8% from 80 K to just below 125 K, less than 1.5% from 40 K to just below 80 K, and less than 1% from 20 K to just below 40 K. The maximum error introduced solely by linear interpolation of log ρ versus log T compared to the correct values is less than 0.1% from 200 K to the melting point of 1357.6 K, but increases at lower temperatures; it is less than 0.25% from 175 K to just below 200 K, less than 0.5% from 125 K to just below 175 K, less than 0.8% from 80 K to just below 125 K, less than 1% from 30 K to just below 80 K, less than 4% from 10 K to just below 30 K, less than 0.25% from 7 K to just below 10 K, and a negligible percentage error from 1 K to just below 7 K. For the liquid state, the determination of values between those given in the table can be done by using eq (17).

TABLE 2. RECOMMENDED VALUES FOR THE ELECTRICAL RESISTIVITY OF COPPER

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

Solid

T	ρ_i [a, b]	ρ [a, c]	T	ρ_i [a, b]	ρ [a, c]
1		0.00200	175	0.872	0.874
4		0.00200	200	1.044	1.046
7		0.00200	225	1.215	1.217
10		0.00202	250	1.385	1.387
15		0.00218	273.15	1.541	1.543
20	0.000798*	0.00280	293	1.676	1.678
25	0.00249*	0.00449	300	1.723	1.725
30	0.00628	0.00828	350	2.061	2.063
35	0.0127	0.0147	400	2.400	2.402
40	0.0219	0.0239	500	3.088	3.090
45	0.0338	0.0358	600	3.790	3.792
50	0.0498	0.0518	700	4.512	4.514
55	0.0707	0.0727	800	5.260	5.262
60	0.0951	0.0971	900	6.039	6.041
70	0.152	0.154	1000	6.856	6.858
80	0.213	0.215	1100	7.715	7.717
90	0.279	0.281	1200	8.624	8.626
100	0.346	0.348	1300	9.590	9.592
125	0.520	0.522	1357.6	10.169	10.171
150	0.697	0.699			

Liquid

T	ρ [a, d]
1357.6	21.01*
1400	21.43*
1500	22.42*
1600	23.42*
1700	24.41*

[a] The values are corrected for thermal expansion. See text for the uncertainty of the values. See text for an indication of the determination of values between those given in this table (interpolation scheme in the solid state, equation in the liquid state).

[b] Values for the intrinsic resistivity are not given below 20 K because of the large uncertainty.

[c] In the solid state, the values for the total electrical resistivity apply to annealed 99.999% pure or purer bulk copper and the values below 55 K are applicable to a sample obeying Matthiessen's Rule with a residual resistivity of 0.00200 x 10^{-8} Ωm.

[d] In the liquid state, the values apply to 99.99% pure or purer copper.

* Provisional values.

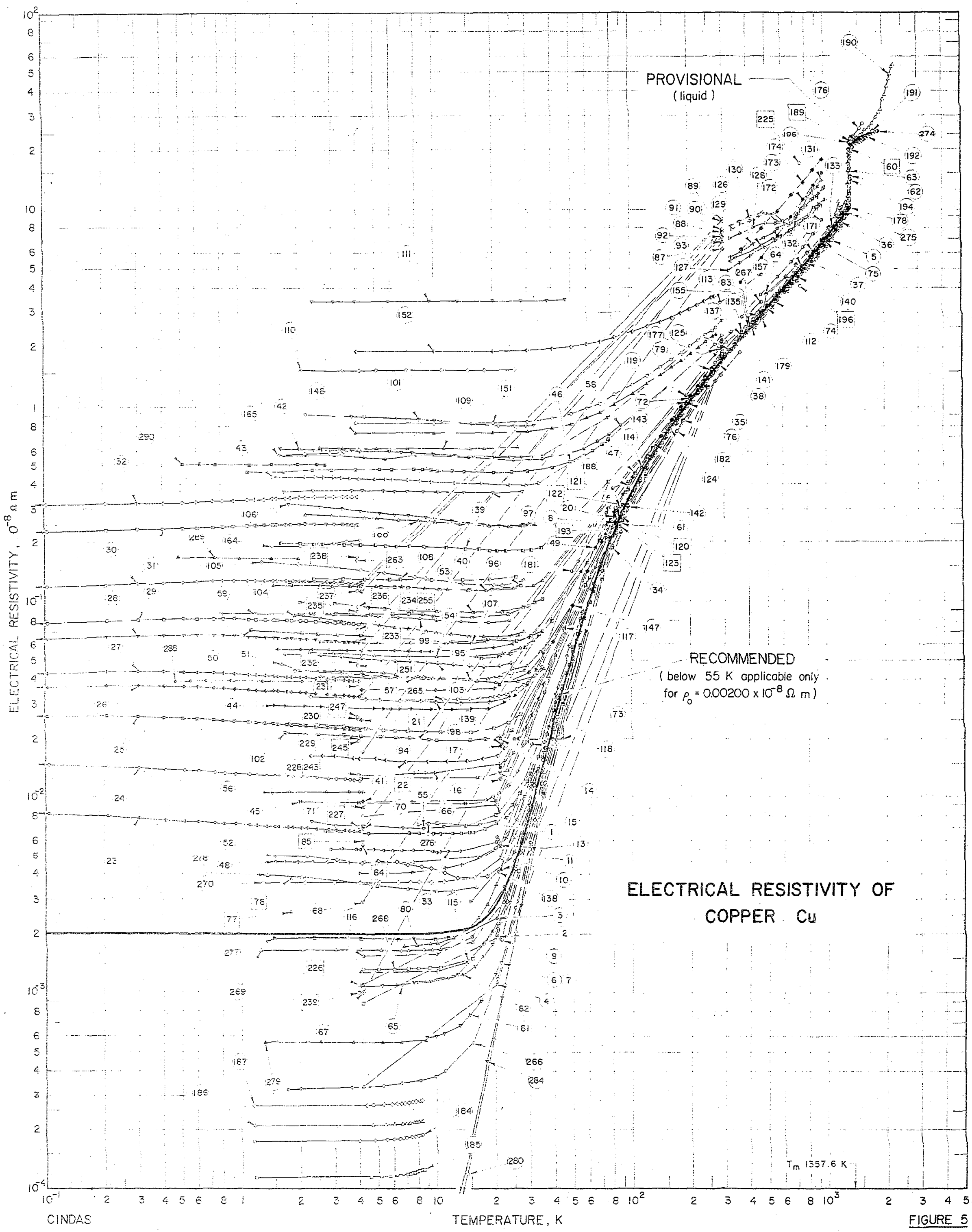
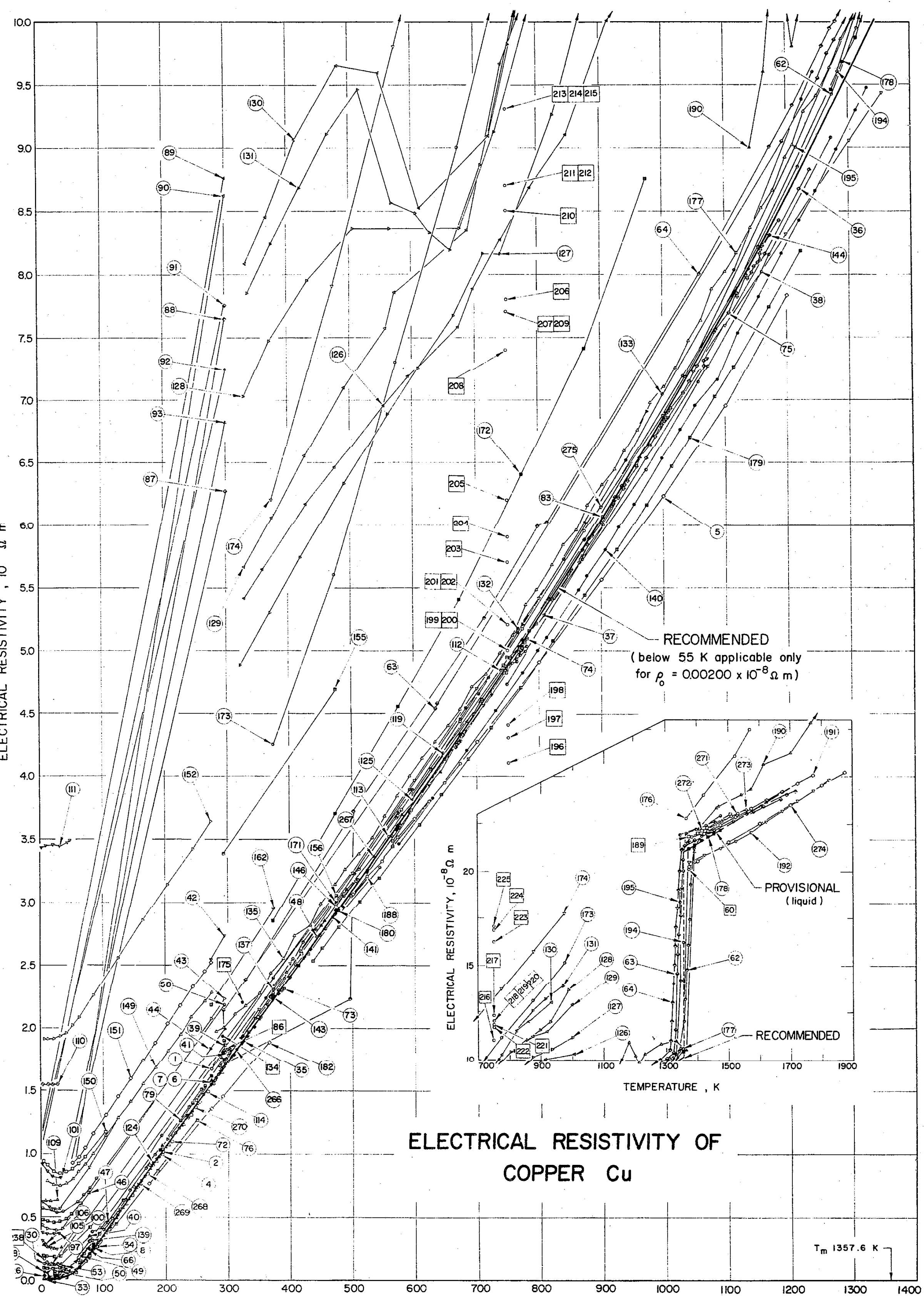

PROVISIONAL
(liquid)
RECOMMENDED
(below 55 K applicable only for ρ_0 = 0.00200 x 10^{-8} Ω m)
ELECTRICAL RESISTIVITY OF COPPER Cu
T_m 1357.6 K
ELECTRICAL RESISTIVITY, 10^{-8} Ω m
TEMPERATURE, K
CINDAS

FIGURE 5



CINDAS FIGURE 6

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	56	Pawlek, F. and Rogalla, D.	1966	→	4-298	Cu 01	0.0124 Fe, 0.00124 Ni, 0.00102 Ag, 0.00102 Sb, 0.00027 Mn, 0.00011 As, 0.0001 Bi, 0.00008 Co, 0.00007 Cr, and 0.00007 Se; specimen 2 mm diam wire; derived from a section of a bar of unknown origin; annealed 1 h in argon at 873 K cooling rate < 50 Kh^{-1}; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 202$, $\rho(293\ K)/\rho(20.4\ K) = 176$; potential drop measurements made with very sensitive voltmeter; data extracted from table.
2	56	Pawlek, F. and Rogalla, D.	1966	→	4-298	Cu 0	0.0056 Ag, < 0.00009 Fe, < 0.000009 Mn, < 0.000009 Ni, and < 0.000008 Cr; specimen 2 mm diam wire; supplied by Elmore Metall AG, Schladern/Sieg double electrolytically refined; used as received and drawn into wire; annealed 1 h in argon at 873 K, cooling rate < 50 Kh^{-1}; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 1810$, $\rho(293\ K)/\rho(20.4\ K) = 901$; potential drop measurements made with very sensitive voltmeter; data extracted from table.
3	56	Pawlek, F. and Rogalla, D.	1966	→	4-298	Cu 0000	0.00102 Ag, < 0.00009 Fe, < 0.00006 Cr, and < 0.000009 Mn; specimen 2 mm diam wire; supplied by Elmore Metall. AG, Schladern/Sieg; double electrolytically refined and material remelted in an electron beam furnace; annealed 1 h in argon at 873 K, cooling rate < 50 Kh^{-1}; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 1430$, $\rho(293\ K)/\rho(20.4\ K) = 771$; potential drop measurements made with very sensitive voltmeter; data extracted from table.
4	56	Pawlek, F. and Rogalla, D.	1966	→	4-298	Cu 9.5	0.00031 Ag, < 0.00009 Fe, 0.00008 Mn, and < 0.00006 Cr; specimen 2 mm diam wire; supplied by Elmore Metall AG, Schladern/Sieg; double electrolytically refined and material remelted by ten passes of zone refining in a graphite boat; annealed 1 h in argon at 873 K, cooling rate < 50 Kh^{-1}; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 4710$, $\rho(293\ K)/\rho(20.4\ K) = 1550$; potential drop measurements made with very sensitive voltmeter; data extracted from table.
5	59	Radenac, A., Lacoste, M., and Roux, C.	1970	R	300-1200		0.0005 Ag, 0.0001 Fe, and 0.0001 Mg; specimen dimensions 4 mm in diam and 3 mm high; data extracted from table.
6	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 1	Very pure; natural crystal from Lake Michigan, the crystal previously investigated by R. Schott; turned on lathe; tempered at 653 K; data extracted from table.
7	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 2	Very pure; porous natural crystal from Lake Superior; turned on lathe; tempered at 653 K; data extracted from table.
8	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 2a	Piece of the previous crystal; hammered from 3 mm to 1.3 mm diam; data from table.
9	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 2b	Identical with specimen copper 2a, however, tempered 3 h at 653 K; data from table.
10	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 3	Purest electrolytic copper; fine grains; data extracted from table.
11	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 4	Purest electrolytic copper; fine grains; origin S and H; not heat treated.
12*	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 4a	Identical with specimen copper 4 except tempered 4.5 h at 653 K; data from table.
13	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 4b	Rod, hammered from above specimen copper 4, tempered 4.5 h at 653 K, and then recrystallized at 1223 K for 5 min; data extracted from table.
14	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 6	Not very pure; single crystal; origin S and H; sawed from a larger block and lathed into rod; data extracted from table.
15	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 6a	Identical with specimen copper 6 but annealed for 7.5 h at 653 K; data from table.
16	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 6b	Lathed from the same block as above specimen copper 6; hammered from 6 mm to 2.5 mm diam and annealed for 3 h at 653 K; data extracted from table.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
17	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 6c	Treated as above sample 6b after that annealed 5 min at 1223 K in vacuum; about 25 grain cross-sections per 1 mm^2; data extracted from table.
18*	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 7	Lathed from the same block as above specimen copper 6; 3 to 4 crystal grains on the gauge length; untempered; data extracted from table.
19*	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 7a	Identical with above sample copper 7, however tempered 4 h at 653 K.
20	21	Grüneisen, E. and Goens, E.	1927		21.2-273.2	Copper 9	Not very pure; single crystal solidified from melt; source S and H; completely undeformed and unworked; data extracted from table.
21	16	Fevrier, A. and Morize, D.	1973		4.2	Copper I	Wire specimen; data extracted from text.
22	16	Fevrier, A. and Morize, D.	1973		4.2	Copper II	Wire specimen; data extracted from text.
23	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.000908 Mn; wire sample 0.3 mm diam; drawn; annealed; an ac method used for the measurements; original data in tabular form supplied by author.
24	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.00219 Mn; wire sample 0.3 mm diam; drawn; annealed; an ac method used for the measurements; original data in tabular form supplied by author.
25	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.00413 Mn; wire sample 0.3 mm diam; drawn; annealed; an ac method used for the measurements; original data in tabular form supplied by author.
26	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.0063 Mn; wire sample 0.3 mm diam; drawn; annealed; an ac method used for the measurements; original data in tabular form supplied by author.
27	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.00826 Mn; wire sample 0.3 mm diam; drawn; annealed; an ac method used for the measurements; original data in tabular form supplied by author.
28	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.01336 Mn; wire sample 0.3 mm diam; drawn; annealed; an ac method used for the measurements; original data in tabular form supplied by author.
29	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.0170 Mn; wire sample 0.3 mm diam; drawn; annealed; an ac method used for the measurements; original data in tabular form supplied by author.
30	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.0284 Mn; wire sample 0.3 mm diam; drawn; annealed; an ac method used for the measurements; original data in tabular form supplied by author.
31	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.0574 Mn; wire sample 0.3 mm diam; drawn; an ac method used for the measurements; original data in tabular form supplied by author.
32	33	Laborde, O. and Radhakrishna, P.	1973	→	0.03-4		0.0827 Mn; wire sample 0.3 mm diam; drawn; an ac method used for the measurements; original data in tabular form supplied by author.
33	6	Berman, R. and MacDonald, D.K.C.	1952		3-21		About 0.0005 Ag, < 0.0004 Pb, and < 0.0003 Ni; wire specimen ~ 1 mm diam; rod (lab. no. 4234) from Johnson, Matthey and Co. Ltd.; drawn; annealed 6 h at 723 K in helium; data points extracted from figure.
34	6	Berman, R. and MacDonald, D.K.C.	1952		2-90		About 0.0005 Ag, < 0.0004 Pb, and < 0.0003 Ni; wire specimen ~ 0.5 mm diam, length considerably longer than specimen immediately above; rod (lab. no. 4234) from Johnson, Matthey and Co. Ltd.; annealed 6 h at 723 K in helium; data points extracted from figure.
35	48	Moore, J.P., McElroy, D.L., and Graves, R.S.	1967	A	85-375		99.999 pure; polycrystalline, free of voids and inclusions, average grain size 574 μ; rod specimen; supplied by Dr. M.J. Laubitz of National Research Council, Ottawa, Canada; hardness, DPH = 40 with load of 0.100 kg; residual resistivity ratio $\rho(273.16)/\rho(4.2) = 9.0 \times 10^2$; guarded longitudinal apparatus used; tabular data presented as smoothed values, uncorrected for thermal expansion; most probable error ± 0.38%.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
36	34, 35	Laubitz, M.J.	1966, 1967	A	278-1238	Main Specimen	99.999+ pure, <0.00005 Ag, <0.00005 Cr, 0.000035 Fe, and <0.00003 Mg; supplied by American Smelting and Refining Co.; cylindrical specimen 1.9 cm diam and 20 cm long; machined from a 2.5 cm (1 in) diam and 38.1 cm (15 in) long bar; annealed after assembly for 2 h at 700 K; density 3.943 ± 0.001 g cm^{-3} at 291 K; residual resistance ratio (measured after the experiment) of 900; measurements performed in argon atmosphere, pressure 10-25 cm Hg; original data in tabular form supplied by author, uncorrected for thermal expansion; Peltier effect eliminated by trial and error reversals; estimated absolute error in measurements varies from ±0.12% at 300 K to ±0.7% at 1200 K.
37	34, 35	Laubitz, M.J.	1966, 1967	A	285-1072	Main Specimen	Same as above specimen; original data in tabular form supplied by author, uncorrected for thermal expansion, Peltier effect corrected for.
38	34, 35	Laubitz, M.J.	1966, 1967	A	273-1272	Small Specimen	99.999+ pure, <0.00005 Ag, <0.00005 Cr, 0.000035 Fe, and <0.00003 Mg; supplied by American Smelting and Refining Co.; cylindrical specimens 0.16 cm diam, two rods drawn from same lot of copper as above specimen; residual resistance ratio for 2 rods 980-1240, depended on state of anneal (not specified in paper); room temperature resistivity measured in argon, at all higher temperatures in vacuum; copper potential probes used; original data in tabular form supplied by author; estimated absolute error in measurements varies from ±0.2% at 300 K to ±1.1% at 1200 K.
39	74	Sharma, R.G. and Chari, M.S.R.	1973	A	1.6-295	Cu-Fe(115) UA	0.0114 Fe (spectrographic analysis); cylindrical specimen about 1 mm in diam and about 6 cm long; rolled and drawn, etched in nitric acid and washed; unannealed; original data in tabular form for T = 1.631 to 34.820 K supplied by author.
40	74	Sharma, R.G. and Chari, M.S.R.	1973	A	1.5-295	Cu-Fe(115) PA	0.0110 Fe (spectrographic analysis); cylindrical specimen about 1 mm in diam and about 6 cm long; rolled and drawn, etched in nitric acid and washed; annealed between 803-823 K under fore-vacuum for 16 h; original data in tabular form for T = 1.488 to 35.020 K supplied by author.
41	74	Sharma, R.G. and Chari, M.S.R.	1973	A	2.3-295	Cu-Fe(115) LA	0.0101 Fe (spectrographic analysis); cylindrical specimen about 1 mm in diam and about 6 cm long; rolled and drawn, etched in nitric acid and washed; annealed between 803-823 K under fore-vacuum for 66 h; original data in tabular form for T = 2.2958 to 35.875 K supplied by author.
42	74	Sharma, R.G. and Chari, M.S.R.	1973	A	1.6-295	Cu-Fe(380) UA	0.0294 Fe (spectrographic analysis); cylindrical specimen about 1 mm in diam and about 6 cm long; rolled and drawn, etched in nitric acid and washed; unannealed; original data in tabular form for T = 1.631 to 35.925 K supplied by author.
43	74	Sharma, R.G. and Chari, M.S.R.	1973	A	1.5-295	Cu-Fe(380) PA	0.0276 Fe (spectrographic analysis); cylindrical specimen about 1 mm in diam and about 6 cm long; rolled and drawn, etched in nitric acid and washed; annealed between 803-823 K under fore-vacuum for 16 h; original data in tabular form for T = 1.488 to 34.080 K supplied by author.
44	74	Sharma, R.G. and Chari, M.S.R.	1973	A	1.5-295	Cu-Fe(380) LA	0.0241 Fe (spectrographic analysis); cylindrical specimen about 1 mm in diam and about 6 cm long; rolled and drawn etched in nitric acid and washed; annealed between 803-823 K under fore-vacuum for 66 h; original data in tabular form for T = 1.5003 to 35.700 K supplied by author.
45	20	Gerritsen, A.N. and Linde, J.O.	1952		2-273		Wire specimen 0.2 mm diam and about 0.3 cm long; annealed 3 h at 723 K, then cut to about 3 cm length, potential lead welded, annealed in helium gas atmosphere for 48 h at 573 or 773 K; residual resistance ratio R(273 K)/R(4 K) = 172; during measurements samples in immediate contact with liquid in cryostat; data extracted from table.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
46	70	Schmitt, R.W. and Jacobs, I.S.	1956		1.1-77.2		Approx 0.172 Mn; data extracted from figure.
47	88	White, G.K.	1953	B	17-192	Cu I	99.999 Cu, about 0.0005 Ag, < 0.0003 Ni, about 0.0004 Pb, and spectral lines barely visible for Ga and Fe; wire specimen about 300 cm long; Johnson, Matthey and Co. Ltd., JM 4272; 40 S.W.G. wire drawn by Garrett, Davidson, and Matthey Pty. Ltd., wire specimen loosely wound on mica cross in copper enclosure containing a small pressure of helium gas; data of ideal resistivity extracted from figure, $\rho = \rho_0 + \rho_i$, $\rho_0 = 0.0510 \times 10^{-8}$ Ω m; reported error 0.05%.
48	88	White, G.K.	1953	B	1.5-185	Cu II	Cu I specimen after annealed at 823 K for 3 h in vacuum; data of ideal resistivity above 10 K and of resistivity below 10 K extracted from figure, above 10 K $\rho = \rho_0 + \rho_i$ where $\rho_0 = 0.00458 \times 10^{-8}$ Ω m; reported error 0.05%.
49	88	White, G.K.	1953	B	1.5-91	Cu III	Similar to Cu I; data of ideal resistivity above 10 K and of resistivity below 10 K extracted from figure, above 10 K $\rho = \rho_0 + \rho_i$ where $\rho_0 = 0.0576 \times 10^{-8}$ Ω m; reported error 0.05%.
50	75	Sharma, R.G. and Chari, M.S.R.	1974	A	1.1-36		0.00261 Cr; wire specimen about 1 mm in diam; ingots received from Dr. Steyert of Los Alamos Laboratory; drawn through dies into wire; unannealed; original data in tabular form supplied by author.
51	75	Sharma, R.G. and Chari, M.S.R.	1974	A	1.6-36		Specimen from the same wire as the above specimen; partially annealed in forepump vacuum at 803-823 K for 16 h; original data in tabular form supplied by author.
52	75	Sharma, R.G. and Chari, M.S.R.	1974	A	1.5-36		Specimen from the same wire as the above specimen; long annealed in forepump vacuum at 803-823 K for 66 h; original data in tabular form supplied by author.
53	75	Sharma, R.G. and Chari, M.S.R.	1974	A	2.0-35		0.00408 Cr; wire specimen about 1 mm in diam; ingots received from Dr. Steyert of Los Alamos Laboratory; drawn through dies into wire; unannealed; original data in tabular form supplied by author.
54	75	Sharma, R.G. and Chari, M.S.R.	1974	A	2.3-32		Specimen from the same wire as the above specimen; partially annealed in forepump vacuum at 803-823 K for 16 h; original data in tabular form supplied by author.
55	75	Sharma, R.G. and Chari, M.S.R.	1974	A	2.3-35		Specimen from the same wire as the above specimen; long annealed in forepump vacuum at 803-823 K for 66 h; original data in tabular form supplied by author.
56	3	Baird, D.C. and Boyle, W.S.	1953	→	1.5-4.2		99.999 Cu; sample approx 2 mm thick formed into ring 4 cm in diam; Johnson and Matthey H.S. brand; annealed; resistivity determined from decay of single induced current pulse; data extracted from figure.
57	90	White, G.K. and Woods, S.B.	1955	A	1.8-295		0.0043 Fe; rod specimen 1 to 2 mm in diam and 6 cm long; drawn from homogenized alloy and annealed; data from figure; reported error < 1%.
58	90	White, G.K. and Woods, S.B.	1955	A	1.7-295		0.056 Fe; rod specimen 1 to 2 mm in diam and 6 cm long; drawn from homogenized alloy and annealed; data from figure; reported error < 1%.
59	90	White, G.K. and Woods, S.B.	1955	A	0.8-295		0.02 Ge; rod specimen 1 to 2 mm in diam and 6 cm long; drawn from homogenized alloy and annealed; data from figure; reported error < 1%.
60	81	Takeuchi, S., Suzuki, K., Misawa, M., Ito, F., and Murakami, K.	1973		1373		Liquid state; data from figure.
61	89	White, G.K. and Tainsh, R.J.	1960		90, 294		< 0.002 each of As and Te and < 0.001 each of Fe, Sb, and Se; wire specimen 0.076 cm (0.030 in) in diam; 1.90 cm (0.75 in) diam rod from American Smelting and Refining Co., rolled, drawn, and annealed at 830 K in vacuo for some hr, residual resistivity = 0.87×10^{-9} Ω cm; data extracted from text.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (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	53	Northrup, E. F.	1914	B	293-1416		Measurements made with rising temperature; measurement of resistivity at 293 K made by an independent determination; reported error < 0.5%.
63	53	Northrup, E. F.	1914	B	293-1667		Specimen from different lot as above specimen; melting point 1355.8 ± 0.8 K; only measurements made with falling temperatures recorded here; measurement of resistivity at 293 K made by an independent determination; reported error < 0.5%.
64	53	Northrup, E. F.	1914	B	293-1716		Copper from same lot as used in above specimen; melting point 1355 ± 0.8 K; only measurements made with falling temperature recorded here; measurement of resistivity at 293 K made by an independent determination; reported error < 0.5%.
65	57	Powell, R.L., Roder, H.M., and Hall, W.J.	1959		4.1-76	Sample 1	99.999 pure; supplied by Central Research Laboratories of the American Smelting and Refining Co.; cleaned with 1:1 solution of HNO_3 before any fabrication; swaged from approx 0.95 cm (approx 0.375 in) diam rod to approx 0.18 cm (approx 0.072 in); annealed in vacuum for 2 h at 673 K; drawn through tungsten dies to 0.18 cm (0.070 in); cleaned with acids; annealed in vacuum at 673 K for 2 h; data from figure.
66	57	Powell, R. L., et al.	1959		4.1-83	Sample 2	Specimen from adjacent segment of same rod as above specimen; cleaned with 1:1 solution of HNO_3 before any fabrication; swaged to approx 0.0816 in, cleaned with acids, annealed in vacuum for 2 h at 673 K, drawn through tungsten carbide dies to 0.18 cm (0.070 in), i.e., cross-sectional area reduced by 26.4%, not annealed after area reduction; data from figure.
67	57	Powell, R. L., et al.	1959	A	4.2, 273	Sample 3	Specimen from adjacent segment of same rod as above specimen; same treatment as sample 1.
68	57	Powell, R. L., et al.	1959	A	4.2, 273	Sample 3	The above specimen, cold-drawn through tungsten carbide die to a reduction in area of 2.2%, not annealed after reduction in area.
69*	57	Powell, R. L., et al.	1959	A	4.2, 273	Sample 3	The above specimen, cold-drawn through tungsten carbide die to a reduction in area of 4.97%, not annealed after reduction in area.
70	57	Powell, R. L., et al.	1959	A	4.2, 273	Sample 3	The above specimen cold-drawn through tungsten carbide die to a reduction in area of 7.70%, not annealed after area reduction.
71	57	Powell, R. L., et al.	1959	A	4.2, 273	Sample 3	The above specimen cold-drawn through tungsten carbide die to a reduction in area of 10.40%, not annealed after reduction in area.
72	62	Roder, H.M., Powell, R.L., and Hall, W.J.	1958		4.1-295		0.0343 Ag; manufactured by American Smelting and Refining Co.; supplied through Los Alamos Scientific Laboratory; annealed; residual resistance ratio R(273 K)/R(4 K) = 400; smooth values from figure.
73	14	Domenicali, C.A. and Christenson, E.L.	1961	A	2-391		Pure copper, contains perhaps 10^{-4} to 10^{-3} percent unintentional impurities including probably iron; wire specimen; obtained from American Smelting and Refining Co.; data for six runs; data from figure.
74	14	Domenicali, C.A. and Christenson, E.L.	1961	A	439-796		The above specimen measured in a higher temperature range.
75	14	Domenicali, C.A. and Christenson, E.L.	1961	A	821-1188		The above specimen measured in a higher temperature range.
76	73	Schroder, P.A., Wolf, R., and Woollam, J.A.	1965		4.2-300		Wire specimen 0.2 mm in diam; copper purchased from American Smelting and Refining Co.; specimen made by induction heating and chill casting; annealed in vacuum at 953 K; residual resistance ratio R(273 K)/R(4.2 K) = 1080; smooth values from figure.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
77	80	Swanson, M.L., Piercy, G.R., and Mackinnon, D.J.	1962	A	1.8	1.	99.999 pure; strip specimen 0.076 cm (0.003 in) thick; annealed 0.025 cm (0.010 in) wires rolled at room temperature; annealed; data from table.
78	80	Swanson, M. L., et al.	1962	A	1.8	2.	Similar to the above specimen.
79	61	Richter, F. and Kierspe, W.	1965	B	81–295		99.9997 pure; rod specimen 3 mm in diam; drawn; data from table.
80	72	Schriempf, J. T.	1968		6.7–297	Cu 1	99.999 pure, 0.0100 Mn; no indication of oxide pockets; rod specimen 0.302 cm (0.119 in) in diam; prepared from American Smelting and Refining Co. copper; swaged from rod of 0.95 cm (0.375 in) stock diam to 0.32 cm (0.125 in), annealed at 1273 K for 12 h in air in pressure of approx 10^{-3} Torr, etched to final diam; $\rho = \rho_0 + \rho_i$, $\rho_0 = 1.73 \times 10^{-11}$ Ω m; $(\rho_{exp} - \rho_0)$ data from figure; reported error <± 3%; $\rho = \rho_{exp}$.
81	72	Schriempf, J. T.	1968		8.8–297	Cu 2	99.999 pure, metallic impurities <0.0010; no indication of oxide pockets; rod specimen approx 0.19 cm (0.076 in) in diam; this specimen made from same stock as above specimen, swaged to 0.20 cm (0.080 in) in diam, heavily etched in 50% nitric acid between steps in swaging process, etched to final diam, annealed at 803 K for 3 h in vacuum of 1×10^{-6} Torr; $\rho = \rho_0 + \rho_i$, $\rho_0 = 0.579 \times 10^{-11}$ Ω m; $(\rho_{exp} - \rho_0)$ data from figure; reported error <± 3%; $\rho = \rho_{exp}$.
82	72	Schriempf, J. T.	1968		7.6–297	Cu 2-0	After measurements completed on Cu 2 it was annealed at 1273 K for approx 22 h in an air atmosphere of 5×10^{-4} Torr; slightly larger diam than Cu 2; "holes," presumably pockets of copper oxide, formed during oxidation annealing process; $\rho = \rho_0 + \rho_i$, $\rho_0 = 1.12 \times 10^{-11}$ Ω m; $(\rho_{exp} - \rho_0)$ data from figure; reported error <± 3%; $\rho = \rho_{exp}$.
83	71	Schofield, F.H.	1925	A	287–904		99.9 pure; material supplied by T. Bolton and Sons, Ltd., Oakmoor; billets cast from mixture of 0.33 cathodes and 0.67 electrolytic wire bars immediately after poling; rolled hot to 1 in diam, drawn cold to 2.22 cm (0.875 in) diam, machined and polished to 1.90 cm (0.75 in) diam, and then annealed; density 8.92 g cm^{-3} at 294 K; data extracted from table; reported error 1%.
84	5	Bauer, W. and Sosin, A.	1967		4.2	A	No details reported; data extracted from table.
85	5	Bauer, W. and Sosin, A.	1967		4.2	B	No details reported; data extracted from table.
86	60	Ramanathan, K.G. and Dhillon, J.S.	1955	→	298		Experimental method described as inducing an emf in a plane uniform ring of conducting material suspended in a uniform magnetic field and observing the resulting ballistic throw; data extracted from text.
87	25	Hudson, W.R.	1966		4.2, 300	A	Polycrystalline; wire specimen 0.000254 m in diam and 0.398 m long; unannealed.
88	25	Hudson, W.R.	1966		4.2, 300	B	Specimen A material drawn through diamond dies; wire specimen 95.0×10^{-6} m in diam and 1.47 m in length; wound on fiber reinforced plastic spool; unannealed.
89	25	Hudson, W.R.	1966		4.2, 300	D	Polycrystalline; wire specimen 25.4×10^{-6} m in diam and 5.18 m long; wound on copper spool; unannealed; data extracted from table.
90	25	Hudson, W.R.	1966		4.2, 300	E	Polycrystalline; wire specimen 25.4×10^{-6} m in diam and 5.18 m long; wound on copper spool; unannealed; data extracted from table.
91	25	Hudson, W.R.	1966		4.2, 300	F	Commercial grade; polycrystalline; wire specimen 78.7×10^{-6} m in diam and 10.13 m long; wound on copper spool; data extracted from table.
92	25	Hudson, W.R.	1966		4.2, 300	G	Commercial grade; polycrystalline; wire specimen 50.8 m in diam and 2.67 m long; wound on fiber reinforced plastic spool; data extracted from table.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
93	25	Hudson, W.R.	1966		4.2, 300	H	Polycrystalline; wire specimen 254 x 10^{-6} m in diam and 0.386 m long; wound around circumference of sample holder; annealed at 544 K for 21.5 h.
94	31	Kjekshus, A. and Pearson, W.B.	1962		1.8-27		0.0026 Mn (nominal content), iron content generally below 0.0053; Cu used was nominally pure 99.99 from American Smelting and Refining Co. containing 0.00062 Fe, electrolytic Mn from A.D. MacKay containing 0.0013 Mg and 0.00073 Ca, alloy prepared by melting accurately weighed quantities of Cu and solute metals in graphite crucible in sealed quartz tube, after melting, alloy homogenized in sealed evacuated quartz tube at approx 1323 K for 3 d and quenched, wires prepared, annealed for 18 h at 793-803 K, and quenched; data from figure.
95	31	Kjekshus, A. and Pearson, W.B.	1962		1.9-29		Similar to the above specimen except impurity content 0.0086 Mn.
96	31	Kjekshus, A. and Pearson, W.B.	1962		1.8-28		Similar to the above specimen except impurity content 0.026 Mn.
97	31	Kjekshus, A. and Pearson, W.B.	1962		1.7-28		Similar to the above specimen except impurity content 0.086 Mn.
98	31	Kjekshus, A. and Pearson, W.B.	1962		2.3-24		0.00220 Fe, nominal content; Cu used was nominally pure 99.99 from American Smelting and Refining Co. containing 0.00062 Fe, iron high purity material from Johnson and Matthey, alloy prepared by melting accurately weighed quantities of Cu and solute metals or previous alloys in crucibles of pure alumina, after melting, alloy homogenized in sealed evacuated quartz tube at approx 1323 K for 3 d, quenched, wires prepared, annealed for 18 h at 793-803 K or higher, and quenched; data from figure.
99	31	Kjekshus, A. and Pearson, W.B.	1962		2.3-24		Similar to the above specimen except impurity content 0.0066 Fe.
100	31	Kjekshus, A. and Pearson, W.B.	1962		2.2-33		Similar to the above specimen except impurity content 0.0220 Fe.
101	31	Kjekshus, A. and Pearson, W.B.	1962		2.2-33		Similar to the above specimen except impurity content 0.088 Fe.
102	31	Kjekshus, A. and Pearson, W.B.	1962		1.7-25	D	Dilute alloy of chromium in copper; Cu used was nominally pure 99.99 from American Smelting and Refining Co. containing 0.00062 Fe, electrolytic chromium from Johnson and Matthey with about 0.0001 at.% of Ca, Co, Mg, and Na; alloy prepared by melting accurately weighed quantities of Cu and solute metals or previous alloys in crucibles of pure alumina, after melting, alloy homogenized in sealed evacuated quartz tube at approx 1323 K for 3 d, quenched wires prepared, annealed for 18 h at 793-803 K or higher, and quenched; data from figure.
103	31	Kjekshus, A. and Pearson, W.B.	1962		1.7-24	2C	Similar to the above specimen except impurity content is presumably different.
104	31	Kjekshus, A. and Pearson, W.B.	1962		1.9-28	C	Similar to the above specimen except impurity content presumably different.
105	31	Kjekshus, A. and Pearson, W.B.	1962		1.3-29	B	Similar to the above specimen except impurity content presumably different.
106	31	Kjekshus, A. and Pearson, W.B.	1962		1.8-31	A	Similar to the above specimen except impurity content presumably different.
107	31	Kjekshus, A. and Pearson, W.B.	1962		2.6-27	D	Dilute alloy of cobalt in copper; Cu used was nominally pure 99.99 from American Smelting and Refining Co., containing 0.00062 Fe, high purity cobalt material supplied by Johnson and Matthey; alloy prepared by melting accurately weighed quantities of Cu and solute metals or previous alloys in crucibles of pure alumina, after melting, alloy homogenized in sealed evacuated quartz tube at approx 1323 K for 3 d, quenched, wires prepared, annealed for 18 h at 793-803 K or higher, and quenched; data from figure.
108	31	Kjekshus, A. and Pearson, W.B.	1962		2.4-26	E	Similar to the above specimen except impurity content presumably different.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
109	31	Kjekshus, A. and Pearson, W. B.	1962		2.6-27	B	Similar to the above specimen except impurity content presumably different.
110	31	Kjekshus, A. and Pearson, W. B.	1962		2.1-26	2B	Similar to the above specimen except impurity content presumably different.
111	31	Kjekshus, A. and Pearson, W. B.	1962		2.4-47	3A	Similar to the above specimen except impurity content presumably different.
112	68	Sager, G. F.	1930	B	368-770	1	Wire specimen approx 0.25 cm in diam; annealed for approx 10 min at a bright red heat current and potential leads of nickel were silver soldered to specimen; density 8.87 g cm^{-3}; data extracted from table.
113	68	Sager, G. F.	1930	B	302-744	2	Similar to the above specimen.
114	36	Lees, C.H.	1908		96-290		Pure; rod specimen 0.585 cm in diam and approx 7.5 cm long; turned from larger rod of soft-drawn high-conductivity copper; density 8.84 g cm^{-3} at 296 K; knife edges, 4 cm apart, serve as potential probes; data from table.
115	67	Saeger, K. E.	1968		4.1-278	3e-I	99.999 pure; single crystal; specimen dimensions 7 mm wide, 0.18 mm thick and 60 mm long; material from Johnson and Matthey; specimen produced from above purity Cu by recrystallization technique; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K)$ approx 1200; current direction approx $[\bar{8}33]$, normal to sample surface close to $[\bar{2}38]$; measurements uncorrected for thermal expansion; data and smooth values from figure.
116	67	Saeger, K. E.	1968		4.2-76	3e-II	After measurements completed on above specimen, new specimen cut; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K)$ approx 1000; current direction approx [643], normal to surface close to $[\bar{2}38]$; measurements uncorrected for thermal expansion; data and smooth values from figure.
117	67	Saeger, K.E.	1968		4.1-76	15a	99.999 pure; single crystal; specimen dimensions 7 mm wide, 0.18 mm thick, and 60 mm long; material from Johnson and Matthey; specimen produced from above purity Cu by recrystallization technique; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K)$ approx 126; current direction $[\bar{2}06]$, normal to sample surface $[6\bar{1}1]$; measurements uncorrected for thermal expansion; data and smooth values from figure.
118	67	Saeger, K.E.	1968		4.2-31	16a	Similar to the above specimen except residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K)$ approx 168; current direction $[6\bar{1}1]$, normal direction to sample surface $[11\bar{5}]$.
119	54	Otter, F.A., Jr.	1956	A	81-749		99.99^{+} pure; obtained from Vacuum Metals Corp. (Cuprovac); high temperature experiments performed in vacuum; data extracted from figure.
120	29	Kapitza, P.	1929		88	Cu_{II}	99.9^{+} pure, 0.04 As, 0.04 O, 0.03 Fe, 0.02 Ni, 0.01 Pb, and 0.001 Ca, analysis of impurities done by Hilger; wire specimen 0.15 mm in diam and 20-30 cm long; material from Hilger; drawn, semihard; residual resistance ratio R(290 K)/R(88 K) = 6.37; units not explicitly given, presume they are in Ω cm.
121	29	Kapitza, P.	1929		55	Cu_{I}	99.9^{+} pure, compared spectroscopically with Cu_{II} and purity found to be about the same; wire specimen 0.15 mm in diam and 20-30 cm long; wire obtained from Hartmann and Braun, already drawn, hard; residual resistance ratio R(290 K)/R(88 K) = 5.9; units not explicitly given, presume they are in Ω cm.
122	29	Kapitza, P.	1929		55	Cu_{I}	The above specimen after magnetoresistivity measurements performed with magnetic field perpendicular to current; residual resistance ratio R(240 K)/R(88 K) = 6.45; units not explicitly given, presume they are in Ω cm.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
123	29	Kapitza, P.	1929		88	Cu_I	Specimen cut from the same copper wire as the above specimen except annealed to a temperature of about 973 K in vacuum and residual resistance ratio R(290 K)/R(88 K) = 7.09; units not explicitly given, presume they are in Ω cm.
124	91	White, G.K. and Woods, S.B.	1959		15-295	Cu A	99.999 pure; wire specimen 0.1 mm in diam and 6 to 8 cm long; from American Smelting and Refining Co., New York; vacuum annealed 803 K; residual resistance ratio R(295 K)/R(residual) = 621; error in reading galvanometer amplifier 1 in 400; values normalized using $\rho_i(273)$ in Gerritsen, A.N. (Handbook der Physik, 19, 137, 1956) due to uncertainty in diam of wire; $\rho = \rho_0 + \rho_i$, smoothed values of ρ_i given in tabular form as 0.00017, 0.0008, 0.0025, 0.0063, 0.022, 0.050, 0.095, 0.153, 0.215, 0.280, 0.350, 0.490, 0.635, 0.775, 0.92, 1.06, 1.20, 1.40, 1.55, and 1.70 x 10^{-8} Ω m at 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 220, 250, 273, and 295 K, respectively; ρ_0 = 0.00276 x 10^{-8} Ω m obtained from residual resistance ratio and assuming $\rho(295\ K) = \rho_i(295\ K)$.
125	43	Mikryukov, V.E.	1956		320-773		99.99 pure; data from table.
126	44	Mikryukov, V.E.	1957		329-956		0.085 Be; hardened; data from figure.
127	44	Mikryukov, V.E.	1957		322-1001		0.085 Be; annealed in vacuum for 6 h at 673 K following hardening.
128	44	Mikryukov, V.E.	1957		330-988		0.13 Be; hardened; data from figure.
129	44	Mikryukov, V.E.	1957		329-999		0.13 Be; annealed in vacuum for 6 h at 673 K following hardening.
130	44	Mikryukov, V.E.	1957		333-932		0.17 Be; hardened; data from figure.
131	44	Mikryukov, V.E.	1957		337-969		0.17 Be; annealed in vacuum for 6 h at 673 K following hardening.
132	45	Mikryukov, V.E.	1958		311-767		Pure; polycrystalline; data from figure.
133	46	Mikryukov, V.E. and Rabotnov, S.N.	1944		597-1243		Polycrystalline; data from table.
134	27	Jaeger, W. and Diesselhorst, H.	1900		291	Copper I	0.5983 cm in diam; drawn; commercial product; data from table.
135	27	Jaeger, W. and Diesselhorst, H.	1900		291, 373	Copper II	Pure, total of Fe and Zn < 0.05; specimen 1.1083 cm in diam and approx 27 cm long; cast; density 8.65 g cm^{-3} at 291 K; data from table.
136*	27	Jaeger, W. and Diesselhorst, H.	1900		291, 373	Copper II	Wire specimen pulled from the same material above; data from table.
137	27	Jaeger, W. and Diesselhorst, H.	1900		291, 373	Copper III	Pure, 0.05 Pb, traces of Fe and Ni; specimen 1.107 cm in diam and approx 27 cm long; density 8.88 g cm^{-3} at 291 K; data from table.
138	42	Meissner, W.	1915		21-375	Kupfer I	Specimen with an average diam of 0.1001 cm and an average length of 6.294 cm; specimen from Seimens and Halske; electrolytically prepared; resistivities calculated from electrical resistance ratio, r = R(T)/R(273.1 K), and resistivity at 273.1 K; temperature coeff of electrical resistance ratio, $r^{-1}(dr/dT)$, 0.0620, 0.0238, 0.00432, 0.00397, and 0.00300 at 20.7, 90.7, 273.1, 293.7, and 374.7 K, respectively.
139	42	Meissner, W.	1915		22-375	Kupfer II	Specimen with an average diam of 0.1000 cm and an average length of 6.305 cm; electrolytically prepared; resistivities calculated from electrical resistance ratio, r = R(T)/R(273.1 K), and resistivity at 273.1 K; temperature coeff of electrical resistance ratio, $r^{-1}(dr/dT)$, 0.0170, 0.0220, 0.00427, 0.00386, and 0.00300 at 21.5, 91.4, 273.1, 298.3, and 374.6 K, respectively.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
140	2	Ascoli, A., Guarini, G., and Queirolo, G. T.	1970	A	575-1328		99.999+ pure; supplied by Johnson, Matthey and Co., Ltd., London; well-annealed; sample kept in vacuum, 10^{-5} mmHg, below 973 K and above 973 K in purified argon at atmospheric pressure; temperature known better than ± 0.1 K; seven samples used, each went through several up-temperature and down-temperature curves; data of $\ln(\rho/T)$ versus T extracted from figure for typical curve; with estimated extraction error ± 4.1 K in temperature and ± 0.001 in $\ln(10^3\,\rho/T)$; resistivity reported in paper calculated from $\rho(T) = R(T, \text{measured})\,(\rho(293\,K)/R(293\,K, \text{measured}))\,(1+\bar{\alpha}(T-293\,K))$, $\rho(293\,K) = 1.673 \times 10^{-8}\,\Omega$ m from p. 685 of C.J. Smithells (Metals Reference Book, Vol. III, 4th ed., Butterworths, London, 1967) and $\bar{\alpha}$ is average linear expansion coeff between T and 293 K from Leksina, I.E. and Novikova, S.I. (Sov. Phys. Solid State, 5, 798, 1963).
141	79	Svensson, B.	1936		273-773		No details reported; data extracted from table.
142	40	Matyushenko, L.A., Shmatov, V.T., and Rodionov, K.P.	1970		82-291	3	99.996 pure; 9.5 mm bar specimen; annealed in vacuum furnace for 2 h at 973 K; data extracted from figure.
143	9	Broom, T.	1952		90-373		< 0.01 Ag, Cd, Pb, Si, << 0.01 Fe, Mg; wire diam 0.056 cm; drawn from initial diam of 0.183 cm to final diam; annealed 873 K for 2 h, furnace cooled.
144	58	Powell, R.W. and Tye, R.P.	1967	→	293-1173	J.M. and Co., Sample 1	High purity, approx estimate of impurities: 0.0005 Ag, < 0.0004 Pb, and < 0.0003 Ni; Johnson Matthey and Co. spectrographically standardized rod, Laboratory No. 4351; 7 mm in diam and 15 cm long; heat treated to 1173 K; comparative potential drop method used; data from table, originally read from smooth curve.
145*	58	Powell, R.W. and Tye, R.P.	1967	→	293-373	Q.M.C., Sample 2	Pure; 1 cm in diam and approx 10 cm long; supplied by Queen Mary College, London; no heat treatment given prior to measurements; comparative potential drop method used; data from table, originally read from smooth curve.
146	58	Powell, R.W. and Tye, R.P.	1967	→	293-873	M.S., Sample 3	Pure; 1.27 cm in diam and 10 cm long; supplied by Ministry of Supply; no heat treatment given prior to testing; comparative potential drop method used; data from table, originally read from smooth curve.
147	30	Kierspe, W.	1967		4.2-273		Cylindrical specimen; data from table.
148	30	Kierspe, W.	1967		4.2-273		0.080 (0.1 at.%) V; cylindrical specimen; data from table.
149	30	Kierspe, W.	1967		10-273		0.088 (0.1 at.%) Fe; cylindrical specimen; data from table.
150	30	Kierspe, W.	1967		4.2-273		0.098 (0.12 at.%) Cr; cylindrical specimen; data from table.
151	30	Kierspe, W.	1967		4.2-273		0.186 (0.2 at.%) Co; cylindrical specimen; data from table.
152	30	Kierspe, W.	1967		4.2-273		0.151 (0.2 at.%) Ti; cylindrical specimen; data from table.
153*	10	Coltman, R.R., Klabunde, C.E., and Redman, J.K.	1967		3.2		High purity; fcc crystal structure; wire specimen 0.079 cm (0.031 in) in diam and 88.4 cm (34.8 in) long; annealed at 1273 K for 2 h in 0.5 mTorr air, furnace cooled; data from table.
154*	78	Smith, C.S. and Palmer, E.W.	1935		293, 473		99.986 Cu, 0.022 O, 0.0016 Fe, and 0.00155 S; annealed at 823 K for 1 h.
155	78	Smith, C.S. and Palmer, E.W.	1935		293, 473		99.80 Cu, 0.19 Si, and 0.02 Fe; annealed at 973 K for 2 h; data from table.
156	78	Smith, C.S. and Palmer, E.W.	1935		293, 473		99.94 Cu, 0.07 Mn, 0.02 Mg, and 0.01 Fe; annealed at 973 K for 2 h; data from table.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
157	78	Smith, C.S. and Palmer, E.W.	1935		293, 473		99.88 Cu; 0.14 Mn, 0.01 Fe, and 0.01 Mg; annealed at 973 K for 2 h; data from table.
158*	78	Smith, C.S. and Palmer, E.W.	1935		293, 473		99.95 Cu; 0.07 Al and 0.01 Fe; annealed at 1023 K for 2 h; data from table.
159*	15	Ellis, W.C., Morgan, F.L., and Sager, G.F.	1928		305		Electrolytically pure; 2.5 mm in diam and 4.69 cm long; density 8.93 g cm^{-3} at 305 K; data from table.
160*	1	Aoyama, S. and Ito, T.	1940		78, 273	Electrolytic Cu	0.015 Sb, 0.010 Fe, 0.007 S, and 0.0003 As; annealed in nitrogen stream at 653 to 673 K for 20 h; data extracted from tables.
161*	77	Smith, A.W.	1925		296		99.97^+ pure; data extracted from table.
162	39	Lorenz, L.	1881		273, 373		Data extracted from table.
163*	87	Van Witzenberg, W. and Laubitz, M.J.	1968		4.2, 273		99.999^+ pure; 1.6 mm thick wire supplied by Asarco; annealed in 10^{-5} mmHg vacuum at 1140 K for 114 h; data extracted from table.
164	50	Natarajan, N.S. and Chari, M.S.R.	1970		1.5–4.2		0.095 Mn (0.11 at.%); polycrystalline; supplied by Kamerlingh Onnes Laboratory, Leiden, Holland; prepared from Johnson, Matthey pure Cu and Mn; strained; data from figure.
165	50	Natarajan, N.S. and Chari, M.S.R.	1970		1.6–4.2		0.18 Mn (0.21 at.%); similar to the above specimen; data from figure.
166*	65	Rubanenko, I.R. and Grossman, M.I.	1969		293.2		28 mm x 7 mm x 7 mm; measuring temperature assumed to be 293 K; data from figure.
167*	86	Van Dael, H. and Dupré, A.	1970		4.2, 300		0.0737 Mn, 0.0015 Fe, and 0.0004 Si; annealed at 1123 K for 22 h; data from table.
168*	86	Van Dael, H. and Dupré, A.	1970		4.2, 300		0.0213 Mn, 0.0020 Fe, and 0.0004 Si; annealed at 1123 K for 41 h; data from table.
169*	86	Van Dael, H. and Dupré, A.	1970		300		0.0197 Mn, 0.0015 Fe, and 0.0001 Si; annealed at 1123 K for 21 h; data from table.
170*	19	Fletcher, R., Friedman, A.J., and Stott, M.J.	1972		4.2, 273		Plate specimen 0.25 cm thick; obtained from National Research Council, Ottawa; fabricated from material supplied by American Smelting and Refining Co.; rolled, etched, and annealed in vacuum at 773 K for 18 h; data from tables.
171	84	Tye, R.P.	1973		373–973	C1	2.54 cm diam x 2.54 cm long; data from table.
172	84	Tye, R.P.	1973		373–973	C2	2.51 cm diam x 2.54 cm long; fabricated from sintered spherical powder particles obtained from OFHC copper stock; porosity 10.31%; data from table.
173	84	Tye, R.P.	1973		373–973	C3	2.54 cm diam x 2.54 cm long; fabricated from the same material as the above specimen; porosity 20.96%; data from table.
174	84	Tye, R.P.	1973		373–973	C4	Similar to the above specimen but porosity 30.77%; data from table.
175	24	Holgersson, S. and Sedström, E.	1924		323	Electrolytic copper	From Merck, Darmstadt; calculated density 8.90 g cm^{-3}; data extracted from figure.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
176	69	Scala, E. and Robertson, W.D.	1953	A	1364-1565		99.999 pure with major impurities 0.0002 As, 0.0002 Te, 0.0001 Ni, 0.0001 Pb, 0.0001 S, 0.0001 Se, and 0.0001 Sn determined by chemical analysis; analysis after measurement showed no significant accumulation of impurities or detectable solution of Mo contacts; in liquid state; metal from A.S. and R.; specimen contained in refractory insulating tube approx 0.6 cm I.D. and 13 cm long; measurements performed in dried Ar gas; data corrected for thermal expansion; temperature difference over length of specimen generally less than 1 K; data points extracted from figure with estimated extraction error ± 1.4 K in temperature and ± 0.06 x 10^{-8} Ω m in resistivity; resistivity, interpolated from smooth curve, reported as 22.9, 24.0, 25.1, 26.2, and 27.3 x 10^{-8} Ω m at 1373, 1423, 1473, 1523, and 1573 K, respectively.
177	63	Roll, A., Felger, H., and Motz, H.	1956	R	281-1351	Electrolytic copper	Specimen 6 mm diam x 10 mm long; $d\rho/dT$ = 0.0067 x 10^{-8} Ω m K^{-1} between 273 and 373 K; data from figure; reported error ±1.0%.
178	64	Roll, A. and Motz, H.	1957	R	1273-1473		99.99 pure; in solid and liquid states; mp 1356 K; rotating field method used in liquid state with thermal expansion correction carried out; accuracy of temperature measurements ± 1 K; max measurement uncertainty in resistivity in liquid state ± 0.7% for errors in frequency, current density, torsional deviation, and sample temperature; accuracy of rotating field method, in liquid state, about 1% on the basis of reproduced experiments on same metals under most diverse conditions; data points extracted from figure with estimated extraction error ± 1.6 K in temperature and ± 0.16 x 10^{-8} Ω m in resistivity.
179	41	Meechan, C.J. and Eggleston, R.R.	1954		437-1223		99.999 pure; wire specimen 0.023 cm (0.009 in) in diam; specimen furnished by Johnson and Matthey Co.; drawn; resistance 0.15275, 0.15852, 0.16802, 0.18064, 0.19249, 0.21770, 0.23210, 0.24933, 0.26402, 0.28350, 0.30555, 0.32716, 0.34998, 0.37159, 0.38979, 0.40420, 0.42307, 0.43798, 0.46690, and 0.49350 Ω at 437.1, 452.5, 478.9, 512.4, 543.0, 607.8, 643.8, 686.7, 723.4, 770.4, 822.9, 873.5, 925.1, 1013.1, 1043.8, 1083.3, 1113.6, 1171.0, and 1222.5 K, respectively; pressure maintained below 10^{-4} mmHg; electrical leads made of commercial purity wires of same material as specimen and spot welded; resistance measurements made using Rubicon Type "B" potentiometer; precision of temperature measurements within 0.5 K; ρ(293 K) of 1.67 x 10^{-8} Ω m from Smart, J.S., Smith, A.A., and Phillips, A.J., (Trans A.I.M.M.E., 143, 272, 1941); resistivity, ρ(T), calculated using ρ(293 K)[R(T)/R(293 K)]; R(T) calculated using equation given by author, R(T) = 0.004134 + 3.0955 x 10^{-4} T + 0.689 x 10^{-7} T^2 with T in K and R in Ω, R(293 K) = 0.1007 Ω; resistance extracted from table.
180	13	Dewar, J. and Fleming, J.A.	1893	B	76-478	Shorter coil	Wire specimen 0.025789 cm mean diam and 300 cm long; purest material obtained prepared by J.W. Swan by electrolysis of pure copper nitrate using his special process, drawn without heating or melting and annealed by heating in hydrogen; resistance 0.1653, 0.5883, 0.7452, 0.8982, 0.9594, 0.9658, 0.9659, 1.1262, 1.2726, 1.4346, and 1.6810 Ω at 76.1, 191.3, 233.8, 273.70, 289.60, 291.40, 291.45, 333.10, 371.10, 414.3, and 478.2 K, respectively; mean temperature coeff between 273 and 373 K 0.00428, Wheatstone bridge used to measure resistance; temperature measured using platinum resistance thermometer; data uncorrected for thermal expansion, length and mean diam measured at 288 K; data extracted from table; resistivity at 273 K 1.561 x 10^{-8} Ω m; temperatures of 76.1 (taken in liquid oxygen boiling at 761 millimicrons), 191.3 (taken in CO_2 and ether), and 233.8 K are "platinum" temperatures arrived at using standard platinum wire with all other temperatures corrected Celsius temperatures.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
181	13	Dewar, J. and Fleming, J.A.	1893	B	50-273	Longer coil	Specimen from the same piece as above wire specimen; wire specimen 2100 cm long; resistance 0.5692, 0.6341, 0.6391, and 1.1687 at 50.0, 53.9, 54.0, and 76.1 K, respectively; Wheatstone bridge used to measure resistance; temperature measured using platinum resistance thermometer; data uncorrected for thermal expansion, length measured at 288 K; data extracted from table; all temperatures; taken in boiling liquid oxygen under pressures down to 14 mmHg are "platinum" temperatures arrived at using standard platinum wire.
182	12	Dewar, J. and Fleming, J.A.	1892	B	76-366	Electrolytic	Pure; wire specimen had probable dimensions of 0.0076 cm (0.003 in) in diam and 50 or 100 cm long; procured from London Electric Wire Co.; annealed; experiment carried out with ambient temperature approx constant at 293 K; mean diam of wire measured to nearest ten-thousandth of an inch; resistance measured on Wheatstone bridge; measurement of resistance repeated several times, mean observed specific resistance reported; data uncorrected for thermal expansion; data extracted from table.
183*	22	Grüneisen, E. and Reddemann, H.	1934		22-273	Cu 26	Identical with the similarly named sample of Grüneisen, E. and Goens, E. (Z. Physik, 44, 615-42, 1927), see p. 639 of their article; very pure; since 1927 probably a little deformed and, therefore, the residual resistance slightly higher.
184	66	Rumbo, E.R.	1976	→	1.2-8.5	Cu 3	Very pure; concentration of magnetic impurities less than 1 part in 10^9; single crystal; crystal orientation <011>; specimen thickness 0.386 mm, width 2.38 mm, and length 28.6 mm; ASARCO material supplied by Prof. S. Schultz; history: annealed in oxygen; fitted value of residual resistivity 0.00017591 x 10^{-8} Ω m (least-squares fit to data made with $\rho_0 + aT^3 + bT^5$, for each point below 3 K, a and b used to obtain individual values for ρ_0 which were plotted versus T and extrapolated to T = 0 K to give final value of ρ_0); mean free path 0.370 mm; residual resistance ratio 8810; resistance measured with superconducting galvanometer, the slug, in a potentiometer circuit, limiting resolution of slug circuit 1 to 3 parts in 10^4; uncertainty in absolute resistivity 0.3% due to balancing resistor and 0.5% due to form factor; form factor calculated from measured resistance at 273 K and value tabulated for resistivity at 273 K in Hall, L.A. (National Bureau of Standards Technical Note 365, 111 pp., 1968); data extracted from table.
185	66	Rumbo, E.R.	1976	→	1.2-8.5	Cu 1	Similar to the above specimen and conditions except crystal orientation approx <231>; specimen thickness 0.427 mm; ASARCO material; history: material distilled using specially prepared graphite crucibles free of magnetic impurities, grown into single crystal by Bridgman method, annealed in oxygen at 1223 K at 1 Pa pressure for 6 h, cut using spark erosion, and before measurement annealed in vacuum at 1223 K to remove spark damage; fitted value of residual resistivity 0.00011315 x 10^{-8} Ω m; residual resistance ratio 13690; mean free path 0.575 mm.
186	66	Rumbo, E.R.	1976	→	1.2-8.5	Cu 4	Similar to the above specimen and conditions except crystal orientation approx <231>; specimen thickness 0.336 mm; fitted value of residual resistivity 0.00021010 x 10^{-8} Ω m; residual resistance ratio 7380; mean free path 0.310 mm.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
187	66	Rumbo, E.R.	1976	→	1.2-8.4	Cu 2	Very pure; concentration of magnetic impurities less than 1 part in 10^9; single crystal; crystal orientation approx <331>; specimen thickness 0.499 mm; width 2.38 mm, and length 28.6 mm; ASARCO material supplied by Prof. S. Schultz; history: annealed in oxygen; residual resistivity 0.0002650 x 10^{-8} Ω m; mean free path 0.246 mm; resistance ratio 5850; resistance measured with super-conducting galvanometer, the slug, in a potentiometer circuit with limiting resolution of slug circuit 1 to 3 parts in 10^4; uncertainty in absolute resistivity 0.3% due to balancing resistor and 0.5% due to form factor; form factor calculated from measured resistance at 273 K and value tabulated for resistivity at 273 K in Hall, L.A. (National Bureau of Standards Technical Note 365, 111 pp., 1968); original data in tabular form and additional information supplied by author.
188	52	Niccolai, G.	1908	B	84-673		Pure; material from C.A.F. Kahlbaum, Berlin; wire specimen about 0.5 mm in diam and approx 8 m long; resistance measured using a Wheatstone Bridge; data extracted from table.
189	55	Ozelton, M.W., Wilson, J.R., and Pratt, J.N.	1967	R	1373		In liquid state; data point at zero at.% Ge extracted from figure with estimated extraction error ± 0.3 at.% Ge in concentration and ± 0.6 x 10^{-8} Ω m in resistivity.
190	4	Banchila, S.N. and Filippov, L.P.	1973		1141-2275		99.99 Cu, 0.01 Zn, 0.002 P, 0.002 S, 0.001 Ag, 0.0001 Bi, 0.001 Pb, 0.001 Si, and 0.001 Sn; conductivity measured by a contact method by using a thin-walled tantalum crucible containing the liquid metal with the crucible heated in an induction furnace; data measured during rise of temperature and during fall of temperature to check interaction of liquid metal with crucible with no "non-return" of results found; data extracted from table for results using two crucibles, one with R_1 = 7 mm, R_2 = 11.1 mm, and ℓ = 40 mm and the other with R_1 = 7.5 mm, R_2 = 10.5 mm, and ℓ = 30 mm; systematic error in the range of 2% and random error about 1%; units in which resistivity were reported, i.e., 10^{-8} Ω mm, presumably should be 10^{-8} Ω m (in English translation).
191	8	Bornemann, K. and Wagenmann, K.	1914		1373-1773	Electrolytic	Pure; in liquid state; data extracted from table.
192	7	Bornemann, K. and Von Rauschenplat, G.	1912		1373-1833		Pure; in liquid state; data extracted from table.
193	11	Dawson, H.I.	1965		78		99.999 pure; polycrystalline; approx grain size 0.1 mm; wire specimen 0.20 or 0.25 mm in diam; from Johnson Matthey; annealed for 1 h at 723 K in vacuum of 10^{-5} mmHg; data point extracted from table.
194	83	Tsutsumi, H.	1918		288-1475		In solid and liquid states; obtained from Kahlbaum; mp 1350 K, 1355 K; resistivity at mp in solid state ρ_S = 10.9 x 10^{-8} Ω m and in liquid state ρ_L = 21.6 x 10^{-8} Ω m with a ratio ρ_L/ρ_S = 2.04(sic); to prevent oxidation, hydrogen gas continually passed through furnace; data extracted from table; measurements taken with increasing temperature.
195	83	Tsutsumi, H.	1918		749-1457		Same as the above specimen and conditions except measurements taken with decreasing temperature.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
196	28	Jäger, H., Seydel, U., and Wadle, H.	1976		750		Thin copper wire specimen 0.05 to 0.3 mm in diam and 4-8 cm in length; measurements made with current pulses generated using a capacitor discharge circuit; wires embedded in water; temperature deduced from the time behaviour of the discharge current and voltage attached to wire; measured at current density of 0.567 x 10^8 A cm^{-2}; data extracted from figure with estimated extraction error of ± 0.008 x 10^8 A cm^{-2} in current density and ± 0.08 x 10^{-8} Ω m in resistivity.
197	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.584 x 10^8 A cm^{-2}.
198	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.557 x 10^8 A cm^{-2}.
199	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.477 x 10^8 A cm^{-2}.
200	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.585 x 10^8 A cm^{-2}.
201	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.563 x 10^8 A cm^{-2}.
202	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.698 x 10^8 A cm^{-2}.
203	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.583 x 10^8 A cm^{-2}.
204	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.604 x 10^8 A cm^{-2}.
205	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.613 x 10^8 A cm^{-2}.
206	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.693 x 10^8 A cm^{-2}.
207	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.795 x 10^8 A cm^{-2}.
208	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.892 x 10^8 A cm^{-2}.
209	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.023 x 10^8 A cm^{-2}.
210	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.097 x 10^8 A cm^{-2}.
211	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.108 x 10^8 A cm^{-2}.
212	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.993 x 10^8 A cm^{-2}.
213	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.001 x 10^8 A cm^{-2}.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
214	28	Jäger, H., Seydel, U., and Wadle, H.	1976		750		Similar to the above specimen and conditions except current density 1.074 x 10^8 A cm^{-2}.
215	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.147 x 10^8 A cm^{-2}.
216	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.892 x 10^8 A cm^{-2}.
217	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 0.992 x 10^8 A cm^{-2}.
218	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.107 x 10^8 A cm^{-2}.
219	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.259 x 10^8 A cm^{-2}.
220	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.340 x 10^8 A cm^{-2}.
221	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.384 x 10^8 A cm^{-2}.
222	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.496 x 10^8 A cm^{-2}.
223	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.799 x 10^8 A cm^{-2}.
224	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.590 x 10^8 A cm^{-2}.
225	28	Jäger, H., et al.	1976		750		Similar to the above specimen and conditions except current density 1.522 x 10^8 A cm^{-2}.
226	17	Fickett, F.R.	1974	→	4		0.0000527 Fe (0.00006 at.%); accuracy of Fe impurity taken as 5% although author feels it correct to a precision of 1%; master alloy technique used to obtain desired Fe impurity; master alloy of approx 0.1 at.% Fe made of stock 7 copper, which is "five nines" pure and 325 mesh-powder 99.5 Fe, Fe content of master alloy 0.0690 at.% determined by atomic absorption spectroscopy; desired concentration of specimen obtained by dilution of master alloy with pure Cu; rod specimen 6 mm diam; resistivity measured using four-probe technique; original data in tabular form supplied by author; results of data show $\rho(4\ K)/n_2 = 1.81 \pm 0.08$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 \leq 100$ at. ppm Fe.
227	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.000369 Fe (0.00042 at.%).
228	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.000633 Fe (0.00072 at.%).
229	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.000967 Fe (0.00110 at.%).
230	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00123 Fe (0.00140 at.%).
231	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00176 Fe (0.00200 at.%).
232	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00229 Fe (0.00260 at.%).

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
233	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00316 Fe (0.0036 at.%) and data extracted from figure with estimated extraction error of ± 0.25 nΩ cm in resistivity and ± 0.126 ppm Fe.
234	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00352 Fe (0.0040 at.%) and data supplied in tabular form by author.
235	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00431 Fe (0.0049 at.%) and data extracted from figure with estimated extraction error of ± 0.25 nΩ cm in resistivity and ± 0.126 ppm Fe.
236	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00457 Fe (0.00520 at.%) and original data supplied in tabular form by author.
237	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00554 Fe (0.0063 at.%) and data extracted from figure with estimated extraction error of ± 0.25 nΩ cm in resistivity and ± 0.126 ppm Fe.
238	17	Fickett, F.R.	1974	→	4		Similar to the above specimen and conditions except 0.00817 Fe (0.0093 at.%) and original data supplied in tabular form by author.
239	13	Fickett, F.R.	1976		4	7 + 0	0.0000527 Fe (0.00006 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 226; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2$ = 1.80 ± 0.02 nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for n_1 < 100 at. ppm Fe; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, n_2 < 100.
240*	18	Fickett, F.R.	1976		4	7 + 0	The above specimen internally oxidized by annealing in a reduced pressure of 6.7 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for n_2 < 100 at. ppm Fe.
241*	18	Fickett, F.R.	1976		4	7 + 5	0.000369 Fe (0.00042 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 227; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2$ = 1.80 ± 0.02 nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for n_1 < 100 at. ppm Fe; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm and 1.50 ± 0.05 nΩ cm/at. ppm respectively, n_2 < 100.
242*	18	Fickett, F.R.	1976		4	7 + 5	The above specimen internally oxidized by annealing in a reduced pressure of 6.7 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for n_2 < 100 at. ppm Fe.
243	18	Fickett, F.R.	1976		4	7 + 10	0.000633 Fe (0.00072 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 228; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2$ = 1.80 ± 0.02 nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for n_2 < 100; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, n_2 < 100.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
244*	18	Fickett, F.R.	1976		4	7 + 10	The above specimen internally oxidized by annealing in a reduced pressure of 6.7 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
245	18	Fickett, F.R.	1976		4	7 + 15	0.000967 Fe (0.00110 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 229; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2 = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.
246*	18	Fickett, F.R.	1976		4	7 + 15	The above specimen internally oxidized by annealing in a reduced pressure of 6.7x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
247	18	Fickett, F.R.	1976		4	7 + 20	0.00123 Fe (0.00140 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 230; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2 = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.
248*	18	Fickett, F.R.	1976		4	7 + 20	The above specimen internally oxidized by annealing in a reduced pressure of 6.7 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
249*	18	Fickett, F.R.	1976		4	7 + 30	0.00176 Fe (0.00200 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 231; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.
250*	18	Fickett, F.R.	1976		4	7 + 30	The above specimen internally oxidized by annealing in a reduced pressure of 6.7 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
251	18	Fickett, F.R.	1976		4	7 + 40	0.00229 Fe (0.00260 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 232; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2 = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
252*	18	Fickett, F.R.	1976		4	7 + 40	The above specimen internally oxidized by annealing in a reduced pressure of 6.7 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
253*	18	Fickett, F.R.	1976		4	7 + 50	0.00308 Fe (0.0035 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 233; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.
254*	18	Fickett, F.R.	1976		4	7 + 50	The above specimen internally oxidized by annealing in a reduced pressure of 6.67 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
255	18	Fickett, F.R.	1976		4	7 + 60	0.00352 Fe (0.0040 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 234; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2 = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.
256*	18	Fickett, F.R.	1976		4	7 + 60	The above specimen internally oxidized by annealing in a reduced pressure of 6.7 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
257*	18	Fickett, F.R.	1976		4	7 + 70	0.00431 Fe (0.0049 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 235; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2 = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.
258*	18	Fickett, F.R.	1976		4	7 + 70	The above specimen internally oxidized by annealing in a reduced pressure of 6.7 x 10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8 x 10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
259*	18	Fickett, F.R.	1976		4	7 + 80	0.00457 Fe (0.00520 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 236; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2 = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
260*	18	Fickett, F.R.	1976		4	7 + 80	The above specimen internally oxidized by annealing in a reduced pressure of 6.7×10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8×10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
261*	18	Fickett, F.R.	1976		4	7 + 90	0.00554 Fe (0.0063 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 237; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2 = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.
262*	18	Fickett, F.R.	1976		4	7 + 90	The above specimen internally oxidized by annealing in a reduced pressure of 6.7×10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8×10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
263	18	Fickett, F.R.	1976		4	7 + 100	0.00817 Fe (0.00930 at.%); 3 mm diam rod specimen approx 4.5 cm in length; made from 6 mm diam rod previously measured, see Data Set 238; annealed at 1273 K for 1 h in vacuum of 10^{-6} Torr; original data in tabular form supplied by author; precision of measurement a few percent; results of data for vacuum annealed specimen shows $\rho(4\ K)/n_2 = 1.80 \pm 0.02$ nΩ cm/at. ppm Fe, where n_2 is in at. ppm Fe and for $n_2 < 100$; for 76 K and 273 K author reports 1.72 ± 0.02 nΩ cm/at. ppm Fe and 1.50 ± 0.05 nΩ cm/at. ppm Fe respectively, $n_2 < 100$.
264*	18	Fickett, F.R.	1976		4	7 + 100	The above specimen internally oxidized by annealing in a reduced pressure of 6.7×10^{-2} Pa of air at 1273 K for 92 h; data extracted from figure and text; data indicate slight linear variation of $\rho(4\ K)/n_2$ of 4.8×10^{-3} nΩ cm/at. ppm Fe, for $n_2 < 100$ at. ppm Fe.
265	51	Nelson, W.E. and Hoffman, A.R.	1976	→	7.0–35	Commercial Grade, OFHC Copper, Alloy 101	99.99 Cu; 0.0001 Pb, 0.0001 O, 0.0001 Te, 0.00003 P, 0.00001 Zn, and As, Bi, Mn, Sb, Sn totalling 0.0004; machined from 1.3 cm (0.5 in) diam rod with final length of 2.5 cm; specimen from Admiral Brass and Copper Co.; unannealed except for soldering operations, maximum temperature of 433 K; residual resistance ratio R(273 K)/R(0 K) = 55; measurements taken using standard dc 4-probe technique; current polarity reversed successively with resulting voltage deflections averaged to allow for unknown offsets due to thermal emf's; data extracted from table; data fits $\rho(T) = (3.15 + 2.28 \times 10^{-7}\ T^{4.42}) \times 10^{-8}\ \Omega$ cm within 1% over 7 to 35 K for $\rho_0 = 3.15 \times 10^{-8}\ \Omega$ cm.
266	37	Lengeler, B., Schilling, W., and Wenzl, H.	1970	→	1.7–324		High-purity Cu specimens supplied by ASARCO as wires of 500 μm diam; annealed for 2 h at 1073 K in air at 5×10^{-4} mmHg and slowly cooled; residual resistivity $\rho_0 = 0.000325 \times 10^{-8}\ \Omega$ m; resistance measured by compensation method using a DANA digital voltmeter (resolving power $\pm 1 \times 10^{-7}$ V) and current between 25 mA and 1 A supplied by a PAR current stabilizer; geometry factor f = $\rho(273\ K)/R(273\ K)$ = cross section of wire divided by its length between potential leads and determined from measurement of resistance at 273 K and by taking $\rho(273\ K) = 1.550 \times 10^{-8}\ \Omega$ m from Landolt-Börnstein (Zahlenwerte und Funktionen (Borchers, H., et al., Editors), Vol. Technik II, p. 685, 1964); original data in tabular form and additional information supplied by author.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
267	76	Siu, M.C.I., Carroll, W.L., and Watson, T.W.	1976		300-705	Oxygen free copper; R5	Pure; radiographs obtained by exposure to 1.25 Mev gamma rays showed no observable voids; specimen provided by NASA, Lewis Research Center, Cleveland, Ohio in the form of either a rectangular bar or right circular cylinder; hot rolled at 1051-1109 K and cold drawn; yield and tensile strength (tensile strain = $2 \times 10^{-3}\ s^{-1}$) at 297 K was 309 and 317 MN/m^2 respectively with an 82% reduction in area, while at 811 K they were 23.5 and 70.3 MN/m^2 respectively with a 65% reduction in area; measurements conducted with specimen chamber backfilled with argon at a pressure of 1 atm; resistivity determined by passing a measured direct current through leads attached to the ends of the specimen and measuring voltage differences between adjacent platinum leads of the thermocouples along the specimen; thermoelectric effects accounted for by taking voltage measurements with both forward and reverse current flow; values of resistivity were computed using specimen dimensions determined at room temperature; original data in tabular form supplied by author; examination of specimen after testing revealed crust about 0.01 cm thick and 7.6 cm long covered hottest end of specimen, this layer was observed to be detached from the specimen, qualitative analysis using an electron beam probe analyzer revealed an abundant amount of oxygen and copper; data fitted to $\rho = 1.553 \times 10^{-8} + 8.390 \times 10^{-11} T - 8.760 \times 10^{-4} T^2 + 1.298 \times 10^{-16} T^3$ with accuracy of ± 2-3% where ρ is in units of Ω m and T is degrees Celsius.
268	82 23	Teixeira, J., Haen, P., and Souletie, J.	1974, 1976		4.2-299	Cu 1	99.999 pure (reported as 5N) with < 0.0002 magnetic impurities as indicated by manufacturer; wire specimen 0.280 mm diam, calculated from specimen mass taking the density of Cu as 8.96, and 153.012 cm between voltage probes; material from Asarco; starting metal molten and cast into a cylinder 7 mm in diam and 22 mm in length; section of cylinder spark-cut using diamond files, hammered down to approx 1.4 mm diam and drawn in dies of tungsten carbide and diamond to obtain 0.282 mm nominal diam; annealed at 823 K for 4 h in vacuum of 10^{-6} Torr then slowly cooled; residual resistivity $\rho_0 = 1.326$ nΩ cm, intrinsic resistivity at 273 K $\rho_i(273\ K) = 1520.7$ nΩ cm, residual resistance ratio $\rho(273\ K)/\rho_0 = 1144$, and a small increase of 3 pΩ cm when temperature is lowered to 1.2 K is attributed to 0.00003 Fe; resistance measured using four-probe dc method; resistivity ρ derived from resistance R by, $\rho = RM/d\ell^2$ where M is the specimen mass, ℓ is specimen length, and d is density of Cu as stated above; data extracted from table and text; uncertainty in voltage measurements is 10^{-4} in worst case but usually 10^{-6}; imprecision of ℓ and M are reported as $\Delta\ell/\ell \cong 2 \times 10^{-3}$ and $\Delta M/M \cong 10^{-4}$; uncertainty in temperature of 0.1 K but relative uncertainty of 0.001 K; author fits data to $\rho = A + DT^5 J_5(\theta/T)(1 + 2\alpha\gamma T)$ with an absolute average quadratic error of 0.594 nΩ cm where $J_5(\theta/T)$ is the integral of Grüneisen evaluated at temperature T, A = 1.32603 nΩ cm, D = 1.85854×10^{-18} Ω cm K^{-5}, $2\alpha\gamma = 0.7890 \times 10^{-4}$, $\theta = 335.95$ K and T is in Kelvins.
269	82	Teixeira, J.	1974	→	1.3-296	Cu 2	Similar to the above specimen and conditions except 0.273 mm in diam and 159.506 cm in length; annealed at 823 K for 4 h in vacuum; $\rho_0 = 1.650$ nΩ cm, $\rho_i(273\ K) = 1523.8$ nΩ cm, $\rho(273\ K)/\rho_0 = 919$; A = 1.64984 n$\Omega$ cm, D = 1.91335×10^{-18} Ω cm K^{-5}, $2\alpha\gamma = 0.7579 \times 10^{-4}$, and $\theta = 333.65$ K; equation fits with an absolute average quadratic error of 0.784×10^{-9} Ω cm.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
270	82	Teixeira, J.	1974	→	1.3-292	Cu 3	Similar to the above specimen and conditions except 0.269 mm in diam and 81.022 cm in length; unannealed; ρ_0 = 3.636 nΩ cm, ρ (273 K) = 1533.4 nΩ cm, ρ(273 K ρ(273 K)/ρ_0 = 422; A = 3.63599 nΩ cm, D = 2.00822 x 10^{-18} Ω cm K^{-5}, $2\alpha\gamma$ = 0.8175 x 10^{-4}, and θ = 329.90 K; equation fits with an absolute average quadratic error of 0.443 nΩ cm.
271	85	Tye, R.P.	1976	→	1383-1529	OFHC	High purity, commercial grade OFHC; cylindrical, square, or hexagonal bar specimen of 20-30 mm cross-section and 600-900 mm in length; sample tube with probe-unit in place filled with triple-distilled Hg to a height of 80 mm, measured resistance of pure Hg used with accepted resistivity of pure Hg at 293 K to determine the A/ℓ system constant, probe withdrawn and sample tube emptied, both heated above 673 K to remove Hg; resistance of specimen measured using four-probe technique in 10^{-5} Torr vacuum; measurements taken with increasing temperature; original data in tabular form supplied by author.
272	85	Tye, R.P.	1976	→	1401-1506	OFHC	Same as the above specimen and conditions except measurements taken with decreasing temperature.
273	85	Tye, R.P.	1976	→	1435-1622	OFHC	Same as the above specimen and conditions except measurements taken with increasing temperature of second heating.
274	47	Mokrovskii, H.P. and Regel, A.R.	1953	→	1373-1873	Electrolytic copper	Liquid state; corundum crucible used with specimens of approx size 12 mm diam and 25 mm high; non-electrode method used based on measurement of torsional motion in a magnetic field; data presented as and calculated from $\rho_T = 20[1 + 5 \times 10^{-4}(t - 1080)]$, $1100 \le t \le 1600$, where ρ_T is in units of μΩ cm and t is in units of °C; value of resistivity at mp in liquid state to that in solid state 2.1.
275	47	Mokrovskii, H.P. and Regel, A.R.	1953		293-1353	Electrolytic copper	Solid state; data presented as and calculated from $\rho_T = 1.73 [1 + 4.2 \times 10^{-3} (t - 20)]$, $20 \le t \le 1080$, where ρ_T is in units of μΩ cm and t is in units of °C; value of resistivity at mp in liquid state to that in solid state 2.1; relative accuracy of measurements order of ± 3%.
276	26	Hust, J.G. and Giarratano, P.J.	1974		8-300	OFHC	Rod specimen fabricated from production OFHC copper: 6.4 mm rod degreased with freon, etched with solution of 50% water and 50% nitric acid, swaged to 3.26 mm with cleaning between each swaging step and vacuum annealed whenever flaking was evident, final anneal before measurement was at 923 K for 1 h, and prior to each anneal specimen was acid etched; residual resistivity ratio RRR = ρ(273.15K)/ρ(4K) = 250; variable-temperature multi-property apparatus used to simultaneously measure thermal conductivity, electrical resistivity, and thermopower; 58 runs conducted on OFHC copper; $$\rho = \sum_{i=1}^{m} b_i [\ln T]^{i-1}$$ least squares fitted to the data using orthonormal fitting techniques, with parameters stated as $b_1 = -3.03423717 \times 10^{-7}$, $b_2 = 1.0871360 \times 10^{-6}$, $b_3 = -1.71261727 \times 10^{-6}$, $b_4 = 1.55906711 \times 10^{-6}$, $b_5 = -9.08503179 \times 10^{-7}$, $b_6 = 3.53969657 \times 10^{-7}$, $b_7 = -9.33564610 \times 10^{-8}$, $b_8 = 1.64546588 \times 10^{-8}$, $b_9 = -1.85507554 \times 10^{-9}$, $b_{10} = 1.20856094 \times 10^{-10}$, and $b_{11} = -3.45814932 \times 10^{-12}$; data, calculated from above equation, extracted from table; typical uncertainty estimate, with 95% confidence, 0.2%; above 20 K temperatures based on IP75-68 temperatured scale and below 20 K based on the NBS P2-20(1965) scale.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
277	32	Kos, J. F. and Moussouros, P. K.	1973		1.5-11	A4	0.0010 Ag, 0.0003 Fe, 0.0001 Bi, < 0.0001 Pb, and < 0.0001 Si; sample from Johnson Matthey; specimen 0.494 mm diam and 4.482 mm long; annealed in vacuum of about 10^{-6} torr for 2 d at 1073 K; temperature of minimum in resistivity T_{min} = 7.65 K and resistivity at T_{min} given as 0.001854 x 10^{-8} Ωm; data extracted from figure with estimated extraction error ± 0.068 K in temperature and ± 0.00000014 x 10^{-8} Ωm in resistivity.
278	32	Kos, J. F. and Moussouros, P. K.	1973		1.4-16	A5	< 0.00007 Fe, < 0.00005 Ni, < 0.00005 Pb, < 0.00005 Sb, < 0.00005 Se, and and < 0.00003 Ag; sample from Atomergic Chemetals Co.; specimen 0.250 mm diam and 3.313 m long; annealed in vacuum of about 10^{-6} torr for 2 d at 1073 K; temperature of minimum in resistivity T_{min} = 11.2 K and resistivity at T_{min} given as 0.00352 x 10^{-8} Ωm; data extracted from figure with estimated extraction error ± 0.068 K in temperature and ± 0.0000034 x 10^{-8} Ωm in resistivity.
279	32, 49	Kos, J. F. and Moussouros, P. K.	1973, 1977		1.3-8.7	A3	< 0.00007 Fe, < 0.00005 Ni, < 0.00005 Pb, < 0.00005 Sb, < 0.00005 Se, and < 0.00003 Ag; sample from Atomergic Chemetals Co.; specimen 0.501 mm diam and 5.326 m long; annealed for 48 h at 1073 K in vacuum of about 10^{-6} torr; temperature of minimum in resistivity T_{min} = 4.58 K; resistivity at T = 0 K 0.000551 x 10^{-8} Ωm; measurement of resistivity carried out using Guild-line nanopot potentiometer and galvoamplifier; accuracy of thermometry about ±10 millidegrees, changes in temperature < 1 millidegree easily detected, and sample chamber could be maintained within ± 2 millidegrees during time required to make a measurement; data points extracted from figure with estimated extraction error ± 0.023 K in temperature and ± 0.000000046 x 10^{-8} Ωm in resistivity.
280	49	Moussouros, P. K. and Kos, J. F.	1973		7.7-55	A3	The above specimen and conditions except ρ_T-ρ_0 versus temperature extracted from figure where ρ_T is measured resistivity corrected for thermal expansion and ρ_0 is residual resistivity; estimated extraction error ± 1.6% in temperature and ± 1.7% in $\rho_T - \rho_0$; data fitted to $\rho_T - \rho_0 = JT^k$ with k = 3.86 ± 0.03 for temperatures between 6.8 K and 11.7 K and k = 4.84 ± 0.03 for temperatures between 11.7 K and 34 K; $\rho_T - \rho_0 - \rho_i$ given in table.
281*	32, 49	Kos, J. F. and Moussouros, P. K.	1973, 1977		1.5-8.5	BU3	< 0.00007 Fe, < 0.00005 Ni, < 0.00005 Pb, < 0.00005 Sb, < 0.00005 Se, and < 0.00003 Ag; sample from Atomergic Chemetals Co.; specimen 0.501 mm diam and 4.640 m long; heated in air for a few seconds until specimen just began to acquire a black coat then annealed at 1073 K for 2 d in vacuum of 10^{-6} torr; resistivity at T = 0 K 0.000632 x 10^{-8} Ωm; measurement of resistivity carried out using Guild-line nanopot potentiometer and galvoamplifier; accuracy of thermometry about ± 10 millidegrees, changes in temperature < 1 millidegree easily detected, and sample chamber could be maintained within ± 2 millidegrees during time required to make a measurement; data points extracted from figure of $\rho - \rho_0$ versus temperature with estimated extraction error ± 0.023 K in temperature and ± 0.000000046 x 10^{-8} Ωm in $\rho - \rho_0$; $\rho - \rho_0 = \rho_i$ given in table.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
282*	49	Moussouros, P.K. and Kos, J.F.	1977		4.5-12	BU3	The above specimen and conditions except $\rho_T - \rho_0$ versus temperature extracted from figure where ρ_T is measured resistivity corrected for thermal expansion and ρ_0 is residual resistivity; estimated extraction error ± 0.80% in temperature and ± 0.83% in $\rho_T - \rho_0$; data fitted to $\rho_T - \rho_0 = JT^k$ with k = 3.75 ± 0.03 for temperatures between 4.2 K and 6.8 K, k = 3.95 ± 0.01 for temperatures between 6.8 K and 11.7 K, and k = 4.41 ± 0.03 for temperatures between 11.7 K and 34 K.
283*	49	Moussouros, P.K. and Kos, J.F.	1977		4.5-12	BU5	< 0.00007 Fe, < 0.00005 Ni, < 0.00005 Pb, < 0.00005 Sb, < 0.00005 Se, and < 0.00003 Ag; sample from Atomergic Chemetals Co.; specimen 0.254 mm diam and 3.737 m long; heated in air for a few seconds until specimen just began to acquire a black coat then annealed at 1073 K for 2 d in vacuum of 10^{-6} torr; resistivity at T = 0 K 0.000802 x 10^{-8} Ω m; measurement of resistivity carried out using Guild-line nanopot potentiometer and galvoamplifier; accuracy of thermometry about ± 10 millidegrees, changes in temperature < 1 millidegree easily detected, and sample chamber could be maintained within ± 2 millidegrees during time required to make a measurement; data points of $\rho_T - \rho_0$ versus temperature extracted from figure where ρ_T is measured resistivity corrected for thermal expansion and ρ_0 is residual resistivity; estimated extraction error ± 0.84% in temperature and ± 0.83% in $\rho_T - \rho_0$; data fitted to $\rho_T - \rho_0 = JT^k$ with k = 3.55 ± 0.02 for temperatures between 4.2 K and 6.8 K and k = 3.99 ± 0.01 for temperatures between 6.8 K and 11.7 K; $\rho_T - \rho_0 = \rho_i$ given in table.
284	49	Moussouros, P.K. and Kos, J.F.	1977		7.3-58	BU5	The above specimen and conditions except data excludes a lower temperature region and includes a higher temperature region; estimated extraction error ± 1.7% in temperature and ± 1.7% in $\rho_T - \rho_0$; data fitted to $\rho_T - \rho_0 = JT^k$ with k = 4.40 ± 0.04 for temperatures between 11.7 K and 34 K.
285*	32, 49	Kos, J.F. and Moussouros, P.K.	1976, 1977		1.3-8.5	AA5	Specimen A5 heated in air at 1 atm pressure for several minutes until it acquired a black coating of CuO and then annealed at 1073 K for about 8 h in a vacuum of 10^{-6} torr; specimen 0.247 mm diam and 1.721 m long; resistivity of T = 0 K 0.000700 x 10^{-8} Ω m; data points extracted from figure of $\rho - \rho_0$ versus temperature with estimated extraction error ± 0.023 K in temperature and ± 0.000000046 x 10^{-8} Ω m in $\rho - \rho_0$; $\rho - \rho_0 = \rho_i$ given in table.
286*	49	Moussouros, P.K. and Kos, J.F.	1977		4.6-11	AA5	The above specimen and conditions except $\rho_T - \rho_0$ versus temperature extracted from figure where ρ_T is measured resistivity corrected for thermal expansion and ρ_0 is residual resistivity; estimated extraction error ± 0.84% in temperature and ± 0.84% in $\rho_T - \rho_0$; data fitted to $\rho_T - \rho_0 = JT^k$ with k = 3.53 ± 0.02 for temperatures between 4.2 K and 6.8 K, k = 4.08 ± 0.02 for temperatures between 6.8 K and 11.7 K, and k = 4.40 ± 0.02 for temperatures between 11.7 K and 34 K; $\rho_T - \rho_0 = \rho_i$ given in table.
287*	49	Moussouros, P.K. and Kos, J.F.	1977		4.8-12	2AA5	Specimen AA5 remeasured after 2 months; specimen 0.247 mm diam and 1.621 m long; resistivity at T = 0 K 0.000822 x 10^{-8} Ω m; data of $\rho_T - \rho_0$ versus temperature extracted from figure where ρ_T is measured resistivity corrected for thermal expansion and ρ_0 is residual resistivity; estimated extraction error ± 0.84% in temperature and ± 0.84% in $\rho_T - \rho_0$; data fitted to $\rho_T - \rho_0 = JT^k$ with k = 3.3 ± 0.1 for temperatures between 4.2 K and 6.8 K; k = 4.12 ± 0.01 for temperatures between 6.8 K and 11.7 K, and k = 4.46 ± 0.04 temperatures between 11.7 K and 34 K; $\rho_T - \rho_0 = \rho_i$ given in table.

* Not shown on either figure.

TABLE 3. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K.	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
288	38	Loram, J. W., Whall, T. E., and Ford, P. J.	1970		0.47-2.7	No. 6	Analyzed Fe concentration 0.0011 (0.0013 at.%); alloy made by induction melting [illegible] pure Cu and a Cu(0.01 at.% Fe) master alloy, prepared in tape form, etched in [illegible] nitric acid, annealed in vacuum at 1173 K for 6 h, and quenched in iced water; resistance measured potentiometrically; data points of ρ versus T^2 extracted from figure with estimated extraction error ± 0.023 in T^2 and ± 0.000002 x 10^{-8} Ω m in resistivity; length to area ratio determined to within ± 0.3%; uncertainty in temperature below 4 K does not exceed 4 millidegrees, above 4 K always less than 0.5%, and over much of the range considerably less than this.
289	38	Loram, J. W., Whall, T. E., and Ford, P. J.	1970		0.49-2.8	No. 7	Similar to the above specimen and conditions except analyzed Fe concentration 0.008 (0.009 at.%), residual resistivity 0.034 x 10^{-8} Ω m, and estimated extraction error ± 0.000009 x 10^{-8} Ω m in resistivity.
290	38	Loram, J. W., Whall, T. E., and Ford, P. J.	1970		0.51-2.8	No. 8	Similar to the above specimen and conditions except analyzed Fe concentration 0.035 (0.040 at.%), residual resistivity not specified, and estimated extraction error ± 0.000045 x 10^{-8} Ω m in resistivity.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu

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

T	ρ
DATA SET 1	
4.2	0.00801
20.4	0.00919
77	0.206
195	1.03
273	1.67
DATA SET 2	
4.2	0.000884
20.4	0.00193
77	0.194
175	1.01
273	1.59
DATA SET 3	
4.2	0.00111
20.4	0.00242
77	0.195*
175	1.000*
273	1.590*
DATA SET 4	
4.2	0.000336
20.4	0.00111
77	0.192*
195	0.996
273	1.580
DATA SET 5	
300	1.73
400	2.40
500	3.06
600	3.66
700	4.27
800	4.90
900	5.56
1000	6.23
1100	6.95
1200	7.83
DATA SET 6	
21.2	0.00143

T	ρ
DATA SET 6 (cont.)	
83.2	0.234
273.2	1.56
DATA SET 7	
21.2	0.00143
83.2	0.234
273.2	1.56
DATA SET 8	
21.2	0.0144
83.2	0.257
273.2	1.576*
DATA SET 9	
21.2	0.00187
83.2	0.235*
273.2	1.56*
DATA SET 10	
21.2	0.00424
83.2	0.239
273.2	1.552*
DATA SET 11	
21.2	0.00499
83.2	0.240*
273.2	1.56*
DATA SET 12*	
21.2	0.00406
83.2	0.240
273.2	1.56
DATA SET 13	
21.2	0.00565
83.2	0.246
273.2	1.60*

T	ρ
DATA SET 14	
21.2	0.0201
83.2	0.259*
273.2	1.59*
DATA SET 15	
21.2	0.0135
83.2	0.249*
273.2	1.58*
DATA SET 16	
21.2	0.0124
83.2	0.247*
273.2	1.57*
DATA SET 17	
21.2	0.0183
83.2	0.257*
273.2	1.585*
DATA SET 18*	
21.2	0.0200
83.2	0.259
273.2	1.59
DATA SET 19*	
21.2	0.0133
83.2	0.248
273.2	1.58
DATA SET 20	
21.2	0.0378
83.2	0.276
273.2	1.61
DATA SET 21	
4.2	0.025
DATA SET 22	
4.2	0.0095

T	ρ
DATA SET 23	
0.035	0.008429*
0.036	0.008431*
0.039	0.008427*
0.041	0.008424*
0.042	0.008418*
0.046	0.008414*
0.050	0.008405*
0.054	0.008396*
0.057	0.008388*
0.061	0.008377*
0.064	0.008375*
0.067	0.008361*
0.070	0.008353*
0.074	0.008340*
0.078	0.008323*
0.082	0.008312*
0.087	0.008292*
0.092	0.008276*
0.099	0.008258*
0.103	0.008249
0.112	0.008219*
0.124	0.008177*
0.132	0.008150*
0.143	0.008122*
0.155	0.008091*
0.173	0.008045*
0.184	0.008020*
0.197	0.007990*
0.207	0.007974
0.214	0.007959*
0.226	0.007938*
0.234	0.007922*
0.251	0.007894*
	007873*
0.284	0.007841*
0.300	0.007813
0.322	0.007787*
0.332	0.007771*
0.344	0.007755*
0.357	0.007738*
0.373	0.007719*
0.391	0.007701*
0.409	0.007678
0.429	0.007654*
0.454	0.007630*
0.483	0.007600*

T	ρ
DATA SET 23 (cont.)	
0.514	0.007571
0.554	0.007540*
0.602	0.007503
0.660	0.007464*
0.733	0.007415
0.820	0.007366
0.939	0.007303
1.105	0.007233
1.215	0.007191
1.350	0.007145
1.480	0.007106
1.565	0.007085
1.740	0.007038
1.845	0.007014
2.030	0.006973
2.180	0.006944
2.450	0.006895
2.800	0.006840
3.070	0.006803
3.410	0.006762
3.610	0.006739
3.815	0.006713
4.060	0.006689
DATA SET 24	
0.035	0.014913*
0.036	0.014919*
0.039	0.014926*
0.041	0.014938*
0.042	0.014945*
0.046	0.014954*
0.050	0.014967*
0.054	0.014980*
0.057	0.014986*
0.061	0.014999*
0.064	0.015009*
0.067	0.015009*
0.070	0.015009*
0.074	0.015014*
0.078	0.015006*
0.082	0.015006*
0.087	0.015002*
0.092	0.014994*
0.099	0.014986*
0.103	0.014972

T	ρ
DATA SET 24 (cont.)	
0.112	0.014958*
0.124	0.014919*
0.132	0.014897*
0.143	0.014869*
0.155	0.014828*
0.173	0.014779*
0.184	0.014745*
0.197	0.014703*
0.207	0.014677
0.214	0.014657*
0.226	0.014623*
0.234	0.014597*
0.251	0.014556*
0.262	0.014522*
0.284	0.014466*
0.300	0.014424
0.322	0.014376*
0.332	0.014347*
0.344	0.014322*
0.357	0.014290*
0.373	0.014258*
0.391	0.014233*
0.409	0.014186
0.429	0.014143*
0.454	0.014094*
0.483	0.014043*
0.514	0.013986
0.554	0.013924*
0.602	0.013854
0.660	0.013774*
0.733	0.013685
0.820	0.013579
0.939	0.013458
1.105	0.013313
1.215	0.013227
1.350	0.013134
1.480	0.013050
1.565	0.013006
1.740	0.012906
1.845	0.012852
2.030	0.012765
2.180	0.012701
2.450	0.012602
2.800	0.012487
3.070	0.012400
3.410	0.012311

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 24 (cont.)	
3.610	0.012263
3.815	0.012211
4.060	0.012159
DATA SET 25	
0.035	0.025613*
0.036	0.025653*
0.039	0.025673*
0.041	0.025709*
0.042	0.025761*
0.046	0.025804*
0.050	0.025852*
0.054	0.025920*
0.057	0.025950*
0.061	0.025984*
0.064	0.026020*
0.067	0.026072*
0.070	0.026104*
0.074	0.026139*
0.078	0.026179*
0.082	0.026211*
0.087	0.026243*
0.092	0.026283*
0.099	0.026319*
0.103	0.026335
0.112	0.026367*
0.124	0.026411*
0.132	0.026420*
0.143	0.026432*
0.155	0.026439*
0.173	0.026434*
0.184	0.026423*
0.197	0.026403*
0.207	0.026391
0.214	0.026379*
0.226	0.026355*
0.234	0.026335*
0.251	0.026299*
0.262	0.026271*
0.284	0.026219*
0.300	0.026175
0.322	0.026124*
0.332	0.026088*
0.344	0.026056*
0.357	0.026020*
0.373	0.025980*
0.391	0.025936*

T	ρ
DATA SET 25 (cont.)	
0.409	0.025884
0.429	0.025832*
0.454	0.025760*
0.483	0.025693*
0.514	0.025613
0.554	0.025517*
0.602	0.025409
0.660	0.025286*
0.733	0.025142
0.820	0.024971
0.939	0.024763
1.105	0.024512
1.215	0.024360
1.350	0.024193
1.480	0.024033
1.565	0.023953
1.740	0.023774
1.845	0.023670
2.030	0.023506
2.180	0.023391
2.450	0.023199
2.800	0.022972
3.070	0.022828
3.410	0.022637
3.610	0.022553
3.815	0.022449
4.060	0.022341
DATA SET 26	
0.035	0.035968*
0.036	0.035984*
0.039	0.036027*
0.041	0.036046*
0.042	0.036073*
0.046	0.036120*
0.050	0.036179*
0.054	0.036237*
0.057	0.036280*
0.061	0.036326*
0.064	0.036381*
0.067	0.036435*
0.70	0.036478*
0.074	0.036533*
0.078	0.036595*
0.082	0.036638*
0.087	0.036708*
0.092	0.036762*

T	ρ
DATA SET 26 (cont.)	
0.099	0.036840*
0.103	0.036883
0.112	0.036976*
0.124	0.037081*
0.132	0.037147*
0.143	0.037214*
0.155	0.037286*
0.173	0.037355*
0.184	0.037389*
0.197	0.037424*
0.207	0.037443
0.214	0.037455*
0.226	0.037467*
0.234	0.037475*
0.251	0.037482*
0.262	0.037482*
0.284	0.037475*
0.300	0.037459
0.322	0.037436*
0.332	0.037420*
0.344	0.037401*
0.357	0.037375*
0.373	0.037350*
0.391	0.037319*
0.409	0.037280
0.429	0.037233*
0.454	0.037179*
0.483	0.037109*
0.514	0.037031
0.554	0.036937*
0.602	0.036829
0.660	0.036692*
0.733	0.036525
0.820	0.036323
0.939	0.036066
1.105	0.035741
1.215	0.035520
1.350	0.035318
1.480	0.035116
1.565	0.035003
1.740	0.034754
1.845	0.034618
2.030	0.034388
2.180	0.034225
2.450	0.033949
2.800	0.033637
3.070	0.033408
3.410	0.033155

T	ρ
DATA SET 26 (cont.)	
3.610	0.033018
3.815	0.032874
4.060	0.032723
DATA SET 27	
0.035	0.042148*
0.036	0.042148*
0.039	0.042148*
0.041	0.042148*
0.042	0.042148*
0.046	0.042232*
0.050	0.042317*
0.054	0.042410*
0.057	0.042480*
0.061	0.042548*
0.064	0.042606*
0.067	0.042672*
0.070	0.042739*
0.074	0.042815*
0.078	0.042895*
0.082	0.042953*
0.087	0.043030*
0.092	0.043103*
0.099	0.043207*
0.103	0.043246
0.112	0.043385*
0.124	0.043516*
0.132	0.043605*
0.143	0.043701*
0.155	0.043811*
0.173	0.043936*
0.184	0.044001*
0.197	0.044071*
0.207	0.044117
0.214	0.044142*
0.226	0.044186*
0.234	0.044211*
0.251	0.044252*
0.262	0.044273*
0.284	0.044302*
0.300	0.044310
0.322	0.044318*
0.332	0.044314*
0.344	0.044310*
0.357	0.044302*
0.373	0.044291*
0.391	0.044271*

T	ρ
DATA SET 27 (cont.)	
0.409	0.044244
0.429	0.044217*
0.454	0.044171*
0.483	0.044121*
0.514	0.044055
0.554	0.043974*
0.602	0.043870
0.660	0.043739*
0.733	0.043577
0.820	0.043373
0.939	0.043102
1.105	0.042755
1.215	0.042541
1.350	0.042290
1.480	0.042059
1.565	0.041932
1.740	0.041646
1.845	0.041488
2.030	0.041230
2.180	0.041041
2.450	0.040721
2.800	0.040355
3.070	0.040085
3.410	0.039785
3.610	0.039627
3.815	0.039453
4.060	0.039276
DATA SET 28	
0.035	0.063498*
0.036	0.063498*
0.039	0.063498*
0.041	0.063498*
0.042	0.063512*
0.046	0.063608*
0.050	0.063693*
0.054	0.063777*
0.057	0.063840*
0.061	0.063905*
0.064	0.063980*
0.067	0.064054*
0.070	0.064114*
0.074	0.064190*
0.078	0.064287*
0.082	0.064375*
0.087	0.064463*
0.092	0.064572*

T	ρ
DATA SET 28 (cont.)	
0.099	0.064696*
0.103	0.064768
0.112	0.064933*
0.124	0.065150*
0.132	0.065302*
0.143	0.065459*
0.155	0.065631*
0.173	0.065856*
0.184	0.065984*
0.197	0.066141*
0.207	0.066233
0.214	0.066309*
0.226	0.066418*
0.234	0.066498*
0.251	0.066631*
0.262	0.066731*
0.284	0.066871*
0.300	0.066984
0.322	0.067088*
0.332	0.067144*
0.344	0.067196*
0.357	0.067249*
0.373	0.067309*
0.391	0.067353*
0.409	0.067405
0.429	0.067441*
0.454	0.067489*
0.483	0.067514*
0.514	0.067534
0.554	0.067538*
0.602	0.067514
0.660	0.067469*
0.733	0.067377
0.820	0.067234
0.939	0.067004
1.105	0.066660
1.215	0.066426
1.350	0.066149
1.480	0.065872
1.565	0.065719
1.740	0.065362
1.845	0.065158
2.030	0.064812
2.180	0.064556
2.450	0.064114
2.800	0.063596
3.070	0.063231
3.410	0.062794

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
DATA SET 28 (cont.)		DATA SET 29 (cont.)		DATA SET 30 (cont.)		DATA SET 31		DATA SET 31 (cont.)		DATA SET 32 (cont.)	
3.610	0.062501	0.429	0.082004*	0.112	0.120663*	0.035	0.232517*	0.660	0.244438*	0.184	0.320894*
3.815	0.062308	0.454	0.082108*	0.124	0.120913*	0.036	0.232522*	0.733	0.245397	0.197	0.321157*
4.060	0.062039	0.483	0.082206*	0.132	0.121083*	0.039	0.232569*	0.820	0.246507	0.207	0.321354
		0.514	0.082296	0.143	0.121314*	0.041	0.232587*	0.939	0.247825	0.214	0.321515*
DATA SET 29		0.554	0.082368*	0.155	0.121603*	0.042	0.232622*	1.105	0.249353	0.226	0.321771*
		0.602	0.082429	0.173	0.121945*	0.046	0.232657*	1.215	0.250200	0.234	0.321978*
0.035	0.076660*	0.660	0.082465*	0.184	0.122157*	0.050	0.232709*	1.350	0.251103	0.251	0.322318*
0.036	0.076660*	0.733	0.082458	0.197	0.122419*	0.054	0.232779*	1.480	0.251821	0.262	0.322596*
0.039	0.076660*	0.820	0.082400	0.207	0.122589	0.057	0.232822*	1.565	0.252187	0.384	0.323062*
0.041	0.076660*	0.939	0.082252	0.214	0.122719*	0.061	0.232866*	1.740	0.252877	0.300	0.323455
0.042	0.076778*	1.105	0.081982	0.226	0.122927*	0.064	0.232935*	1.845	0.253195	0.322	0.323897*
0.046	0.076873*	1.215	0.081780	0.234	0.123093*	0.067	0.233005*	2.030	0.253609	0.332	0.324153*
0.050	0.076873*	1.350	0.081520	0.251	0.123355*	0.070	0.233057*	2.180	0.253840	0.344	0.324423*
0.054	0.076967*	1.480	0.081250	0.262	0.123563*	0.074	0.233092*	2.450	0.254035	0.357	0.324732*
0.057	0.077060*	1.565	0.081095	0.284	0.123894*	0.078	0.233197*	2.800	0.254028	0.373	0.325066*
0.061	0.077157*	1.740	0.080727	0.300	0.124160	0.082	0.233284*	3.070	0.253850	0.391	0.325423*
0.064	0.077252*	1.845	0.080518	0.322	0.124441*	0.087	0.233371*	3.410	0.253491	0.409	0.325844
0.067	0.077346*	2.030	0.080146	0.332	0.124606*	0.092	0.233441*	3.610	0.253240	0.429	0.326283*
0.070	0.077441*	2.180	0.079858	0.344	0.124768*	0.099	0.233615*	3.815	0.252909	0.454	0.326869*
0.074	0.077441*	2.450	0.079371	0.357	0.124961*	0.103	0.233685	4.060	0.252518	0.483	0.327441*
0.078	0.077631*	2.800	0.078794	0.373	0.125146*	0.112	0.233859*			0.514	0.328142
0.082	0.077725*	3.070	0.078339	0.391	0.125353*	0.124	0.234155*	DATA SET 32		0.554	0.328910*
0.087	0.077820*	3.410	0.077831	0.409	0.125577	0.132	0.234347*			0.602	0.329826
0.092	0.078010*	3.610	0.077549	0.429	0.125800*	0.143	0.234574*	0.035	0.318291*	0.660	0.330931*
0.099	0.078199*	3.815	0.077254	0.454	0.126077*	0.155	0.234862*	0.036	0.318308*	0.733	0.332142
0.103	0.078266	4.060	0.076933	0.483	0.126370*	0.173	0.235264*	0.039	0.318326*	0.820	0.333626
0.112	0.078531*			0.514	0.126663	0.184	0.235515*	0.041	0.318347*	0.939	0.335482
0.124	0.078867*	DATA SET 30		0.554	0.126978*	0.197	0.235811*	0.042	0.318361*	1.105	0.337773
0.132	0.078976*			0.602	0.127321	0.207	0.236020	0.046	0.318414*	1.215	0.339131
0.143	0.079173*	0.035	0.118900*	0.660	0.127662*	0.214	0.236188*	0.050	0.318449*	1.350	0.340640
0.155	0.079394*	0.036	0.118942*	0.733	0.128034	0.226	0.236456*	0.054	0.318484*	1.480	0.341966
0.173	0.079680*	0.039	0.118980*	0.820	0.128375	0.234	0.236648*	0.057	0.318519*	1.565	0.342660
0.184	0.079838*	0.041	0.119038*	0.939	0.128673	0.251	0.237014*	0.061	0.318571*	1.740	0.344130
0.197	0.080031*	0.042	0.119077*	1.105	0.128860	0.262	0.237265*	0.064	0.318589*	1.845	0.344892
0.207	0.080157*	0.046	0.119154*	1.215	0.128881	0.284	0.237728*	0.067	0.318659*	2.030	0.346011
0.214	0.080251	0.050	0.119211*	1.350	0.128827	0.300	0.238094	0.070	0.318694*	2.180	0.346741
0.226	0.080399*	0.054	0.119327*	1.480	0.128704	0.322	0.238513*	0.074	0.318764*	2.450	0.347716
0.234	0.080510*	0.057	0.119365*	1.565	0.128611	0.332	0.238746*	0.078	0.318842*	2.800	0.348460
0.251	0.080680*	0.061	0.119442*	1.740	0.128346	0.344	0.239001*	0.082	0.318905*	3.070	0.348740
0.262	0.080806*	0.064	0.119519*	1.845	0.128157	0.357	0.239287*	0.087	0.318942*	3.410	0.348758
0.284	0.080019*	0.067	0.119616*	2.030	0.127807	0.373	0.239593*	0.092	0.319063*	3.610	0.348642
0.300	0.081174	0.070	0.119700*	2.180	0.127506	0.391	0.239907*	0.099	0.319170*	3.815	0.348425
0.322	0.081340*	0.074	0.119777*	2.450	0.126944	0.409	0.240290	0.103	0.319256	4.060	0.348090
0.332	0.031430*	0.078	0.119874*	2.800	0.126216	0.429	0.240691*	0.112	0.319410*		
0.344	0.031520*	0.082	0.119951*	3.070	0.125608	0.454	0.241140*	0.124	0.319641*	DATA SET 33	
0.357	0.081614*	0.087	0.120047*	3.410	0.124884	0.483	0.241680*	0.132	0.319803*		
0.373	0.081708*	0.092	0.120163*	3.610	0.124468	0.514	0.242242	0.143	0.320010*	2.9	0.005471
0.391	0.081805*	0.099	0.120288*	3.815	0.124029	0.554	0.242877*	0.155	0.320275*	3.3	0.005492
0.409	0.081906	0.103	0.120413	4.060	0.123540	0.602	0.243595	0.173	0.320629*	3.9	0.005435

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 33 (cont.)	
4.1	0.005447
4.8	0.005432
5.4	0.005405
6.0	0.005338
6.7	0.005400
7.6	0.005394
9.6	0.005339
10.1	0.005294
10.5	0.005308
11.5	0.005316
13.3	0.005339
20.3	0.005942
20.4	0.006317
20.6	0.006120
DATA SET 34	
2.7	0.006680
4.5	0.006588
7.3	0.006549
8.2	0.006536
9.7	0.006515
10.6	0.006515
12.2	0.006549
13.5	0.006579
14.7	0.006640
15.5	0.006652
17.7	0.006897
20.2	0.007396
24.3	0.009132
26.6	0.01046
29.1	0.01209
33.1	0.01645
36.9	0.02123
40.1	0.02786
42.3	0.03223
44.5	0.03704
46.6	0.04310
48.1	0.04762
50.5	0.05587
53.3	0.06849
57.2	0.08264
61.6	0.09901
63.8	0.1136
64.4	0.1235
71.4	0.1449
72.3	0.1562
DATA SET 34 (cont.)	
80.0	0.1887
90.2	0.2632
DATA SET 35	
85	0.248*
90	0.282
100	0.350
110	0.418
120	0.488
130	0.558
140	0.631
150	0.702
175	0.876
200	1.047
225	1.219
250	1.389
273.16	1.546*
275	1.556*
300	1.725*
325	1.893
350	2.062
375	2.229*
DATA SET 36	
278.4	1.578
279.3	1.586*
280.1	1.593
280.5	1.594*
285.3	1.626
290.3	1.663
290.9	1.664*
290.9	1.667*
292.1	1.670*
292.4	1.676*
293.1	1.682
309.2	1.787
325.0	1.892*
331.5	1.936
342.0	2.005
352.6	2.075*
381.6	2.269
382.2	2.275
433.1	2.617
482.4	2.955
666.4	4.224
DATA SET 36 (cont.)	
678.0	4.324
768.8	4.980
865.1	5.692
972.7	6.525
1066.7	7.309
1066.9	7.268
1165.2	8.160
1220.0	8.669
1237.7	8.825
DATA SET 37	
285.3	1.625*
288.9	1.650
290.3	1.661*
431.4	2.605
431.6	2.616*
469.8	2.875
525.9	3.254
571.1	3.573
614.2	3.878
614.3	3.876*
669.7	4.263
678.0	4.325*
681.3	4.352
711.2	4.559
753.2	4.881
808.9	5.272
863.1	5.706*
870.1	5.746
920.9	6.167
997.8	6.776
1009.9	6.857
1072.3	7.329
DATA SET 38	
273.2	1.547*
282.7	1.608*
283.4	1.614*
283.6	1.614*
283.7	1.614*
284.3	1.619*
284.3	1.617*
285.2	1.625*
287.2	1.638
287.6	1.641*
DATA SET 38 (cont.)	
289.7	1.654*
290.7	1.664*
291.0	1.663*
291.8	1.669*
292.7	1.675*
292.7	1.677*
293.3	1.677*
294.3	1.688*
353.9	2.083
355.1	2.092*
457.0	2.780
459.7	2.798*
575.0	3.586
592.1	3.706
592.6	3.709*
673.0	4.257*
674.0	4.275
674.1	4.266*
676.6	4.288*
677.0	4.293*
757.8	4.896*
757.8	4.896*
764.2	4.923*
764.6	4.926
764.7	4.908*
764.8	4.908
769.1	4.958
773.4	4.958*
773.5	4.938*
773.5	4.938*
773.5	4.976*
773.5	4.975*
774.1	4.988*
774.2	4.932*
774.2	4.989*
774.8	4.959*
774.9	4.958*
775.0	4.940*
776.3	4.976*
776.5	4.977*
778.5	4.989
867.4	5.695*
870.5	5.719*
870.5	5.719*
972.4	6.435
972.4	6.437*
973.1	6.519*
DATA SET 38 (cont.)	
973.2	6.520*
973.7	6.529*
973.8	6.528*
1057.6	7.137
1057.7	7.136*
1057.8	7.141*
1072.3	7.269
1072.3	7.270*
1072.6	7.263*
1072.7	7.262*
1074.2	7.293*
1074.3	7.292*
1159.5	8.013
1159.6	8.016*
1171.8	8.152
1171.8	8.154*
1272.1	9.076*
1272.2	9.075
DATA SET 39	
1.631	0.1980
2.038	0.1971
2.414	0.1969
2.670	0.1965
3.475	0.1958
3.800	0.1955
4.192	0.1947
4.950	0.1934
5.630	0.1926
6.370	0.1919
7.410	0.1918
8.780	0.1905
11.510	0.1878
14.490	0.1853
16.970	0.1843
19.030	0.1828
20.850	0.1825
23.190	0.1817
24.240	0.1817*
25.250	0.1813*
26.650	0.1808*
28.072	0.1815
29.468	0.1824*
30.820	0.1835
32.220	0.1839*
33.560	0.1845*
DATA SET 39 (cont.)	
34.820	0.1870
77	0.4114
273	1.1749*
295	1.8677
DATA SET 40	
1.488	0.12271
1.810	0.12276
2.567	0.12224
2.973	0.12143
3.671	0.12092
4.038	0.12096
4.200	0.12065*
4.473	0.12085*
5.004	0.12086
6.710	0.11948
8.842	0.11759
11.530	0.11596
14.722	0.11474
18.060	0.11478
21.650	0.11483
25.092	0.11603
28.326	0.11833*
31.877	0.12162
35.020	0.12857
77	0.3475
273	1.6715*
295	1.8214
DATA SET 41	
2.2958	0.01645
2.6191	0.01652
3.0394	0.01640
3.7764	0.01608
4.0797	0.01604
4.915	0.015906
5.502	0.015682
6.996	0.015440
9.020	0.015411
11.400	0.015418
14.310	0.015557
17.360	0.015915
20.530	0.016590
22.375	0.017900
26.315	0.020050

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 41 (cont.)	
29.050	0.023120
31.175	0.026525
33.640	0.031998
35.875	0.037860
77	0.3031
273	1.6141*
295	1.8090
DATA SET 42	
1.631	0.62164
2.038	0.61918
2.414	0.61795
2.670	0.61787
3.475	0.61377
3.800	0.61221
4.192	0.60978
5.913	0.60041
6.680	0.59615
7.790	0.59104
9.980	0.58196
12.820	0.57423
15.770	0.56556
18.180	0.56224
20.220	0.55758
22.020	0.55737*
24.330	0.55530
25.319	0.55542*
26.360	0.55484*
27.760	0.55572
29.184	0.55776*
30.581	0.56144
31.950	0.56456
33.340	0.56468*
34.655	0.56708*
35.925	0.57271
77	0.8896
273	2.5392
295	2.7265
DATA SET 43	
1.488	0.4374
2.188	0.4349
2.466	0.4357
2.732	0.4349
3.064	0.4333
3.364	0.4303

T	ρ
DATA SET 43 (cont.)	
3.725	0.4302
4.151	0.4279
4.640	0.4284*
4.995	0.4269
5.640	0.4256
6.130	0.4241
7.400	0.4197
7.784	0.4180*
8.080	0.4169*
8.550	0.4171
9.755	0.4109
10.425	0.4097
11.145	0.4072*
11.614	0.4060*
12.265	0.4042*
12.854	0.4023
17.570	0.4010
24.380	0.3959
29.480	0.3969
34.080	0.4035
77	0.6791
273	2.0704
295	2.2289
DATA SET 44	
1.5003	0.02967
1.7145	0.02951
2.1476	0.02934
2.6194	0.02926
4.8930	0.02862
5.4664	0.02861
5.998	0.02860
6.593	0.02841
7.550	0.02841
9.598	0.02831
12.220	0.02830
15.378	0.02863
18.730	0.02841
22.310	0.03065
25.778	0.03338
29.013	0.03766
32.582	0.04512
35.700	0.05485
77	0.4195*
273	1.8365
295	1.9886

T	ρ
DATA SET 45	
2	0.00941
4	0.00932
14	0.00921
20	0.00956
80	0.216
273	1.55*
DATA SET 46	
1.1	0.463
1.7	0.466
2.4	0.474
3.0	0.475
4.0	0.478
5.3	0.478
6.1	0.478
7.9	0.476
8.8	0.475
9.7	0.473
10.5	0.468
12.5	0.468
14.3	0.464
15.3	0.464*
16.2	0.463*
17.2	0.464*
18.2	0.460*
18.8	0.460*
20.2	0.458
25.2	0.458
28.2	0.462*
30.5	0.465
36.1	0.476*
40.2	0.486
44.9	0.504*
49.5	0.523
58.4	0.571
64.2	0.606
72.1	0.654
77.2	0.690
DATA SET 47	
17.2	0.0514
21.3	0.0526
24.2	0.0542
29.0	0.0588
34.0	0.0665

T	ρ
DATA SET 47 (cont.)	
39.5	0.0796
59.9	0.157
68.9	0.204
79.6	0.265
94.4	0.365
106	0.451
131	0.626
192	1.024*
DATA SET 48	
1.49	0.004634
1.67	0.004632
1.93	0.004618
2.30	0.004613
2.84	0.004591
3.52	0.004585
4.22	0.004604
5.52	0.004576
7.52	0.004596
16.3	0.00495
20.1	0.00557
25.7	0.00769
30.4	0.0113
36.1	0.0194
43.2	0.0317
55.7	0.0779
64.9	0.124
77.4	0.192*
92.7	0.285
103	0.370
126	0.559
185	0.957
DATA SET 49	
1.55	0.05731
2.04	0.05724
2.35	0.05715
2.85	0.05692
3.54	0.05678
6.13	0.05626
7.30	0.05598
8.45	0.05585
9.40	0.05580
9.87	0.05580
19.8	0.0587
24.7	0.0609

T	ρ
DATA SET 49 (cont.)	
29.9	0.0657
55.4	0.142
65.2	0.187
74.6	0.249
91.2	0.355
DATA SET 50	
1.1316	0.07190
2.0919	0.06938
2.5020	0.06839
2.8233	0.06838*
3.1890	0.06796
3.4657	0.06798*
3.6870	0.06782*
3.8703	0.06790*
4.1969	0.06750
12.39	0.06215
18.62	0.06416
21.36	0.06327
23.33	0.06290*
24.75	0.06235*
26.08	0.06280
27.93	0.06270*
28.77	0.06328*
30.99	0.06698
32.03	0.06794*
34.37	0.06918
35.77	0.07078
DATA SET 51	
1.6314	0.04818
2.0381	0.04484
2.4141	0.04482*
3.0814	0.04477
4.2000	0.04401
4.78	0.04342*
5.44	0.04324
6.27	0.04274
8.18	0.04170
10.58	0.04069
13.65	0.03974*
16.34	0.03927
18.46	0.03879*
20.34	0.03874
22.77	0.03866*
24.01	0.03846*

T	ρ
DATA SET 51 (cont.)	
24.92	0.03861*
26.32	0.03905
27.74	0.03948*
29.13	0.04011*
30.43	0.04073*
31.86	0.04178
33.27	0.04231*
34.52	0.04449*
35.95	0.04576
DATA SET 52	
1.4882	0.00498
2.1881	0.00491
3.0641	0.00472
3.3639	0.00496*
4.1506	0.00452
4.58	0.00474*
5.01	0.00465
5.55	0.00460*
5.89	0.00454*
6.26	0.00461
6.70	0.00452*
7.10	0.00448
7.52	0.00443*
7.91	0.00441*
8.35	0.00436
9.32	0.00429
9.91	0.00417*
10.24	0.00423*
10.59	0.00411*
10.91	0.00407
11.46	0.00402*
12.10	0.00400*
12.52	0.00397*
12.68	0.00382
13.41	0.00380*
14.68	0.00382*
18.00	0.00390
21.23	0.00407*
26.76	0.00525
31.55	0.00763
35.98	0.01184
DATA SET 53	
2.0381	0.09950
2.4141	0.09890*

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

DATA SET 53 (cont.)

T	ρ
2.6696	0.09835*
3.0814	0.09820
3.20	0.09673*
4.56	0.09386
5.53	0.09230
7.58	0.08914
10.20	0.08942
13.21	0.08832*
15.76	0.08846
17.84	0.08811*
19.68	0.08857
22.05	0.08920
23.16	0.08936*
24.14	0.08977*
25.54	0.09128*
26.96	0.09259*
28.35	0.09400
29.69	0.09529
31.10	0.09707*
32.46	0.09904
33.72	0.10170*
35.16	0.10393

DATA SET 54

T	ρ
2.2958	0.05525
2.6191	0.05548*
3.0394	0.05485
3.3452	0.05468*
3.7764	0.05440*
4.20	0.05407
4.50	0.05380*
4.92	0.05343
7.28	0.05276
10.12	0.05241
13.16	0.05241*
16.36	0.05250
18.21	0.05290*
22.16	0.05437
24.92	0.05586*
27.10	0.05781
29.54	0.06086*
31.79	0.06379

DATA SET 55

T	ρ
2.2958	0.00749
3.0394	0.00719

DATA SET 55 (cont.)

T	ρ
3.3452	0.00725*
4.20	0.007110
6.70	0.006973
8.52	0.006928
10.86	0.007089
13.63	0.007139*
16.66	0.007222
19.89	0.007430*
22.74	0.007892
25.71	0.008718*
28.12	0.010035
30.72	0.011726
33.15	0.014246
35.40	0.017232

DATA SET 56

T	ρ
1.45	0.01053
1.61	0.01061*
1.70	0.01060*
1.76	0.01062
2.10	0.01053*
2.50	0.01054*
2.73	0.01059
2.96	0.01055*
3.46	0.01068*
3.60	0.01056
3.74	0.01054*
4.05	0.01061
4.19	0.01063*
4.22	0.01053

DATA SET 57

T	ρ
1.8	0.0414*
2.6	0.0414
3.6	0.0414
3.9	0.0411*
3.9	0.0405*
4.7	0.0409
4.7	0.0405*
7.9	0.0409
8.7	0.0413
9.7	0.0406
12.4	0.0402*
13.0	0.0406
15.4	0.0407*
16.7	0.0402*

DATA SET 57 (cont.)

T	ρ
18.6	0.0401
20.8	0.0404*
25.2	0.0450
29.3	0.0470
34.6	0.0552
37.2	0.0607
295	1.75*

DATA SET 58

T	ρ
1.7	0.564
2.2	0.564
3.1	0.565
3.5	0.556*
4.4	0.551
5.6	0.540
8.1	0.568
8.6	0.568*
13.0	0.557*
15.0	0.554
18.5	0.534*
21.6	0.532*
25.5	0.532
30.5	0.534*
35.5	0.541
58.4	0.619
68.6	0.673
77.3	0.739*
78.8	0.728
79.3	0.737*
89.9	0.802
295	2.18

DATA SET 59

T	ρ
0.8	0.0874
1.2	0.0875
1.9	0.0873*
2.4	0.0873
3.1	0.0874
4.7	0.0870
6.1	0.0864
7.3	0.0862
8.6	0.0864
9.8	0.0841
11.0	0.0838*
13.2	0.0838*
15.4	0.0838

DATA SET 59 (cont.)

T	ρ
17.3	0.0839*
20.2	0.0851*
23.7	0.0866
27.2	0.0900*
30.0	0.0948
295	1.92

DATA SET 60

T	ρ
1373	20.1

DATA SET 61

T	ρ
90	0.275
294	1.675*

DATA SET 62

T	ρ
293	1.729
297.2	1.757
344.6	2.075
39[illegible].1	2.392
42[illegible].2	2.678
51[illegible].2	3.261
57[illegible].2	3.665
626.2	4.053
708.2	4.609
768.2	5.029
816.2	5.406
920.2	6.195
1036.2	7.179
1154.2	8.213
1218.2	8.843
1274.2	9.421
1314.2	9.948
1339.2	10.450
1355.2	12.020
1361.2	13.170
1366.2	14.780
1370.2	16.060
1373.2	17.350
1376.2	19.280
1390.2	21.210
1416.2	21.820

DATA SET 63

T	ρ
293	1.7347*

DATA SET 63 (cont.)

T	ρ
293.7	2.133
328.7	2.382
634	4.531
637	4.572
1193	9.045
1251	9.547
1266	9.748
1278	9.85
1300	10.05
1323	10.35
1329	11.56
1337	14.57
1338	15.58
1340	16.58
1345	17.59
1349	19.10
1355	20.57
1360	21.31
1393	21.61
1455	22.11
1517	22.61
1580	23.12
1613	23.39
1667	23.78

DATA SET 64

T	ρ
293	1.7347*
496	2.243
502	3.716
713	5.254
798	5.987
813	6.020
1059	8.000
1173	9.000
1210	9.330
1258	9.800
1271	9.942
1280	10.00
1301	10.24*
1307	10.32*
1311	10.50
1313	11.00
1316	12.00
1318	12.50*
1319	13.00
1320	13.50
1323	14.00

DATA SET 64 (cont.)

T	ρ
1324	14.50*
1325	15.00
1327	15.50*
1328	16.00
1329	16.50*
1331	17.00
1333	17.50*
1336	18.00
1337	18.50*
1338	19.00
1340	19.50*
1343	20.00
1346	20.50*
1350	21.10
1351	21.30*
1354	21.40*
1369	21.50
1431	22.00
1496	22.50*
1558	23.00
1620	23.50*
1688	24.00
1714	24.16*
1716	24.17

DATA SET 65

T	ρ
4.11	0.00108
5.21	0.00108
6.61	0.00110
7.96	0.00113
12.76	0.00124
20.70	0.00222
23.66	0.00290
76.38	0.193*

DATA SET 66

T	ρ
4.11	0.0131
7.73	0.0134
8.89	0.0135
9.82	0.0135
21.04	0.0150
22.44	0.0156
24.66	0.0169
61.52	0.131
65.61	0.148
74.99	0.211

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

DATA SET 66 (cont.)

T	ρ
79.98	0.240
83.18	0.271*

DATA SET 67

T	ρ
4.2	0.00101
273.2	1.545*

DATA SET 68

T	ρ
4.2	0.00292
273.2	1.548*

DATA SET 69*

T	ρ
4.2	0.00461
273.2	1.551

DATA SET 70

T	ρ
4.2	0.00692
273.2	1.553*

DATA SET 71

T	ρ
4.2	0.00886
273.2	1.563*

DATA SET 72

T	ρ
4.06	0.00407
7.50	0.00407
11.1	0.00430
13.5	0.00448
16.7	0.00486
19.8	0.00540
22.6	0.00619
28.4	0.0101*
37.9	0.0228
52.7	0.0630
68.2	0.144
96.2	0.317
125	0.531
155	0.753
202	1.11
295	1.67*

DATA SET 73

T	ρ
2	0.0000*
11	0.0000*
25	0.02
39	0.02
44	0.02
50	0.05
55	0.07
77	0.19*
189	0.97
196	1.00*
196	1.04*
210	1.14
215	1.15*
219	1.16*
219	1.20*
221	1.20
236	1.28
242	1.33
271	1.55
291	1.68*
295	1.71
297	1.75*
299	1.77*
300	1.72*
371	2.22*
387	2.29
391	2.31

DATA SET 74

T	ρ
439	2.59
498	3.05
503	3.07*
565	3.44
565	3.48
595	3.73
648	4.13
652	4.15
674	4.29*
744	4.82
748	4.82
748	4.87
748	4.94
754	4.94
777	5.06
781	5.09
784	5.15
796	5.21

DATA SET 75

T	ρ
821	5.40
847	5.60
849	5.62
852	5.64
870	5.80
878	5.84
880	5.89
886	5.91
901	6.02
917	6.16
922	6.22
928	6.22
933	6.31
936	6.29
938	6.32
943	6.35
957	6.46
962	6.53
979	6.64
988	6.71
999	6.80
1002	6.83
1004	6.85
1005	6.89
1008	6.90
1012	6.93
1032	7.05
1042	7.14
1049	7.22
1056	7.27
1083	7.54
1085	7.56
1107	7.69
1119	7.85
1120	7.82
1134	7.99
1136	7.96
1143	8.01
1147	8.06
1153	8.09
1157	8.11
1157	8.16
1158	8.19
1161	8.22
1163	8.17*
1188	8.42

DATA SET 76

T	ρ
45	0.03
55	0.06
71	0.13
120	0.44
187	0.86
250	1.26

DATA SET 77

T	ρ
1.8	0.00258

DATA SET 78

T	ρ
1.8	0.00380

DATA SET 79

T	ρ
81	0.2136*
203	1.1192*
223	1.2559
243	1.3950
263	1.5306
273	1.6002*
293.2	1.7277*
295.2	1.7414*

DATA SET 80

T	ρ
6.71	0.00173
7.83	0.00175
9.16	0.00178
9.93	0.00180
10.89	0.00185*
12.19	0.00192
13.34	0.00201*
14.29	0.00212
15.31	0.00224*
16.44	0.00241
17.30	0.00263*
18.03	0.00281
19.23	0.00317*
20.14	0.00357
297	1.77

DATA SET 81

T	ρ
8.81	0.000596
9.89	0.000606
10.76	0.000621
11.83	0.000646*
13.15	0.000683
13.89	0.000719*
14.69	0.000771
16.03	0.000831*
16.71	0.000906
17.46	0.000985*
18.58	0.001153*
19.86	0.001255
297	1.69*

DATA SET 82

T	ρ
7.59	0.00113
9.20	0.00115
11.38	0.00119
13.55	0.00125
15.63	0.00137
17.26	0.00154
19.05	0.00177
297	1.69*

DATA SET 83

T	ρ
287.2	1.69
417.7	2.61
418.2	2.59
579.2	3.73
743.2	4.88
903.2	6.07
903.7	6.00

DATA SET 84

T	ρ
4.2	0.00569

DATA SET 85

T	ρ
4.2	0.00593

DATA SET 86

T	ρ
298	1.83

DATA SET 87

T	ρ
4.2	0.0173
300	6.27

DATA SET 88

T	ρ
4.2	0.0334
300	7.64

DATA SET 89

T	ρ
4.2	0.0568
300	8.76

DATA SET 90

T	ρ
4.2	0.1266
300	8.62

DATA SET 91

T	ρ
4.2	0.1137
300	7.75

DATA SET 92

T	ρ
4.2	0.1217
300	7.24

DATA SET 93

T	ρ
4.2	0.0678*
300	6.82

DATA SET 94

T	ρ
1.8	0.0240
2.5	0.0236
3.4	0.0230
3.8	0.0227*
4.4	0.0227
5.4	0.0223
6.2	0.0221
7.2	0.0219
8.9	0.0218
10.6	0.0217
12.7	0.0216*
15.0	0.0217
17.9	0.0221*
19.8	0.0228
23.7	0.0243
27.3	0.0267

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 95	
1.9	0.0447
2.5	0.0439
3.3	0.0431
3.8	0.0427*
4.3	0.0423
5.3	0.0416
6.4	0.0411
7.2	0.0409
8.9	0.0404
10.5	0.0400
12.7	0.0399*
15.1	0.0400
17.9	0.0402*
21.2	0.0412
22.9	0.0417*
28.6	0.0447
DATA SET 96	
1.8	0.1270
2.4	0.1262*
3.3	0.1244
3.8	0.1228*
4.2	0.1219*
5.3	0.1202
6.2	0.1193
7.3	0.1182
8.8	0.1172*
10.6	0.1165
12.7	0.1158*
15.0	0.1156
18.0	0.1158*
19.6	0.1163
23.2	0.1179*
27.5	0.1212
DATA SET 97	
1.7	0.3679
2.4	0.3710
3.8	0.3720
4.3	0.3725
5.5	0.3712
6.3	0.3698
7.3	0.3696
8.8	0.3679
10.6	0.3660
12.6	0.3646*
DATA SET 97 (cont.)	
14.2	0.3637
17.8	0.3633*
20.0	0.3635
22.9	0.3641*
28.1	0.3678
DATA SET 98	
2.3	0.0328
2.6	0.0326*
3.1	0.0324
3.6	0.0322*
3.9	0.0320*
4.4	0.0319
5.2	0.0316
6.6	0.0312
8.4	0.0310
10.0	0.0308
11.6	0.0306*
13.6	0.0304
15.6	0.0303*
18.8	0.0307
21.3	0.0314*
23.9	0.0324
DATA SET 99	
2.3	0.0872
2.5	0.0868*
3.0	0.0864
3.5	0.0862*
4.2	0.0856
5.1	0.0846
6.5	0.0835
8.3	0.0820
10.1	0.0810
11.6	0.0802*
13.6	0.0794
15.6	0.0788*
18.7	0.0784
21.4	0.0788*
23.9	0.0800
DATA SET 100	
2.2	0.2813
2.6	0.2802*
3.0	0.2787
DATA SET 100 (cont.)	
3.5	0.2772*
3.9	0.2752*
4.4	0.2736
5.1	0.2712
6.6	0.2665
8.3	0.2617
10.1	0.2582
11.6	0.2551*
13.5	0.2516
15.6	0.2489*
18.8	0.2463
21.5	0.2445
23.7	0.2447
25.7	0.2453*
27.7	0.2466
29.5	0.2488*
32.6	0.2539
DATA SET 101	
2.2	0.9183
2.5	0.9198*
3.8	0.9028
4.4	0.9021
6.5	0.8825
8.4	0.8680
10.1	0.8583
11.6	0.8460*
13.6	0.8379*
15.7	0.8300
18.7	0.8185
21.4	0.8094
23.7	0.8047*
25.9	0.8014
27.8	0.8006*
29.6	0.8024
31.0	0.8060*
32.5	0.8090
DATA SET 102	
1.7	0.0216
2.5	0.0211
3.4	0.0211
3.7	0.0209*
4.1	0.0207
5.2	0.0207
6.2	0.0205
DATA SET 102 (cont.)	
7.3	0.0202
9.1	0.0199
10.0	0.0198
10.6	0.0198*
12.4	0.0198*
14.9	0.0199
16.1	0.0200*
17.7	0.0201
19.6	0.0203*
21.2	0.0207
23.0	0.0214*
24.5	0.0222
DATA SET 103	
1.7	0.0543
2.6	0.0535
3.3	0.0523
3.8	0.0519*
4.2	0.0514
5.3	0.0506
6.2	0.0500
7.4	0.0495
9.0	0.0488
10.2	0.0487
10.7	0.0483*
12.3	0.0479
13.7	0.0478*
14.8	0.0473
16.3	0.0469*
17.6	0.0467
19.6	0.0470*
21.2	0.0474
22.9	0.0482*
24.4	0.0486
DATA SET 104	
1.9	0.0852
2.6	0.0826
3.3	0.0795
3.8	0.0786*
4.2	0.0771
5.2	0.0756
6.2	0.0740
7.3	0.0724
9.0	0.0707
10.1	0.0694
DATA SET 104 (cont.)	
10.8	0.0692*
12.2	0.0683
13.7	0.0676*
14.9	0.0668
16.2	0.0668*
17.7	0.0665
19.7	0.0665*
21.1	0.0661
22.9	0.0663*
24.5	0.0668
26.0	0.0682*
28.4	0.0701
DATA SET 105	
1.3	0.1603
1.7	0.1566*
2.0	0.1553
2.3	0.1543*
2.6	0.1544*
2.6	0.1522*
3.0	0.1503
3.5	0.1493*
3.5	0.1487*
4.2	0.1459
4.6	0.1446*
4.9	0.1424*
5.5	0.1403
6.3	0.1378*
6.8	0.1363*
7.9	0.1334
9.0	0.1310
11.2	0.1274*
13.9	0.1247
16.3	0.1228
18.9	0.1220
20.4	0.1212*
22.0	0.1215
25.0	0.1244
28.7	0.1293
DATA SET 106	
1.8	0.3190
2.6	0.3089
3.4	0.3014
3.7	0.2980*
4.2	0.2953
DATA SET 106 (cont.)	
5.3	0.2879
6.3	0.2826
7.4	0.2783
9.1	0.2720
10.0	0.2679
10.7	0.2659*
12.3	0.2619
13.8	0.2587*
14.9	0.2558
16.3	0.2534*
17.7	0.2507
19.7	0.2486*
21.3	0.2479
23.0	0.2468*
24.6	0.2459
25.9	0.2464
28.4	0.2482
30.0	0.2505*
30.8	0.2520
DATA SET 107	
2.6	0.0624
3.5	0.0623
4.0	0.0622*
4.4	0.0620*
5.1	0.0618
5.9	0.0617*
7.5	0.0615
11.3	0.0613
15.3	0.0617
18.2	0.0626
27.0	0.0674
DATA SET 108	
2.4	0.1315
2.9	0.1313*
3.4	0.1312
4.4	0.1308
5.9	0.1304
6.7	0.1303
9.6	0.1296
10.8	0.1295*
13.8	0.1296
16.9	0.1300*
19.0	0.1308
23.2	0.1330*
25.8	0.1347

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

DATA SET 109

T	ρ
2.6	0.6267
3.4	0.6268
3.9	0.6263*
5.1	0.6261
5.9	0.6255*
7.3	0.6253
11.3	0.6247
15.3	0.6247
18.1	0.6254
26.9	0.6312

DATA SET 110

T	ρ
2.1	1.5467
2.7	1.5452*
3.4	1.5361
4.2	1.5452
5.1	1.5499
5.9	1.5467*
7.3	1.5423
11.0	1.5455
11.3	1.5421*
15.4	1.5418
18.2	1.5418
25.9	1.5497

DATA SET 111

T	ρ
2.4	3.426
3.1	3.426
3.6	3.430*
4.0	3.430
4.5	3.442*
5.9	3.422
6.4	3.414*
9.6	3.445
11.3	3.438*
13.3	3.445
16.5	3.450*
20.3	3.450
24.7	3.445*
28.2	3.445
31.9	3.442
38.3	3.453
43.7	3.466
47.3	3.481

DATA SET 112

T	ρ
368	2.24
508	3.18
739	4.83
770	5.03

DATA SET 113

T	ρ
302	1.80
409	2.50
559	3.52
744	4.85

DATA SET 114

T	ρ
96.4	0.375*
97.5	0.375
99.3	0.384*
100.2	0.394*
100.5	0.398
102.1	0.401*
103.2	0.410*
114.2	0.484
118.0	0.508*
122.0	0.543*
129.3	0.579*
131.6	0.612*
136.3	0.637
139.8	0.677*
142.9	0.707
168.2	0.884
171.2	0.909*
176.2	0.936*
182.1	0.989
237.2	1.365
240.5	1.388*
256.2	1.502*
257.7	1.506
273.2	1.620*
290.1	1.753
290.1	1.750*

DATA SET 115

T	ρ
4.10	0.001279
10.0	0.001294
12.4	0.001390*
14.3	0.001459
15.7	0.001614*

DATA SET 115 (cont.)

T	ρ
16.2	0.001706*
17.2	0.001706*
17.2	0.001786
18.4	0.002080*
19.5	0.002080
21.0	0.002742*
22.8	0.002931
26.4	0.004819*
29.7	0.009120
31.8	0.01321*
32.7	0.01374
34.2	0.01435*
35.9	0.01803
39.6	0.02972*
41.2	0.03373
43.7	0.04325*
48.8	0.05970
50.4	0.06653*
56.1	0.08810
76.2	0.1828
278.0	1.542

DATA SET 116

T	ρ
4.19	0.001556
9.93	0.001585
12.8	0.001706*
15.1	0.001941
17.9	0.002377*
22.2	0.003491
23.7	0.003999*
25.0	0.004656
25.9	0.005129*
26.4	0.005598*
27.0	0.005970*
27.5	0.006486
28.3	0.007063*
29.5	0.008590
33.3	0.01294*
34.9	0.01633
37.3	0.02275*
39.6	0.02825*
41.0	0.03126
42.7	0.03926*
47.0	0.05297
49.2	0.06180*
55.0	0.08222
57.5	0.09616*

DATA SET 116 (cont.)

T	ρ
62.4	0.1169
76.2	0.1972*

DATA SET 117

T	ρ
4.13	0.0124
16.3	0.0126
18.0	0.0126*
19.7	0.0126*
20.5	0.0136*
21.6	0.0133*
23.1	0.0138
24.2	0.0144*
24.5	0.0158*
25.0	0.0149*
25.9	0.0157*
26.5	0.0163*
27.5	0.0168*
27.5	0.0185*
28.3	0.0179*
29.0	0.0195
30.0	0.0204*
31.3	0.0226*
36.1	0.0345
36.6	0.0373*
37.8	0.0382*
39.4	0.0406*
40.7	0.0454*
41.0	0.0533
42.1	0.0513*
44.7	0.0638*
46.9	0.0728
47.6	0.0774*
58.8	0.122
75.7	0.212*

DATA SET 118

T	ρ
4.19	0.00940*
17.8	0.00968
19.5	0.0101
20.9	0.0105
23.4	0.0115
26.0	0.0138
30.9	0.0189

DATA SET 119

T	ρ
81	0.38
97	0.41
193	1.14
273	1.55*
303	1.83
381	2.29
486	3.05
563	3.52
646	4.18
749	4.84

DATA SET 120

T	ρ
88	0.258

DATA SET 121

T	ρ
88	0.300

DATA SET 122

T	ρ
88	0.270

DATA SET 123

T	ρ
88	0.245

DATA SET 124

T	ρ
15	0.00293
20	0.00356*
25	0.00526
30	0.00906*
40	0.0248
50	0.0528
60	0.0978
70	0.156
80	0.218*
90	0.283*
100	0.353*
120	0.493*
140	0.638*
160	0.778
180	0.923
200	1.06*
220	1.20
250	1.40*
273	1.55*
295	1.70*

DATA SET 125

T	ρ
320.1	1.92
362.6	2.18
407.7	2.50*
443.0	2.72
505.4	3.17
596.4	3.81
684.3	4.43
722.6	4.67
772.5	5.03

DATA SET 126

T	ρ
329	5.41
359	5.64
439	6.17
476	6.46
554	6.95
593	7.18
674	7.58
697	7.88
741	8.27
788	8.68
846	9.10
914	10.01
956	10.32

DATA SET 127

T	ρ
322.2	4.88
370.2	5.30
419.0	5.74
491.7	6.33
561.2	6.88
610.2	7.25
667.2	7.67
714.2	8.16
741.2	8.16
826.8	9.26
873.8	10.12
937.5	10.53
1000.7	11.16

DATA SET 128

T	ρ
330	7.02
371	7.47
434	7.95
506	8.36

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 128 (cont.)	
565	8.36
677	8.36
733	9.22
804	10.43
857	11.04
895	11.56
931	11.96
988	12.67
DATA SET 129	
329.0	5.66
374.2	6.06
427.2	6.55
491.2	7.09
558.2	7.57
573.2	7.86
688.2	8.35
743.2	9.66
810.2	10.45
873.2	11.24
918.2	11.47
999.2	12.87
DATA SET 130	
333	8.08
367	8.45
414	9.06
482	9.65
548	9.59
613	8.52
723	9.09
773	10.22
820	11.51
860	11.98
932	12.99
DATA SET 131	
337.2	7.84
375.2	8.24
421.2	8.68
467.2	9.10
517.2	9.46
568.2	8.56
607.2	8.48
630.2	8.33

T	ρ
DATA SET 131 (cont.)	
662.2	8.19
710.2	8.86
756.2	9.82
816.2	11.48*
875.2	12.65
916.2	13.15
969.2	13.83
DATA SET 132	
321	1.92*
361	2.23
404	2.55
441	2.78
503	3.23
592	3.89
682	4.54
719	4.78
767	5.17
DATA SET 133	
597	3.89
703	4.65
766	5.14
840	5.72
940	6.51
999	7.04
1115	8.03
1225	9.38
1243	9.60
DATA SET 134	
291	1.93
DATA SET 135	
291	1.81
373	2.40
DATA SET 136*	
291	1.78
373	2.36

T	ρ
DATA SET 137	
291	1.75*
373	2.30
DATA SET 138	
20.7	0.00413
90.7	0.2898*
273.1	1.552*
291.1	1.673*
293.7	1.690*
374.7	2.232*
DATA SET 139	
21.5	0.0188
91.4	0.3142
273.1	1.590*
291.1	1.712*
298.3	1.760*
374.6	2.282*
DATA SET 140	
575	3.46
629	3.82
684	4.20
730	4.52
773	4.82
798	5.00
812	5.10
863	5.48
877	5.59
906	5.80
928	5.98
953	6.17
998	6.53
1027	6.76
1051	6.95
1087	7.25
1120	7.53
1154	7.82
1191	8.16
1219	8.42
1245	8.65
1280	8.98
1311	9.29
1328	9.47

T	ρ
DATA SET 141	
273	1.55
323	1.88
373	2.22
423	2.56
473	2.90
523	3.24
573	3.58*
623	3.92
673	4.28*
723	4.64
773	5.00
DATA SET 142	
82.0	0.224
86.7	0.229
92.5	0.273
97.2	0.310
101.2	0.352*
111.7	0.415
121.2	0.482
132.0	0.567
142.4	0.633
152.3	0.708
162.1	0.772*
172.5	0.832
181.7	0.904
192.3	0.983*
201.8	1.047*
211.7	1.115*
222.8	1.184
231.9	1.243
242.8	1.297
252.0	1.379*
261.3	1.444
272.0	1.512*
281.9	1.580*
291.6	1.651*
DATA SET 143	
90	0.291
194.7	1.06
273	1.59
373	2.23

T	ρ
DATA SET 144	
293	1.75
323	1.93
373	2.25
473	2.93
573	3.60
673	4.33
773	5.08
873	5.88
1173	8.30
DATA SET 145*	
293	1.78
323	1.95
373	2.28
DATA SET 146	
293	1.73*
323	1.93*
373	2.27
473	2.97
573	3.68
673	4.43
773	5.17
873	5.95
DATA SET 147	
4.2	0.0357
10	0.0355
20	0.0362
30	0.0436
40	0.0628
50	0.0964
60	0.1437
70	0.2023
83	0.2902
103	0.4316
123	0.5749
143	0.7189
163	0.8620
183	1.0031
203	1.1428
223	1.2816
243	1.4197
263	1.5574
273	1.6264*

T	ρ
DATA SET 148	
4.2	0.7438
10	0.7442
20	0.7467
30	0.7590
40	0.7873
50	0.8287
60	0.8816
70	0.9441
83	1.0381
103	1.1703
123	1.3115
143	1.4531
163	1.5927
183	1.7293
203	1.8655
223	2.0030
243	2.1365
263	2.2706
273	2.3381
DATA SET 149	
10	0.7883
20	0.7532
30	0.7482
40	0.7676
50	0.8057
60	0.8561
70	0.9180
83	1.0065
103	1.1421
123	1.2804
143	1.4174
163	1.5542
183	1.6881
203	1.8213
223	1.9534
243	2.0852
263	2.2152
273	2.2812
DATA SET 150	
4.2	0.9407
10	0.9031
20	0.8594
30	0.8429
40	0.8517*

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 150 (cont.)	
50	0.8792
60	0.9205
70	0.9718
83	1.0764*
103	1.1680
123	1.2941*
143	1.4237*
163	1.5500*
183	1.6753*
203	1.8028*
223	1.9306*
243	2.0572*
263	2.1847*
273	2.2482*
DATA SET 151	
4.2	0.8336
10	0.8330
20	0.8339
30	0.8452
40	0.8758
50	0.9213
60	0.9811
70	1.0492
83	1.1537
103	1.3010
123	1.4498
143	1.5995
163	1.7447
183	1.8893
203	2.0319
223	2.1729
243	2.3224
263	2.4510
273	2.5202
DATA SET 152	
4.2	1.9165
10	1.9165
20	1.9187
30	1.9360
40	1.9695
50	2.0204
60	2.0816
70	2.1471
83	2.2565
103	2.4061
DATA SET 152 (cont.)	
123	2.5560
143	2.6998
163	2.8494
183	2.9947
203	3.1412
223	3.2835
243	3.4248
263	3.5680
273	3.6393
DATA SET 153*	
3.2	0.000314
DATA SET 154*	
293	1.696
473	2.927
DATA SET 155	
293.2	3.381
473.2	4.695
DATA SET 156	
293.2	1.903
473.2	3.108
DATA SET 157	
293.2	2.184*
473.2	3.401
DATA SET 158*	
293.2	1.902
473.2	3.156
DATA SET 159*	
305.2	1.792
DATA SET 160*	
78	0.232
273	1.608
DATA SET 161*	
296.2	1.97
DATA SET 162	
273.2	2.186
373.2	2.957
DATA SET 163*	
4.2	0.0012
273.2	1.596
DATA SET 164	
1.47	0.191
2.05	0.193
2.55	0.196
3.05	0.198
3.55	0.202
4.16	0.205
DATA SET 165	
1.62	0.578
2.19	0.583
2.95	0.592
3.34	0.594
3.47	0.601
4.12	0.611
DATA SET 166*	
293	1.75
DATA SET 167*	
4.2	0.015
300	1.88
DATA SET 168*	
4.2	0.010
300	1.81
DATA SET 169*	
300	1.74
DATA SET 170*	
4.2	0.00254
273.2	1.549
DATA SET 171	
373	2.30*
473	3.00
573	3.70
673	4.45
773	5.20
873	6.02
973	6.90
DATA SET 172	
373	2.85
473	3.70
573	4.55
673	5.40
773	6.40
873	7.40
973	8.75
DATA SET 173	
373	4.25
473	5.6
573	7.3
673	9.0
773	11.15
873	13.1
973	15.1
DATA SET 174	
373	6.2
473	7.9
573	9.8
673	11.8
773	13.7
873	15.7
973	17.7
DATA SET 175	
323	2.2
DATA SET 176	
1364	22.78
1421	23.99
1521	26.05
1565	27.49
DATA SET 177	
281	1.97
293	2.00
311	2.11
328	2.17
351	2.27
368	2.44
389	2.55
407	2.73
432	2.81
449	2.99
472	3.14
488	3.26
510	3.38
532	3.51
552	3.68
572	3.84
592	4.00
612	4.14
633	4.27
654	4.40
673	4.53
692	4.71
715	4.81
737	4.98
758	5.12
778	5.36
796	5.48
821	5.68
839	5.84
860	5.96
878	6.16
901	6.32
922	6.44
937	6.59
959	6.76
979	6.97
1001	7.10
1020	7.25
1041	7.47
1061	7.63
1079	7.88
1100	8.02
DATA SET 177 (cont.)	
1119	8.17
1141	8.37
1159	8.52
1178	8.66
1198	8.92
1210	9.02
1228	9.28
1249	9.41
1270	9.63
1289	9.86
1309	10.05
1328	10.28*
1351	10.58
DATA SET 178	
1273	9.46
1291	9.78
1313	9.87
1331	10.21
1352	10.43
1373	21.16
1393	21.32
1413	21.60
1433	21.80
1453	21.97
1473	22.12
DATA SET 179	
437.1	2.53
452.6	2.63
478.9	2.79
512.4	3.00
543.0	3.19
607.8	3.61
643.8	3.85
686.7	4.13
723.4	4.38
770.4	4.70
822.9	5.07
873.5	5.43
925.1	5.80
973.1	6.16
1013.1	6.46
1043.8	6.70
1083.3	7.02
1113.6	7.26
1171.0	7.74
1222.5	8.18

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 180	
76.1	0.2887*
191.3	1.0243
233.8	1.2975
273.70	1.5639*
289.60	1.6705*
291.40	1.6816*
291.45	1.6818*
333.10	1.9609
371.10	2.2158*
414.3	2.4977
478.2	2.9269
DATA SET 181	
50.0	0.1436
53.9	0.1600
54.0	0.1613*
76.1	0.2887
DATA SET 182	
76	0.178*
91	0.272*
173	0.757
273.9	1.353
291.40	1.447
366.4	1.881
DATA SET 183*	
22	0.00217
83	0.235
273	1.56
DATA SET 184	
1.160	0.00017596
1.430	0.00017597*
1.978	0.00017605*
2.203	0.00017611*
2.302	0.00017613*
2.561	0.00017621*
2.833	0.00017630*
2.866	0.00017630*
3.082	0.00017638*
3.274	0.00017649*
3.520	0.00017660*
3.810	0.00017676*

T	ρ
DATA SET 184 (cont.)	
4.028	0.00017690
4.358	0.00017719*
4.607	0.00017743*
4.814	0.00017763
5.133	0.00017804*
5.356	0.00017837*
5.588	0.00017876
5.793	0.00017911*
6.014	0.00017955
6.270	0.00018010*
6.467	0.00018059
6.729	0.00018129
6.980	0.00018220
7.280	0.00018305*
7.451	0.00018365
7.728	0.00018471
8.003	0.00018626
8.251	0.00018748
8.457	0.00018840
DATA SET 185	
1.183	0.0001132
1.201	0.0001133*
1.379	0.0001132*
1.804	0.0001132*
2.085	0.0001133*
2.381	0.0001135*
2.590	0.0001133*
2.922	0.0001136*
3.300	0.0001137*
3.606	0.0001140*
4.007	0.0001142*
4.361	0.0001147*
4.591	0.0001149
4.862	0.0001151*
5.170	0.0001156
5.520	0.0001162*
5.752	0.0001167
5.909	0.0001170*
6.158	0.0001176
6.429	0.0001184
6.737	0.0001193*
6.984	0.0001198
7.218	0.0001205
7.418	0.0001212
7.664	0.0001225
7.872	0.0001232

T	ρ
DATA SET 185 (cont.)	
8.087	0.0001243
8.314	0.0001254
8.504	0.0001261
DATA SET 186	
1.173	0.00021010
1.194	0.00021012*
1.406	0.00021010*
1.653	0.00021013*
1.936	0.00021015*
2.220	0.00021020*
2.470	0.00021028*
2.798	0.00021026*
3.034	0.00021037*
3.312	0.00021068*
3.312	0.00021062*
3.748	0.00021080*
4.105	0.00021103*
4.512	0.00021148*
4.716	0.00021171
5.210	0.00021232*
5.480	0.00021271
5.776	0.00021319*
6.069	0.00021371
6.265	0.00021409*
6.614	0.00021488
6.930	0.00021525
7.272	0.00021610
7.647	0.00021752
7.838	0.00021820
8.099	0.00021923
8.324	0.00022035
8.496	0.00022133
DATA SET 187	
1.1607	0.0002650
1.1677	0.0002650*
1.4081	0.0002650*
1.6472	0.0002651*
2.0006	0.0002651*
2.0671	0.0002652*
2.2852	0.0002652*
2.3929	0.0002653*
2.5525	0.0002653*
2.5808	0.0002653*
2.8587	0.0002655*

T	ρ
DATA SET 187 (cont.)	
2.8678	0.0002655*
3.0961	0.0002656*
3.1611	0.0002656*
3.3943	0.0002658*
3.4818	0.0002659*
3.6611	0.0002660*
3.9338	0.0002663*
4.0136	0.0002663*
4.2278	0.0002666*
4.4089	0.0002668
4.7237	0.0002673
5.1133	0.0002680*
5.3471	0.0002685
5.5709	0.0002691*
5.8800	0.0002699
6.2536	0.0002711
6.5946	0.0002723
6.8236	0.0002732
7.1454	0.0002746
7.4987	0.0002764
7.7906	0.0002781
8.1601	0.0002803
8.3891	0.0002816
DATA SET 188	
84	0.302
98	0.391
123	0.558
148	0.733
173	0.904
198	1.057*
223	1.251*
248	1.418
273	1.577*
298	1.759*
323	1.921*
348	2.083
373	2.249*
398	2.403*
423	2.565*
448	2.730
473	2.888*
498	3.045*
523	3.207
548	3.322
573	3.512
598	3.659*

T	ρ
DATA SET 188 (cont.)	
623	3.797
648	3.941
673	4.093
DATA SET 189	
1373	21.8
DATA SET 190	
1141	9.0
1164	9.6
1180	10.9
1200	10.2
1211	9.8
1230	10.3
1282	10.8
1330	11.0
1363	10.5
1373	21.6
1392	21.0
1405	22.2
1462	23.3
1468	23.4
1541	24.0
1573	24.3
1614	25.6
1700	26.2
1766	27.8
1836	29.6
1908	31.4
1943	32.3
2018	36.7
2060	38.4
2126	42.7
2170	46.6
2195	48.8
2245	53.7
2275	57.4
DATA SET 191	
1373	21.52*
1423	21.97
1473	22.41
1523	22.85
1573	23.29
1623	23.73

T	ρ
DATA SET 191 (cont.)	
1673	24.17
1723	24.61
1773	25.05
DATA SET 192	
1373	20.45
1423	20.81
1473	21.19
1523	21.59
1573	22.05
1623	22.60
1673	23.15
1723	23.69
1773	24.24
1823	24.80
DATA SET 193	
78	0.21
DATA SET 194	
288	1.77
543	3.28
1032	7.18
1138	8.04
1283	9.60
1345	10.6
1355	14.2
1355	16.2
1355	20.0
1365	22.0
1430	22.4
1475	22.9
DATA SET 195	
749	4.73
1215	9.00
1330	10.3
1345	14.2
1345	18.4
1345	21.9
1397	22.2
1457	22.6

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
DATA SET 196		DATA SET 208		DATA SET 220		DATA SET 232		DATA SET 244*		DATA SET 256*	
750	4.1	750	7.4	750	12.0	4	0.0491	4	<0.001	4	<0.001
DATA SET 197		DATA SET 209		DATA SET 221		DATA SET 233		DATA SET 245		DATA SET 257*	
750	4.3	750	7.7	750	11.8	4	0.0635	4	0.0197	4	0.0893
DATA SET 198		DATA SET 210		DATA SET 222		DATA SET 234		DATA SET 246*		DATA SET 258*	
750	4.4	750	8.5	750	11.7	4	0.0723	4	<0.001	4	<0.001
DATA SET 199		DATA SET 211		DATA SET 223		DATA SET 235		DATA SET 247		DATA SET 259*	
750	5.0	750	8.7	750	16.2	4	0.0899	4	0.0259	4	0.0931
DATA SET 200		DATA SET 212		DATA SET 224		DATA SET 236		DATA SET 248*		DATA SET 260*	
750	5.0	750	8.7	750	16.8	4	0.0942	4	<0.001	4	<0.001
DATA SET 201		DATA SET 213		DATA SET 225		DATA SET 237		DATA SET 249*		DATA SET 261*	
750	5.2	750	9.3	750	17.0	4	0.1150	4	0.0368	4	0.114
DATA SET 202		DATA SET 214		DATA SET 226		DATA SET 238		DATA SET 250*		DATA SET 262*	
750	5.2	750	9.3	4	0.0011	4	0.168	4	<0.001	4	<0.001
DATA SET 203		DATA SET 215		DATA SET 227		DATA SET 239		DATA SET 251		DATA SET 263	
750	5.7	750	9.3	4	0.0071	4	0.001	4	0.0476	4	0.162
DATA SET 204		DATA SET 216		DATA SET 228		DATA SET 240*		DATA SET 252*		DATA SET 264*	
750	5.9	750	11.0	4	0.0132	4	<0.001	4	<0.001	4	<0.001
DATA SET 205		DATA SET 217		DATA SET 229		DATA SET 241*		DATA SET 253*		DATA SET 265	
750	6.2	750	12.3	4	0.0206	4	0.00712	4	0.0636	7.0	0.0315
										9.0	0.0315
DATA SET 206		DATA SET 218		DATA SET 230		DATA SET 242*		DATA SET 254*		11.0	0.0317
										13.0	0.0319
750	7.8	750	12.0	4	0.0255	4	<0.001	4	<0.001	15.0	0.0319
										17.0	0.0321
DATA SET 207		DATA SET 219		DATA SET 231		DATA SET 243		DATA SET 255		19.0	0.0325
										20.0	0.0328
750	7.7	750	12.0	4	0.0370	4	0.0132	4	0.0723	21.1	0.0331
										23.0	0.0338
										24.0	0.0344

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 265 (cont.)	
26.0	0.0357
28.1	0.0376
30.0	0.0395
32.11	0.0421
33.1	0.0436
34.9	0.0466
DATA SET 266	
1.73	0.000325
2.00	0.000328
3.25	0.000328*
3.69	0.000331
4.05	0.000331*
4.25	0.000336*
5.33	0.000338
6.46	0.000354*
6.58	0.000352
8.22	0.000360
9.10	0.000367*
9.83	0.000379
11.05	0.000402
12.45	0.000428*
13.77	0.000479*
15.36	0.000560
16.96	0.000675*
18.84	0.000900*
20.59	0.001180
21.95	0.001515*
23.80	0.002058*
25.40	0.002724
26.96	0.003552*
27.01	0.003570*
28.50	0.004536*
30.22	0.005933
32.59	0.008301*
34.79	0.011055
36.88	0.014375*
38.43	0.017232*
39.91	0.020167*
41.60	0.023918
43.68	0.029175*
47.50	0.040410*
50.67	0.051633
55.21	0.070056*
61.33	0.099287*
65.38	0.120798
69.46	0.144561*

T	ρ
DATA SET 266 (cont.)	
75.86	0.183639*
82.96	0.229701*
87.70	0.261739*
93.88	0.304360*
103.41	0.371668*
112.64	0.437530
112.98	0.439765*
123.10	0.512081
123.37	0.514139*
137.25	0.612941*
148.74	0.694696*
148.91	0.695983*
158.15	0.761426*
160.24	0.775937*
163.62	0.792468*
166.38	0.819251*
166.52	0.819846
178.02	0.900366*
188.07	0.970095*
194.06	1.01152*
206.78	1.09884*
206.86	1.09929*
215.59	1.15927
224.22	1.21804*
231.57	1.26812*
241.25	1.33391*
241.33	1.33450*
247.41	1.37563*
247.45	1.37590*
249.71	1.39123*
260.17	1.46201
269.74	1.52711*
273.13	1.54990*
273.15	1.55011*
284.33	1.62542*
296.89	1.70981*
314.67	1.82968
323.76	1.89107*
323.90	1.89196*
DATA SET 267	
300.6	1.74*
301.21	1.74*
301.59	1.799*
302	1.74*
302.04	1.81*
302.61	1.81*

T	ρ
DATA SET 267 (cont.)	
303.13	1.76*
303.34	1.79*
304.0	1.78*
304.31	1.77*
305.2	1.77
305.32	1.81*
316.53	2.24*
394.29	2.44
408.37	2.53
450.28	2.81
455.92	2.85
492.21	3.10
517.55	3.27
534.25	3.36
576.92	3.62
579	3.69
641.50	4.03
705.22	4.59
DATA SET 268	
4.207	0.001328
4.211	0.001327*
4.375	0.001328*
4.476	0.001327*
4.637	0.001329*
4.813	0.001328*
4.877	0.001328*
5.064	0.001327
5.139	0.001327*
5.283	0.001327*
5.356	0.001327*
5.565	0.001327*
5.809	0.001327*
6.083	0.001328
6.111	0.001328*
6.149	0.001329*
6.371	0.001328*
6.789	0.001330*
7.117	0.001331
7.527	0.001332*
8.019	0.001334
8.503	0.001335*
9.137	0.001342
9.810	0.001349*
10.430	0.001356
10.970	0.001365*
11.280	0.001370*

T	ρ
DATA SET 268 (cont.)	
11.580	0.001376*
11.900	0.001384*
12.220	0.001396*
12.550	0.001400*
12.970	0.001419*
13.520	0.001434*
14.280	0.001469*
14.870	0.001500*
15.110	0.001508
15.540	0.001543*
16.350	0.001600*
16.430	0.001607*
16.910	0.001648*
17.310	0.001687*
17.970	0.001761*
18.140	0.001782*
18.500	0.001822*
19.290	0.001937*
19.860	0.002037*
21.360	0.002344
21.550	0.002388*
23.630	0.003012*
26.150	0.004120
29.700	0.006466*
34.570	0.011746
35.560	0.013151*
38.190	0.017503*
42.110	0.025787
45.910	0.035983*
50.640	0.051604*
56.400	0.074946*
63.750	0.110627
68.460	0.136585*
73.250	0.164405*
79.380	0.202637*
85.990	0.245775
89.870	0.271893*
96.350	0.315857*
96.380	0.316235*
108.250	0.398574
121.120	0.488349*
126.670	0.526729*
133.920	0.578063*
138.440	0.609410*
146.240	0.663994
154.800	0.723218*
162.380	0.775541*
170.720	0.832919

T	ρ
DATA SET 268 (cont.)	
181.330	0.905916*
190.160	0.965084*
201.380	1.042460*
209.270	1.094912
220.740	1.173085*
228.270	1.222734*
240.040	1.301836
247.460	1.350757*
260.710	1.440202*
267.910	1.486344
273	1.52203*
296.070	1.674870*
298.650	1.688848*
DATA SET 269	
1.255	0.001663
1.307	0.001661*
1.373	0.001662*
1.438	0.001663*
1.529	0.001662*
1.600	0.001663*
1.665	0.001661*
1.753	0.001663*
1.875	0.001663*
1.943	0.001663*
2.043	0.001661
2.163	0.001661*
2.288	0.001661*
2.383	0.001660*
2.473	0.001645*
2.599	0.001661*
2.716	0.001661*
2.872	0.001662*
3.007	0.001660
3.185	0.001660*
3.332	0.001659*
3.501	0.001659*
3.708	0.001658*
3.943	0.001660*
4.047	0.001660
4.175	0.001661*
4.195	0.001658*
4.322	0.001650*
4.335	0.001642*
4.371	0.001653*
4.486	0.001654*
4.615	0.001630*

T	ρ
DATA SET 269 (cont.)	
4.817	0.001655*
4.969	0.001652*
5.136	0.001657
5.237	0.001657*
5.346	0.001656*
5.499	0.001656*
5.796	0.001649*
6.505	0.001657
7.054	0.001658
7.680	0.001658*
8.456	0.001661
9.347	0.001664
9.860	0.001672*
10.329	0.001677
11.198	0.001690*
11.890	0.001705*
12.581	0.001722*
13.417	0.001748*
14.448	0.001793*
15.079	0.001827
15.825	0.001880*
16.662	0.001950*
17.643	0.002051*
18.818	0.002208*
20.233	0.002457*
22.060	0.002916
23.028	0.003202*
23.959	0.003542*
25.495	0.004221
26.708	0.004863*
28.704	0.006242*
30.368	0.007603
32.137	0.009383*
34.195	0.011916*
35.412	0.013646
35.644	0.013944*
37.940	0.017880*
40.171	0.022370
44.661	0.033489*
48.976	0.047383*
49.236	0.048008*
54.736	0.069308*
61.626	0.101710
70.571	0.151178*
82.196	0.223423*
83.117	0.229584
91.766	0.287554*
101.424	0.354041*

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

DATA SET 269 (cont.)

T	ρ
109.795	0.412357*
117.237	0.464423
125.974	0.525584*
136.655	0.600223
147.825	0.678491*
159.432	0.758464
164.778	0.800919*
175.257	0.867249*
185.672	0.937761
193.191	0.988971*
204.858	1.067411
206.318	1.078533*
228.969	1.229238
249.873	1.370790*
250.302	1.374141*
268.472	1.494264*
290.490	1.640498
296.341	1.677541*

DATA SET 270

T	ρ
1.281	0.003642
1.531	0.003642*
1.755	0.003644*
1.950	0.003640*
2.117	0.003638
2.290	0.003639*
2.504	0.003637*
2.724	0.003637*
2.871	0.003640*
3.012	0.003639
3.185	0.003634*
3.289	0.003633*
3.465	0.003637*
3.652	0.003637*
3.891	0.003639*
4.063	0.003636
4.182	0.003635*
4.283	0.003653*
4.369	0.003638*
4.450	0.003642*
4.471	0.003646*
4.553	0.003645*
4.645	0.003644*
4.761	0.003646*
4.861	0.003644*
4.968	0.003641*
5.100	0.003643

DATA SET 270 (cont.)

T	ρ
5.230	0.003646*
5.349	0.003644*
5.473	0.003644*
5.601	0.003643*
5.743	0.003645*
5.997	0.003646*
6.388	0.003646
6.821	0.003644*
7.365	0.003644
8.112	0.003646
9.389	0.003656
10.175	0.003664*
10.929	0.003676
11.785	0.003686*
12.222	0.003710*
13.197	0.003731*
14.235	0.003779*
14.886	0.003818*
15.697	0.003874
16.526	0.003950*
17.505	0.004058*
18.605	0.004214*
19.970	0.004468*
21.643	0.004890
22.807	0.005269*
23.744	0.005627*
25.222	0.006309
26.387	0.006961*
28.363	0.008318*
29.989	0.009695*
31.758	0.011507
33.813	0.014041*
35.031	0.015793
37.581	0.020065*
39.822	0.024571*
44.288	0.035700
48.683	0.049545*
54.105	0.070463*
60.877	0.102112*
69.740	0.150812
75.308	0.184628*
88.475	0.271162*
94.201	0.310583*
97.833	0.335743
103.593	0.375895*
109.623	0.418279*
113.006	0.442049*
115.591	0.460306*

DATA SET 270 (cont.)

T	ρ
118.745	0.482657*
121.257	0.500395
124.823	0.525414*
130.376	0.564681*
136.333	0.606532*
147.733	0.686597*
154.509	0.733385
160.520	0.775306*
166.809	0.819039*
172.854	0.860673*
178.979	0.902776
185.019	0.943960*
191.138	0.985938*
197.391	1.028660*
203.572	1.070602*
209.769	1.112538*
215.936	1.154136*
222.148	1.196029*
228.727	1.240521*
234.783	1.280995*
240.969	1.322200*
247.348	1.365014
253.598	1.406436
260.168	1.450489*
266.329	1.491410*
272.793	1.534735*
279.034	1.576151*
285.433	1.618789*
291.910	1.661988*

DATA SET 271

T	ρ
1383	21.8
1434	22.1
1449	22.35*
1473	22.5*
1509	22.9
1529	23.05

DATA SET 272

T	ρ
1401	22.0
1417	22.15
1431	22.35
1456	22.55*
1506	22.95

DATA SET 273

T	ρ
1435	22.25*
1479	22.6
1505	22.9*
1534	23.05*
1558	23.25
1579	23.3*
1604	23.4
1622	23.65

DATA SET 274

T	ρ
1373	20.2
1400	20.5
1500	21.5
1600	22.5
1700	23.5
1800	24.5
1873	25.2

DATA SET 275

T	ρ
293	1.73*
300	1.78
350	2.14
400	2.51
500	3.23
600	3.96
700	4.69
800	5.41
900	6.14
1000	6.87
1100	7.59
1200	8.32
1300	9.05
1353	9.43

DATA SET 276

T	ρ
8	0.007156
9	0.007302
10	0.007305
12	0.007132*
14	0.007070
16	0.007243*
18	0.007605*
20	0.008098
25	0.009911*
30	0.01324

DATA SET 276 (cont.)

T	ρ
35	0.01915*
40	0.02845*
45	0.04146*
50	0.05819
60	0.1017*
70	0.1561*
80	0.2180*
90	0.2849*
100	0.3545*
120	0.4972*
140	0.6397*
160	0.7801*
180	0.9185*
200	1.056*
220	1.192*
240	1.328*
260	1.464*
280	1.599*
300	1.732*

DATA SET 277

T	ρ
1.46	0.00188340
1.53	0.00188367*
1.87	0.00188137*
1.87	0.00188056*
2.35	0.00187839
2.62	0.00187663*
2.62	0.00187595*
2.89	0.00187541*
2.89	0.00187514*
3.03	0.00187352
3.24	0.00187243*
3.51	0.00187040*
3.78	0.00186864*
4.06	0.00186647
4.19	0.00186539*
4.74	0.00186160*
4.87	0.00186078*
5.14	0.00185943*
5.42	0.00185794*
5.69	0.00185659*
5.89	0.00185550*
6.23	0.00185429
6.50	0.00185361*
6.64	0.00185293*
6.84	0.00185266*
7.18	0.00185212*

DATA SET 277 (cont.)

T	ρ
7.52	0.00185172*
7.65	0.00185172*
7.92	0.00185186*
8.12	0.00185240*
8.52	0.00185376*
8.86	0.00185471*
8.99	0.00185634*
9.65	0.00185974
10.45	0.00186829*
10.84	0.00187425*
11.36	0.00188253

DATA SET 278

T	ρ
1.35	0.0039446
1.48	0.0039480*
1.89	0.0038554*
1.96	0.0038349*
2.02	0.0038280
2.36	0.0037594*
2.70	0.0037149*
2.70	0.0037011*
2.84	0.0036806*
3.10	0.0036531
3.24	0.0036291*
3.51	0.0036017*
3.78	0.0035709*
4.05	0.0035434*
4.19	0.0035263*
4.93	0.0034646
5.27	0.0034509*
5.47	0.0034371*
5.67	0.0034234*
5.81	0.0034166*
6.08	0.0033960*
6.35	0.0033857*
6.62	0.0033789*
6.82	0.0033651*
7.02	0.0033583
7.22	0.0033480*
7.49	0.0033411*
7.70	0.0033343*
7.97	0.0033240*
8.17	0.0033171*
8.64	0.0032966*
8.91	0.0032966*
9.25	0.0032897*
9.65	0.0032794*

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

T	ρ
DATA SET 278 (cont.)	
9.99	0.0032760
10.46	0.0032760*
10.94	0.0032691*
11.41	0.0032726*
11.61	0.0032726*
12.02	0.0032794
12.62	0.0032863*
13.23	0.0032966*
14.11	0.0033240*
14.65	0.0033686*
15.80	0.0034406
DATA SET 279	
1.319	0.00055723
1.410	0.00055714*
1.796	0.00055677*
1.887	0.00055677*
2.296	0.00055654*
2.523	0.00055627
2.614	0.00055618*
3.182	0.00055581*
3.454	0.00055554*
3.704	0.00055540
4.000	0.00055522*
4.159	0.00055522*
4.727	0.00055512*
4.931	0.00055521*
5.204	0.00055521
5.727	0.00055562*
6.000	0.00055603*
6.296	0.00055649*
6.501	0.00055690
6.751	0.00055754*
7.229	0.00055909*
7.503	0.00056032*
7.708	0.00056110*
8.187	0.00056356*
8.688	0.00056648

T	ρ_i
DATA SET 280	
7.74	0.00001104*
8.13	0.00001219*
8.55	0.00001486*
8.98	0.00001968*
9.44	0.0000232*
9.75	0.0000264*
10.42	0.0000339*
11.51	0.0000486*
11.89	0.0000593*
12.29	0.0000712*
13.13	0.0000881*
14.03	0.0001186
14.50	0.0001596*
15.75	0.000225*
17.39	0.000352*
19.20	0.000577
21.9	0.001099
25.0	0.00202
27.6	0.00343*
30.0	0.00526
34.8	0.01086
40.4	0.01901
44.6	0.0307*
55.2	0.0748
DATA SET 281*	
1.480	0.00000009
1.640	0.00000009
1.823	0.00000013
2.006	0.00000013
2.144	0.00000031
2.395	0.00000031
2.715	0.00000044
2.852	0.00000049
3.219	0.00000067
3.562	0.00000090
3.837	0.00000112
4.043	0.00000131
4.111	0.00000140
4.226	0.00000167
4.501	0.00000181
4.799	0.00000226
4.891	0.00000254
5.143	0.00000295
5.373	0.00000345
5.603	0.00000418

T	ρ_i
DATA SET 281 (cont.)*	
5.833	0.00000473
6.063	0.00000542
6.178	0.00000597
6.385	0.00000652
6.569	0.00000720
6.891	0.00000830
6.985	0.00000922
7.262	0.00001082
7.494	0.00001224
7.725	0.00001380
7.888	0.00001499
8.074	0.00001655
8.329	0.00001833
8.469	0.00001962
DATA SET 282*	
4.53	0.000001725
4.80	0.00000215
4.96	0.00000242
5.21	0.00000297
5.43	0.00000341
5.71	0.00000412
5.95	0.00000467
6.15	0.00000532
6.25	0.00000592
6.46	0.00000654
6.62	0.00000721
6.90	0.00000823
7.13	0.00000907
7.43	0.00001079
7.62	0.00001221
7.94	0.00001359
8.07	0.00001475
8.34	0.00001628
8.48	0.00001812
8.62	0.00001951
8.77	0.0000219
9.06	0.0000242
9.37	0.0000273
9.68	0.0000302
9.84	0.0000330
10.09	0.0000353
10.69	0.0000433
10.87	0.0000486
11.42	0.0000602
11.80	0.0000670

T	ρ_i
DATA SET 283*	
4.54	0.000001797
4.82	0.00000225
4.94	0.00000246
5.24	0.00000305
5.42	0.00000348
5.65	0.00000394
5.95	0.00000468
6.20	0.00000530
6.31	0.00000576
6.47	0.00000636
6.64	0.00000713
6.92	0.00000801
7.16	0.00000884
7.47	0.00001060
7.59	0.00001152
7.99	0.00001325
8.12	0.00001463
8.54	0.00001726
8.83	0.00001922
8.98	0.0000212
9.29	0.0000238
9.61	0.0000265
9.94	0.0000305
10.02	0.0000334
10.37	0.0000372
10.99	0.0000473
11.47	0.0000539
11.86	0.0000616
12.06	0.0000658
12.47	0.0000782
DATA SET 284	
7.29	0.00001140*
7.41	0.00001259*
7.65	0.00001346*
7.77	0.00001439*
8.16	0.00001563*
8.16	0.00001754*
8.29	0.00001901*
8.56	0.0000210*
8.70	0.0000236*
9.28	0.0000265*
9.43	0.0000288*
9.74	0.0000328*
9.90	0.0000351*
10.22	0.0000374*

T	ρ_i
DATA SET 284 (cont.)	
10.39	0.0000420*
10.56	0.0000449*
10.90	0.0000512*
11.26	0.0000547*
11.44	0.0000604*
11.82	0.0000646*
12.80	0.0000912*
14.33	0.0001472
15.29	0.0000215*
16.31	0.000267*
17.11	0.000347*
17.96	0.000445
19.46	0.000598*
21.4	0.000933
22.9	0.001318*
24.4	0.001837*
26.8	0.00277
27.7	0.00316*
31.0	0.00544
35.9	0.01038
38.9	0.01514*
41.5	0.01910*
47.2	0.0308*
58.1	0.0703
DATA SET 285*	
1.297	0.00000000
1.343	0.00000018
1.343	0.00000000
1.915	0.00000031
2.555	0.00000031
3.035	0.00000053
3.287	0.00000062
3.378	0.00000062
3.745	0.00000094
3.814	0.00000103
3.928	0.00000112
4.203	0.00000130
4.409	0.00000162
4.638	0.00000185
5.028	0.00000263
5.418	0.00000327
5.785	0.00000395
5.854	0.00000418
6.038	0.00000473
6.130	0.00000491

T	ρ_i
DATA SET 285 (cont.)*	
6.245	0.00000542
6.429	0.00000587
6.683	0.00000693
6.867	0.00000757
6.937	0.00000812
7.307	0.00001018
7.514	0.00001119
7.745	0.00001210
7.838	0.00001302
8.023	0.00001407
8.279	0.00001609
8.418	0.00001723
8.465	0.00001806
DATA SET 286*	
4.57	0.000001630
4.68	0.000001741
5.11	0.00000244
5.54	0.00000318
5.81	0.00000393
6.10	0.00000472
6.20	0.00000508
6.40	0.00000561
6.66	0.00000650
6.88	0.00000748
7.40	0.00000965
7.58	0.00001083
7.70	0.00001157
7.83	0.00001216
8.02	0.00001342
8.21	0.00001531
8.41	0.00001662
8.69	0.00001881
8.97	0.00002111
9.11	0.00002408
9.56	0.0000275
9.72	0.0000293
9.79	0.0000319
9.95	0.0000343
10.44	0.0000405
11.14	0.0000535

* Not shown on either figure.

TABLE 4. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF COPPER Cu (continued)

DATA SET 287*

T	ρ_i
4.79	0.000001739
5.03	0.00000204
5.23	0.00000234
5.49	0.00000281
5.67	0.00000327
5.90	0.00000373
6.09	0.00000422
6.29	0.00000470
6.39	0.00000511
6.55	0.00000560
6.82	0.00000629
7.04	0.00000700
7.39	0.00000848
7.56	0.00000936
7.81	0.00001078
7.94	0.00001152
8.20	0.00001294
8.33	0.00001453
8.60	0.00001579
8.74	0.00001673
8.88	0.00001788
9.02	0.00001943
9.39	0.0000229
9.54	0.0000251
9.77	0.0000275
10.01	0.0000297
10.01	0.0000309
10.42	0.0000350
10.84	0.0000403
11.75	0.0000566

DATA SET 288

T	ρ
0.466	0.0391179
0.511	0.0391447*
0.512	0.0391233*
0.554	0.0391268
0.593	0.0391286*
0.629	0.0391340*
0.663	0.0391554
0.697	0.0391394*
0.728	0.0391412*
0.816	0.0391108*
0.830	0.0391073*
0.856	0.0391109*
0.856	0.0391037*

DATA SET 288 (cont.)

T	ρ
0.895	0.0391091
0.895	0.0391037*
0.920	0.0390895*
0.955	0.0391002*
0.990	0.0391056*
1.001	0.0390752*
1.056	0.0390788*
1.097	0.0390967*
1.128	0.0390824*
1.186	0.0390824*
1.232	0.0390646*
1.303	0.0390646
1.329	0.0390468*
1.395	0.0390450*
1.488	0.0390487*
1.518	0.0390272*
1.583	0.0390326*
1.604	0.0390077*
1.679	0.0390059*
1.783	0.0390346*
1.820	0.0389917*
1.869	0.0389989*
1.985	0.0389722*
2.063	0.0389848
2.169	0.0389599*
2.275	0.0389474*
2.423	0.0389244*
2.509	0.0389262*
2.619	0.0388817*
2.748	0.0388836

DATA SET 289

T	ρ
0.484	0.166063
0.549	0.166054*
0.570	0.166027*
0.626	0.166018*
0.678	0.165991*
0.678	0.165974*
0.741	0.165965
0.786	0.165947*
0.828	0.165893*
0.867	0.165875*
0.893	0.165857*
0.942	0.165804*
1.011	0.165804*
1.000	0.165768
1.055	0.165759*

DATA SET 289 (cont.)

T	ρ
1.097	0.165723*
1.147	0.165687*
1.204	0.165652*
1.223	0.165616*
1.312	0.165571*
1.387	0.165464*
1.450	0.165464
1.489	0.165437*
1.511	0.165428*
1.612	0.165330*
1.694	0.165267*
1.778	0.165250*
1.894	0.165107*
1.993	0.165008
2.059	0.164928*
2.150	0.164830*
2.263	0.164732*
2.421	0.164571*
2.508	0.164455*
2.622	0.164348*
2.752	0.164187*

DATA SET 290

T	ρ
0.513	0.51041
0.535	0.51023*
0.594	0.51009*
0.631	0.51005
0.682	0.50996*
0.730	0.50973*
0.760	0.50964
0.804	0.50946*
0.858	0.50923*
0.896	0.50914*
0.933	0.50896*
0.969	0.50887*
1.014	0.50869*
1.089	0.50846*
1.130	0.50824
1.169	0.50806*
1.225	0.50788*
1.243	0.50783*
1.339	0.50743*
1.413	0.50715*
1.475	0.50684
1.542	0.50661*
1.613	0.50621*
1.702	0.50584*

DATA SET 290 (cont.)

T	ρ
1.798	0.50544*
1.901	0.50494*
2.005	0.50444
2.077	0.50408*
2.172	0.50363*
2.283	0.50304*
2.431	0.50219*
2.522	0.50178
2.631	0.50124*
2.756	0.50061

* Not shown on either figure.

4.2. Gold

Gold is a metal and in the bulk form shows a deep yellow appearance. It has an atomic number of 79, a relative atomic mass of 196.9665 (see table 1), and is a member of subgroup IB of the periodic table. There is only one stable naturally-occurring isotope with mass number 197, and, therefore, this isotope has a natural abundance of 100% [232, p. B-490]. The crystal structure is face-centered cubic. Gold has a melting point of 1337.58 K and a normal boiling point of 3135 K [228, p. 39a]. Gold has a density of 18.88 Mg m^{-3} at 293.2 K [228, p. 39a]. At 293 K it has a coefficient of thermal linear expansion of 14.2×10^{-6} K^{-1} [228, p. 125]. At 300 K it has a thermal conductivity of 3.17×10^{2} W m^{-1} K^{-1} for well-annealed high-purity material [211, p. I-311]. Gold has a latent heat of fusion of 12.26 kJ mol^{-1} [214, p. 228]. Gold with a purity of 99.999^{+}% is commercially available.

There are 125 sets of experimental data reported in this work for the temperature dependence of the electrical resistivity of gold. Information pertaining to the specimen characterization, measurement conditions, and method of data extraction for each of the data sets is given in table 6. The data are tabulated in table 7. The data are shown in figures 7 and 8; the former figure has logarithmic scales, which highlight the low-temperature region, and the latter figure has both scales linear, which emphasize the high-temperature region. Data for the electrical resistivity exist over the temperature range from 0.03 K to 1773 K.

The earliest data on electrical resistivity of gold reported in this work is that of Dewar and Fleming [12] (data set 99) who in 1892 reported results from 91 K to 370 K on purest soft gold. Other measurements made before 1940 include the 1900 report of Jaeger and Diesselhorst [27] (data sets 74, 75) on two specimens of gold at 291 K and 373 K. Niccolai [52] (data set 103) performed measurements that were reported in 1908 on pure gold from 84 K to 673 K. In 1914 Northrup [119] (data sets 71,72) reported data on chemically pure material from 293 K to 1773 K that is well into the liquid region. Grüneisen and Goens [21] (data sets 1–6) in 1927 reported measurements on several gold specimens over a temperature range of 21 K to 273 K.

Noteworthy measurements at high temperatures include the following. In 1963 Misek and Polak [117] (data set 95) reported measurements on annealed 99.999% pure gold. They covered the temperature range from 273 K to 1201 K. Several years later, in 1967, Iyer and Asimow [108] (data set 84) reported measurements from 292 K to 1175 K for 99.999% pure material. Their data were corrected for thermal expansion and presented in a figure. Laubitz [112] (data sets 7, 8) in 1969 reported data on annealed 99.999% pure gold over the temperature range from 273 K to 1171 K. His data were presented in the form of a polynomial along with a plot of the deviation of the data points from the polynomial. A year later, in 1970, Ascoli et al. [2] (data set 79) reported measurements on well-annealed 99.9995^{+}% pure material. The data were presented as a plot of $\ell n(\rho/T)$ against T where ρ was corrected for thermal expansion. In 1974 Rowland et al. [122] (data set 96) reported measurements on spectroscopically pure gold from 4.2 K to 1200 K, but mostly above 90 K. Their data as reported here are given to two significant digits past the decimal point, though the reported error is ±5%.

Reports on the low-temperature behavior of ρ_i are not all in agreement. In 1959 White and Woods [91] (data set 50) reported measurements on vacuum-annealed 99.999% pure gold from 10 K to 295 K. They presented smoothed data of intrinsic resistivity in tabular form. They found a $T^{5.1}$ dependence for the intrinsic resistivity above 10 K [91, p. 286]. In 1965 Damon and Klemens [99] (data set 10) reported tabular data for the intrinsic resistivity of pure gold, mostly in the range of 80 K to 480 K. In the paper by Damon et al. [100] (data sets 13–5) the measurement range was extended from 40 K down to 10 K, while the same values of ρ_i from 80 K to 480 K were reported. Their data of intrinsic resistivity between 10 K and 14 K indicate a $T^{4.5}$ power relation. In 1968 Stewart [127] (data sets 111–6) reported data for annealed pure gold over the temperature range of 1.6 K to 372 K. Of the two pure gold specimens at low temperatures, one showed a $T^{3.9}$ dependence and the other specimen showed a $T^{4.1}$ behavior [127, p. 32]. In 1970 Cook and Van der Meer [98] (data set 9) reported data from 4 K to 340 K on annealed 99.999% pure gold using a sample cut from the specimen used by Laubitz. Their data indicate a $T^{3.2}$ relation between 20 K and 30 K. In 1973 Fitzer [103] (data set 94) reported the results of an unnamed participant in a program of comparative measurements. The data were taken on 99.999% pure gold from 7 K to 280 K. A power law of $T^{2.6}$ is indicated for 7 K to 10 K after subtracting a residual resistivity of 0.019×10^{-8} Ω m. In 1974 Teixeira [82] (data set 110) reported measurements on vacuum-annealed 99.999% pure gold over a temperature range of 1.3 K to 292 K. He pointed out that his data show a slight departure from a T^{5} dependence, which agrees with the results of White and Woods [82, p. 33]. These disagreements probably arise from problems in sample control, the formal difficulty of separating out the residual resistivity, and the general applicability of Matthiessen's Rule for all impurities. In addition, in 1971, Hust and Sparks [111] (data sets 118–20, see data set 120 in particular) reported intrinsic resistivity from 8 K to 300 K for 99.999% pure gold. In 1974 Mydosh et al. [118] (data set 117) reported intrinsic resistivity data from 10 K to 290 K based on measurements on two specimens of pure gold.

Our evaluated data for the electrical resistivity of pure bulk gold in the solid state were primarily based on the data of Laubitz [112] (data sets 7, 8) and of Cook and Van der Meer [98] (data set 9). In the overlap region the data merged well. One reason for selecting these data sets is the fact that the measurements are for pure specimens of comparable purity with specimen characterization and conditions of the measurements well stated. The data on nominal intrinsic resistivity were computer fitted using eq (12) over the range 60 K to 1200 K. The values for the parameters from the fit were $A=1.2359\times10^{-8}$ Ω m, $B=-9.8996\times10^{-4}$, $C=3.3994\times10^{-2}$, $\theta=172.1$ K, and the fit had an rms fractional deviation of 0.00402. A plot of the fractional deviations against temperature was smoothed to match the data sets. Below 60 K, a plot of ρ_i(nominal)/T^5 was used to obtain interpolated values. From 1200 K to the melting point, values of ρ_i(nominal) were obtained by graphical extrapolation using a plot of ρ_i(nominal)/T against T. The thermal expansion correction using eq (11) was applied to ρ_i(nominal) to obtain ρ_i, and a residual resistivity of 0.0220×10^{-8} Ω m was added to obtain the reported total electrical resistivity. This value of residual resistivity is representative of the residual resistivities of the data used in developing the recommended values. The CINDAS recommended values of $\Delta\ell(T)/\ell(293\ \text{K})$ for gold [228, p. 125], extrapolated from 1300 K to the melting point, were used in the thermal expansion correction.

The uncertainty in the recommendations was arrived at by applying the general ideas mentioned in subsection 3.4. The error estimates given by Laubitz as well as Cook and Van der Meer were supplemented in the high-temperature region by comparison with the data of Ascoli et al. and Misek and Polak. In the low-temperature region comparisons were made between the recommended values and the data of Damon and Klemens, Fitzer, Hust and Sparks, Mydosh et al., Teixeira, and White and Woods.

A check was made to determine whether deviations from Matthiessen's Rule could be expected to be important in gold. For the residual resistivity of 0.0220×10^{-8} Ω m used here, the plots in Cimberle et al. [199, p. 650, figure 4.1] indicate no deviation from Matthiessen's Rule at 41.2 K, approximately 10% deviation at 30.2 K, 5% at 20.0 K, and 33% at 10.7 K. The percentage deviation is $\Delta\times100/\rho_i$ where Δ is defined by eq (2). Because of this large percentage deviation at 10.7 K, no values are given here for the intrinsic resistivity below 15 K.

There are seven data sets reported in this work that contain data for the resistivity of gold in the liquid state or at the melting point. The work of Northrup [119] (data sets 71, 72) was the earliest reported. In 1914 he reported measurements on chemically pure material to 1773 K. The measurements made after the container was preheated to 1523 K showed non-linear behavior from approximately 1500 K to 1773 K. In contrast, measurements made after a preheating to approximately 1873 K showed linear behavior from 1351 K to 1740 K. In 1957 Roll and Motz [64] (data set 85) reported data up to 1461 K for 99.95% pure material, with the thermal expansion correction carried out. The data, presented in a figure, showed linear behavior. The slope of Roll and Motz's data is similar to that of Northrup's data (compare curves 85 and 71). The other data sets are either single point values or cover a very limited temperature range; three of these, those of Howe and Enderby [107] (data set 102), Ozelton et al. [55] (data set 104), and Busch and Güntherodt [97] (data set 105) lie between the data of Northrup and of Roll and Motz. Thus the data on the molten state are fairly consistent.

The evaluated data for the resistivity of molten gold were based on the work of Roll and Motz [64] (data set 85) and of Northrup [119] (data set 71). The data points of Roll and Motz between 1343 K and 1465 K were fitted by a straight line using a least squares criterion to get

$$\rho = 31.08 + 0.01428\,(T - 1337.58) \qquad (18)$$

(T in K, ρ in 10^{-8} Ω m). Because the data of Northrup (data set 71) were also essentially linear up to 1740 K with a slope differing from that of Roll and Motz by less than 1%, the evaluated data to 1740 K are based on eq (18). The estimated uncertainty in the evaluated data is intended to take account of the apparent accuracy of the rotating field method of measurement, the uncertainty estimated by Roll and Motz, and the error in extracting data from their figure. It is 2.5%, which makes the values recommended values, in the usage of CINDAS.

The recommended values for the temperature dependence of the electrical resistivity of gold are tabulated in table 5. The values for the solid and liquid states are corrected for thermal expansion. The values tabulated are for the total electrical resistivity. In addition, the intrinsic resistivity values are given for the solid state. The recommended values for the total resistivity are shown in figures 7 and 8. For the solid state, the values for the total resistivity apply to annealed 99.999% pure or purer bulk gold and the values below 293 K are applicable to a sample obeying Matthiessen's Rule with a residual resistivity of 0.0220×10^{-8} Ω m. (The criterion for the selection of 293 K is that, at this temperature or above, the percentage error in using the intrinsic resistivity instead of the total resistivity, or vice versa, is within the uncertainty in the total resistivity given below.) The values for the intrinsic resistivity apply to pure gold with various impurity concentrations and residual resistivities. Values for the total resistivity of samples other than one with a residual resistivity of 0.0220×10^{-8} Ω m can be obtained by adding the residual resistivity of the particular sample to the intrinsic resistivity. For the liquid state, the values apply to 99.95% pure or purer gold. The uncertainty in the recommended values for the total electrical resistivity is negligible below 7 K, 1% from 7 K to 10 K, 2.5% above 10 K to 15 K, 6% above 15 K to 25 K, 7% above 25 K to 40 K, 3% above 40 K to 80 K, 1% above 80 K to 500 K, and 2.5% above 500 K to the melting point. There is negligible uncertainty below 7 K, because, in determining the uncertainty in the total resistivity, the residual resistivity is considered to be exactly specified. The percentage uncertainty in the intrinsic resistivity is the same as that for the total resistivity down to 40 K. The uncertainty increases to 10% down to just above 25 K, is 15% from 25 K down to 15 K, and values for the intrinsic resistivity below 15 K are not given because of the large uncertainty. For the liquid state, the uncertainty is 2.5% from the melting point to 1740 K. The values in the table have been given beyond the physically significant figures and for values in the solid state permit linear interpolation of log ρ_i versus log T and log ρ versus log T. The maximum error introduced solely by linear interpolation of log ρ_i versus log T compared to the correct values is less than 0.1% from 150 K to the melting point of 1337.58 K, but increases at lower temperatures; it is less than 0.15% from 125 K to just below 150 K, less than 0.5% from 70 K to just below 125 K, less than 1.5% from 40 K to just below 70 K, less than 1% from 20 K to just below 40 K, and less than 4% from 15 K to just below 20 K.

The maximum error introduced solely by linear interpolation of log ρ versus log T compared to the correct values is less than 0.1% from 150 K to the melting point of 1337.58 K, but increases at lower temperatures; it is less than 0.15% from 125 K to just below 150 K, less than 0.5% from 70 K to just below 125 K, less than 1% from 40 K to just below 70 K, less than 2% from 20 K to just below 40 K, less than 3% from 10 K to just below 20 K, less than 1% from 7 K to just below 10 K, less than 0.5% from just above 4 K to just below 7 K, and a negligible percentage error from 1 K to 4 K. For the liquid state, the determination of values between those given in the table can be done by using eq (18).

TABLE 5. RECOMMENDED VALUES FOR THE ELECTRICAL RESISTIVITY OF GOLD

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

Solid

T	$\rho_i^{a,b}$	$\rho^{a,c}$	T	$\rho_i^{a,b}$	$\rho^{a,c}$
1		0.0220	175	1.240	1.262
4		0.0220	200	1.440	1.462
7		0.0221	225	1.640	1.662
10		0.0226	250	1.842	1.864
15	0.00376*	0.0258	273.15	2.029	2.051
20	0.0126*	0.0346*	293	2.192	2.214
25	0.0282*	0.0502*	300	2.249	2.271
30	0.0505*	0.0725*	350	2.663	2.685
35	0.0798*	0.1018*	400	3.085	3.107
40	0.119*	0.141*	500	3.952	3.974
45	0.159	0.181	600	4.853	4.875
50	0.199	0.221	700	5.794	5.816
55	0.248	0.270	800	6.786	6.808
60	0.286	0.308	900	7.840	7.862
70	0.373	0.395	1000	8.964	8.986
80	0.459	0.481	1100	10.169	10.191
90	0.544	0.566	1200	11.464	11.486
100	0.628	0.650	1300	12.832	12.854
125	0.835	0.857	1337.58	13.366	13.388
150	1.039	1.061			

Liquid

T	$\rho^{a,d}$
1337.58	31.08
1400	31.97
1500	33.40
1600	34.83
1700	36.26
1740	36.83

[a] The values are corrected for thermal expansion. See text for the uncertainty of the values. See text for an indication of the determination of values between those given in this table (interpolation scheme in the solid state, equation in the liquid state).

[b] Values for the intrinsic resistivity are not given below 15 K because of the large uncertainty.

[c] In the solid state, the values for the total electrical resistivity apply to annealed 99.999% pure or purer bulk gold and the values below 293 K are applicable to a sample obeying Matthiessen's Rule with a residual resistivity of 0.0220 x $10^{-8}\ \Omega$m.

[d] In the liquid state, the values apply to 99.95% pure or purer gold.

* Provisional values.

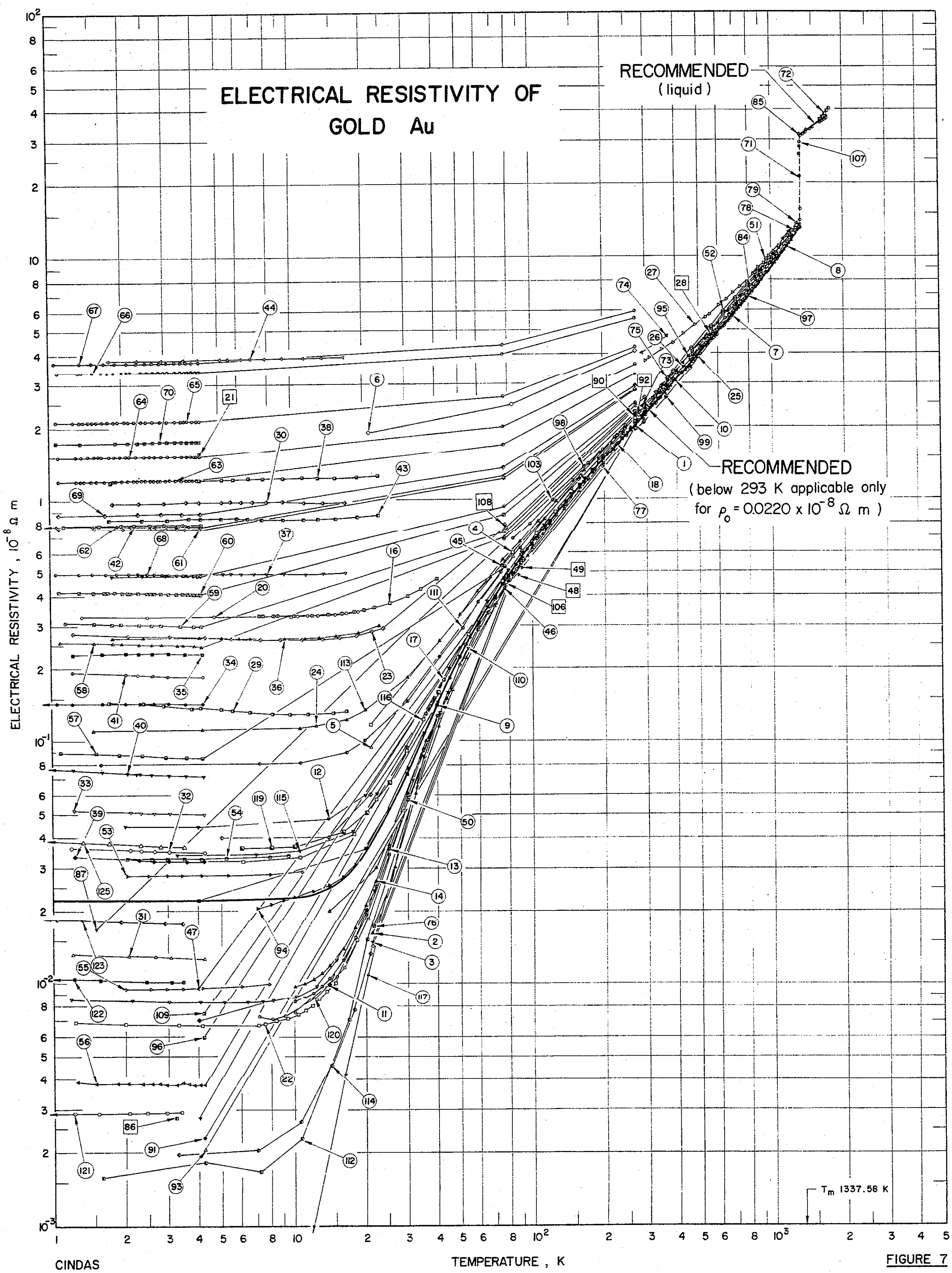

ELECTRICAL RESISTIVITY OF
GOLD Au
RECOMMENDED
(liquid)
RECOMMENDED
(below 293 K applicable only
for ρ_0 = 0.0220 x 10^{-8} Ω m)
T_m 1337.58 K
ELECTRICAL RESISTIVITY, 10^{-8} Ω m
TEMPERATURE, K
CINDAS

FIGURE 7

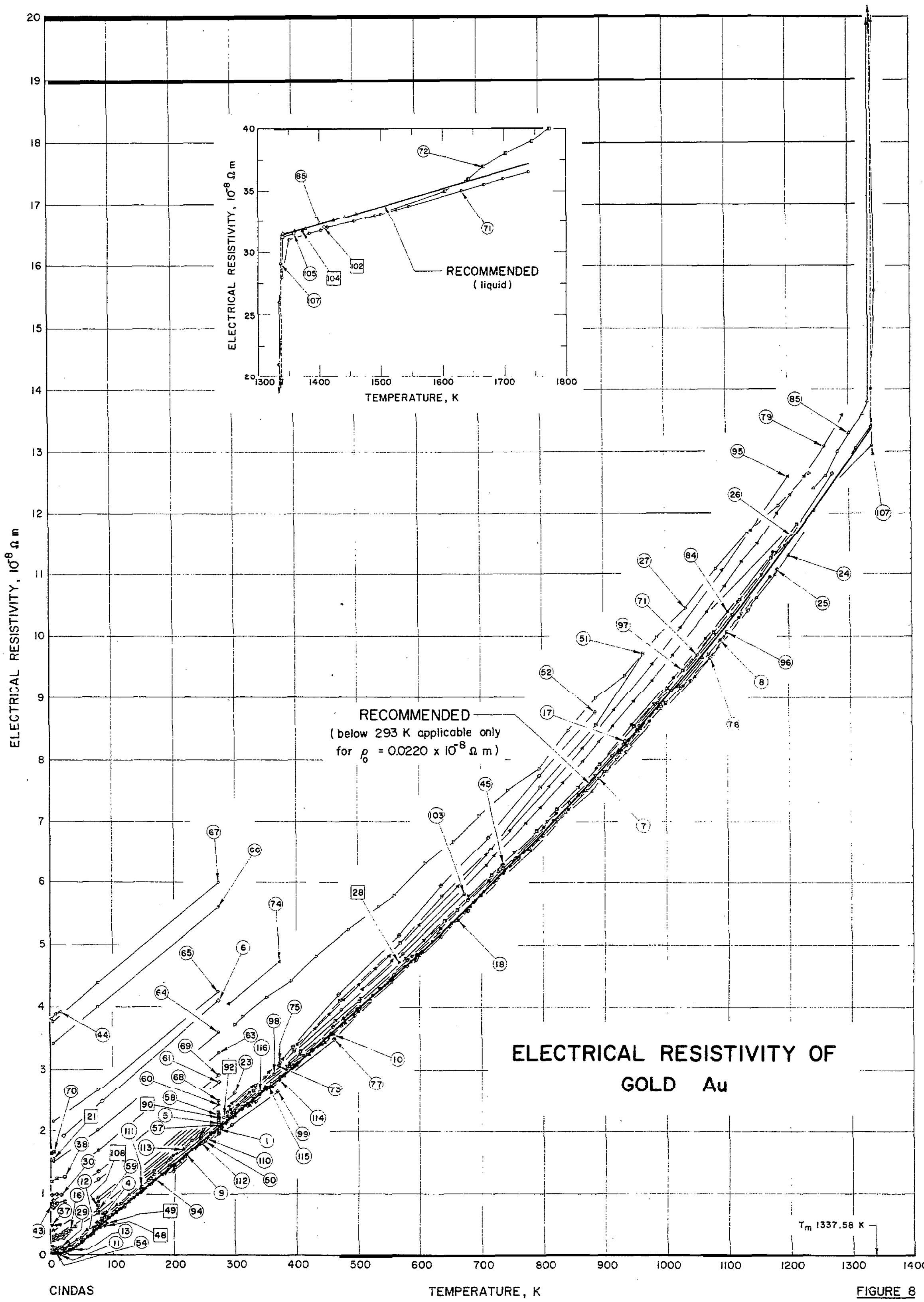

ELECTRICAL RESISTIVITY, 10^{-8} Ω m
TEMPERATURE, K
RECOMMENDED (liquid)
RECOMMENDED
(below 293 K applicable only for ρ_0 = 0.0220 x 10^{-8} Ω m)
ELECTRICAL RESISTIVITY OF GOLD Au
T_m 1337.58 K
CINDAS
FIGURE 8

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	21	Grüneisen, E. and Goens, E.	1927		21-273	Gold 12	High purity; single crystal; from Mylius, refined gold; entirely unworked; data points extracted from table.
2	21	Grüneisen, E. and Goens, E.	1927		21-273	Gold 14	High purity; single crystal; from Mylius, refined gold; entirely unworked; data points extracted from table.
3	21	Grüneisen, E. and Goens, E.	1927		21-273	Gold 13	Originally single crystal; from Mylius, refined gold; hammered to 2 mm diam; annealed 5.5 h at 653 K; data points extracted from table.
4	21	Grüneisen, E. and Goens, E.	1927		21-273	Gold II	Technically pure; from Gold and Silver Refinery in Frankfurt (1898); a piece of the original rod of Jaeger, W. and Diesselhorst, H., (Wiss. Abh. d. P.T.R., 3, 269, 1900) remelted, hammered to thin rods of 2 mm with intermediate annealing, unannealed at end; data points extracted from table.
5	21	Grüneisen, E. and Goens, E.	1927		21-273	Gold IIa	Technically pure; from Gold and Silver Refinery in Frankfurt (1898); a piece of the original rod of Jaeger, W. and Diesselhorst, H., (Wiss. Abh. d. P.T.R., 3, 269, 1900) remelted, hammered to thin rods of 2 mm with intermediate annealing, annealed 3 h at 663 K; data points extracted from table.
6	21	Grüneisen, E. and Goens, E.	1927		21-273	Gold I	Very impure; from Gold and Silver Refinery in Frankfurt (1898); a piece of the original rod of Jaeger, W. and Diesselhorst, H., (Wiss. Abh. d. P.T.R., 3, 269, 1900) hammered into thin rods, unannealed; data extracted from table.
7	112	Laubitz, M.J.	1969		273-1124		99.999 pure (reported as gold of 5N quality); 0.0003-0.0005 Fe, ND-0.0002 Ca, 0.0001-0.0002 Si, 0.0001 Ag, <0.0001 Cu, and 0.0001 Mg; range of impurities detected in three spectrographic analyses; purchased from Cominco; annealed in oxygen for 7 weeks at 1100 K; density after annealing 19.28 g cm^{-3} at 293 K; residual resistivity ratio after annealing 150; thermocouples used as potential probes; experimental results, uncorrected for thermal expansion, deduced from i) $\rho = -0.1982 + 8.3123 \times 10^{-3} T - 0.7091 \times 10^{-6} T^2 + 1.4795 \times 10^{-9} T^3$, ρ in $10^{-8}\ \Omega$ m, T in K, with a root mean square deviation of 0.09% and a max deviation of 0.27%, and ii) data points, extracted from figure of percent deviation from equation given in i); estimated extraction error ± 2.1 K in temperature and ± 0.017% in percent deviation; max error varies from ± 0.12 at 300 K to ± 0.4 at 1200 K.
8	112	Laubitz, M.J.	1969		278-1171		The above specimen and conditions except gold wires used as potential probes.
9	98	Cook, J.G. and Van der Meer, M.P.	1970	→	4-340		99.999 pure; smaller sample cut from above specimen; specimen machined to 1 cm diam and 15 cm long; annealed in air for 2 h at 873 K; resistance determined by both dc and ac methods; smoothed data extracted from table; data corrected for thermal expansion; data for uncorrected electrical resistivity and ideal resistivity also reported in paper; max calculated error 9.4% at 4 K and 0.5% at 290 K.
10	99	Damon, D.H. and Klemens, P.G.	1965		4.2-480		Pure; wire specimen about 2.5×10^{-2} cm in diam, length somewhere between 50-100 cm; annealed at 700 K for somewhere between 8 and 24 h; sample chamber filled with He gas; resistivity corrected for thermal expansion; resistivity deduced from graphically smoothed values of ideal resistivity extracted from table and residual resistivity of $0.0091 \times 10^{-8}\ \Omega$ m at 4.2 K, resistivity at 273.2 K from table; absolute values of room temperature resistivity accurate to ± 0.3%; accuracy of temperature ± 0.1 K at 100 K and ± 0.15 K at 500 K.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
11	20	Gerritsen, A.N. and Linde, J.O.	1952		4-273	Au 1	Wire specimen 0.1 mm diam; Johnson Matthey no. 3459; residual resistance ratio R(273 K)/R(4 K) = 288; data extracted from table.
12	20	Gerritsen, A.N. and Linde, J.O.	1952		2-273	Au 2	Wire specimen 0.2 mm diam; prepared by author; annealed for 3 h at 723 K; residual resistance ratio R(273 K)/R(4 K) = 46.1; data extracted from table.
13	100	Damon, D.H., Mathur, M.P., and Klemens, P.G.	1968		10-480	No. 1	Pure; wire specimen about 20 cm long; annealed at 750 K for some time between 8 and 24 h; potential probes spot welded to specimen; ideal resistivity extracted from table, residual resistivity = 0.00779 x 10^{-8} Ω m, total resistivity = ideal + residual resistivities; accuracy of total resistivity ± 0.3%.
14	100	Damon, D.H., et al.	1968		10-480	No. 2	Similar to the above specimen except residual resistivity = 0.00910 x 10^{-8} Ω m.
15*	100	Damon, D.H., et al.	1968		10-480	No. 3	Similar to the above specimen except residual resistivity = 0.00907 x 10^{-8} Ω m.
16	100	Damon, D.H., et al.	1968		7.3-40	No. 4	0.171 In; wire specimen about 20 cm long; annealed at 750 K for some time between 8 and 24 h; potential probes spot welded to specimen; ideal resistivity extracted from figure, residual resistivity = 0.3309 x 10^{-8} Ω m, total resistivity = ideal + residual resistivities; accuracy of total resistivity ± 0.3%.
17	14	Domenicali, C.A. and Christenson, E.L.	1961	A	5-958		Pure gold, contains perhaps 10^{-4} to 10^{-3} percent unintentional impurities including probably iron; wire specimen; obtained from Baker Platinum Division, Englehard Industries (mint gold); data points extracted from figure with estimated extraction error ± 1.6 K in temperature and ± 0.013 x 10^{-8} Ω m in resistivity.
18	14	Domenicali, C.A. and Christenson, E.L.	1961	A	5-1060		Pure gold, contains perhaps 10^{-4} to 10^{-3} percent unintentional impurities including probably iron; wire specimen; obtained from Johnson-Matthey; data for four runs; data points extracted from figure with estimated extraction error ± 1.6 K in temperature and ± 0.013 x 10^{-8} Ω m in resistivity.
19*	109	Kannuluik, W.G.	1931	A	273		99.99 pure; wire specimen 0.07960 cm in diam and 20.12 cm long; supplied by Heraeus; temperature coefficient of resistance between 273 and 373 K = 0.003958.
20	92	Arajs, S. and Dunmyre, G.R.	1966	A	1.4-19		0.042 Er (0.05 at.%, nominal composition determined by weighing before arc-melting); gold constituent was 99.999 pure, grade A-60 "splatters" purchased from American Smelting and Refining Co., according to supplier, impurities detected 0.0002 Cu, 0.0001 Ag, <0.0001 Fe, 0.0001 Mg, 0.0001 Pb, and <0.0001 Si with following impurities not detected using standard spectrographic methods: Al, Bi, Ca, Cd, Cr, In, Ir, Mn, Ni, Os, Pb, Pd, Pt, Rh, Ru, Sb, Sn, Tl, and Zn; erbium constituent had ρ(4.2 K) of 3.79 x 10^{-8} Ω m; rod specimen 0.1765 (±0.0004) cm in diam; Au-Er ingots weighing approx 5 g prepared by arc-melting 4 or more times, cleaned with boiling HCl-H_2O solution, homogenized for 24 h at 1050 K, quenched in ice water, cleaned with boiling HCl-H_2O solution, swaged, cleaned with boiling HCl-H_2O solution, annealed for 2 h at 1050 K, and quenched in ice water; resistivity voltage measured on Rubicon 6-dial thermofree potentiometer, voltage reliably measured to ± 0.01 μV, current constant to 1 part in 10^5 (equipment used cited in Arajs, S., Colvin, R.V., and Marcinkowski, M.J., "Initial Study of Electrical Resistivity of a Chromium Crystal," J. Less-Common Metals, 4(1), 46-51, 1962); data points extracted from figure except point at 4.2 K from table; estimated extraction error ± 0.08 K in temperature and ± 0.0003 x 10^{-8} Ω m in resistivity.
21	92	Arajs, S. and Dunmyre, G.R.	1966	A	4.2		Similar to the above specimen except 0.196 Er (0.23 at.%) and data from table.

* Not shown on either figure.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
22	92	Arajs, S. and Dunmyre, G.R.	1966	A	1.2-20		99.999 pure, impurities detected, according to supplier, 0.0002 Cu, 0.0001 Ag, <0.0001 Fe, 0.0001 Mg, 0.0001 Pb, and <0.0001 Si with the following impurities not detected using standard spectrographic methods: Al, Bi, Ca, Cd, Cr, In, Ir, Mn, Ni, Os, Pb, Pd, Pt, Rh, Ru, Sb, Sn, Tl and Zn; material purchased from American Smelting and Refining Co., grade A-60; three specimens prepared, which one data given for not stated: sample 1, hammered, cleaned with boiling HCl, annealed for 1 h at 1050 K, residual resistivity ratio ρ(297 K)/ρ(4.2 K) = 417; sample 2, melted in evacuated (10^{-5} Torr) and sealed silica capsule, swaged to 0.2540 ($\pm$0.0005) cm rod, cleaned with boiling HCl, annealed for 1 h at 1050 K, residual resistivity ratio ρ(297 K)/ρ(4.2 K) = 370; sample 3, arc-melted as Au-Er ingots (see above specimen) then swaged, cleaned, and annealed as sample 2; resistivity voltage measured on Rubicon 6-dial thermofree potentiometer, voltage reliably measured to $\pm$0.01 μV, current constant to 1 part in 105 (equipment used cited in Arajs, S., Colvin, R.V., and Marcinkowski, M.J., "Initial Study of Electrical Resistivity of a Chromium Crystal," J. Less-Common Metals, 4(1), 46-51, 1962); data points extracted f from figure except point at 4.2 K from table; estimated extraction error $\pm$0.08 K in temperature and $\pm$0.0002 x 10^{-8} Ω m in resistivity.
23	94	Berman, R., Brock, J.C.F., and Huntley, D.J.	1964		1.2-298		Spectroscopically pure plus 0.0085 Fe; wire specimen; data points extracted from figure; est extraction error $\pm$2.5% in temperature and $\pm$0.0004 x 10^{-8} Ω m for temperatures less than 25 K and $\pm$0.009 x 10^{-8} Ω m for temperatures above 25 K.
24	124	Shanks, H.R., Burns, M.M., and Danielson, G.C.	1968		304-1226	Au 1	99.999 pure; rod specimen 0.35 cm in diam and 30 cm long; supplied by Johnson, Matthey and Co; annealed to 1225 K for 1 h; residual resistance ratio R(300 K)/R(4.2 K) = 600; data points extracted from figure.
25	124	Shanks, H.R., et al.	1968		300-1183	Au 2	99.99 pure; rod specimen 0.35 cm in diam and 30 cm long; supplied by Sigmund Cohn; annealed to 1225 K for 1 h; residual resistance ratio R(300 K)/R(4.2 K) = 310; data points extracted from figure.
26	124	Shanks, H.R., et al.	1968		298-1205	Au 3	99.9999 pure; rod specimen 0.35 cm in diam and 30 cm long; supplied by Aremco; annealed to 1225 K for 1 h; residual resistance ratio R(300 K)/R(4.2 K) = 110; data points extracted from figure.
27	124	Shanks, H.R., et al.	1968		300-1235	Au 4	Rod specimen 0.35 cm in diam and 30 cm long; supplied by Mint Gold; annealed to 1225 K for 1 h; residual resistance ratio R(300 K)/R(4.2 K) = 3; data points extracted from figure.
28	126	Sirota, N.N.	1962		568		No details reported; data point extracted from figure (exponent "8" by ρ is presumed to go with the "10", i.e., 10^8).
29	115	MacDonald, D.K.C., Pearson, W.B., and Templeton, I.M.	1962		1.7-17		0.005 Cr (0.019 at.%) nominal concentration; prepared from Royal Canadian Mint Gold, Dr. Z.S. Basinski attempted to purify this gold, believed purity comparable with "proof plate" gold, i.e., 99.99 pure; wire specimen; alloy prepared by melting Au and pure Cr in graphite crucible, heated in sealed evacuated tube, homogenized by annealing at high temperature, drawn, re-annealed to 773 to 823 K (if danger of precipitation existed, specimen instead was annealed and quenched from higher temperatures; data points extracted from figure with estimated extraction error $\pm$0.06 K in temperature and $\pm$0.0003 x 10^{-8} Ω m in resistivity.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
30	115	MacDonald, D.K.C., Pearson, W.B., and Templeton, I.M.	1962		1.8-17		0.053 Cr (0.2 at.%) nominal concentration; prepared from Heraeus spectrographically pure 99.999 Au with 0.00024 Fe, 10^3 R(4.2 K)/[R(295 K) - R(4.2 K)] = 8 x 10^{-4} and which showed no resistance minimum; wire specimen; alloy prepared by melting Au and pure Cr in graphite crucible, heated in sealed evacuated tube, homogenized by annealing at high temperature, drawn, re-annealed to 773 to 823 K (if danger of precipitation existed, specimen instead was annealed and quenched from higher temperatures); data points extracted from figure with estimated extraction error ± 0.06 K in temperature and ± 0.0003 x 10^{-8} Ω m in resistivity.
31	115	MacDonald, D.K.C., et al.	1962		1.2-4.2		99.99 pure; Royal Canadian Mint "proof plate"; 10^3 R(4.2 K)/[R(295 K) - R(4.2 K)] = 5.5 x 10^{-3}; minimum exists in resistance versus temperature curve; data points extracted from figure with estimated extraction error ± 0.02 K in temperature and ± 0.00006 x 10^{-8} Ω m in resistivity.
32	115	MacDonald, D.K.C., et al.	1962		1.2-4.2		0.00056 Mn (0.002 at.%), nominal composition; prepared from Royal Canadian Mint "proof plate" 99.99 Au with 10^3 R(4.2 K)/[R(295 K) - R(4.2 K)] = 5.5 x 10^{-3} and which showed resistance minimum; wire specimen; alloy prepared by melting Au and pure Mn in graphite crucible, heated in sealed evacuated tube, homogenized by annealing at high temperature, drawn, re-annealed to 773 to 823 K (if danger of precipitation existed, specimen instead was annealed and quenched from higher temperatures); data points extracted from figure with estimated extraction error ± 0.02 K in temperature and ± 0.00005 x 10^{-8} Ω m in resistivity.
33	115	MacDonald, D.K.C., et al.	1962		1.2-4.2		Similar to the above specimen and conditions except 0.0022 Mn (0.008 at.%) nominal composition.
34	115	MacDonald, D.K.C., et al.	1962		0.03-4.2		Similar to the above specimen and conditions except 0.011 Mn (0.04 at.%) nominal composition.
35	115	MacDonald, D.K.C., et al.	1962		1.2-4.2		Similar to the above specimen and conditions except 0.028 Mn (0.1 at.%) nominal composition.
36	115	MacDonald, D.K.C., et al.	1962		1.8-23		Similar to the above specimen and conditions except estimated extraction error ± 0.1 K in temperature and 0.001 x 10^{-8} Ω m in resistivity.
37	115	MacDonald, D.K.C., et al.	1962		1.8-17		0.056 Mn (0.2 at.%) nominal composition; prepared from Heraeus spectrographically pure 99.999 Au with 0.00024 Fe, 10^3 R(4.2 K)/[R(295 K) - R(4.2 K)] = 8 x 10^{-4}, and which showed no resistance minimum; wire specimen; alloy prepared by melting Au and pure Mn in graphite crucible, heated in sealed evacuated tube, homogenized by annealing at high temperature, drawn, re-annealed to 773 to 823 K (if danger of precipitation existed, specimen instead was annealed and quenched from higher temperatures); data points extracted from figure with estimated extraction error ± 0.1 K in temperature and ± 0.001 x 10^{-8} Ω m in resistivity.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
38	115	MacDonald, D.K.C., Pearson, W.B., and Templeton, I.M.	1962		1.8–23		0.14 Mn (0.5 at.%) nominal composition; prepared from Royal Canadian Mint "proof plate" 99.99 Au with 10^3 R(4.2 K)/[R(295 K) - R(4.2 K)] = 5.5 x 10^{-3} and which showed resistance minimum; wire specimen; alloy prepared by melting Au and pure Mn in graphite crucible, heated in sealed evacuated tube, homogenized by annealing at high temperature, drawn, re-annealed to 773 to 823 K (if danger of precipitation existed, specimen instead was annealed and quenched from higher temperatures); data points extracted from figure with estimated extraction error ± 0.1 K in temperature and ± 0.001 x 10^{-8} Ωm in resistivity.
39	115	MacDonald, D.K.C., et al.	1962		1.2–4.2		0.00057 Fe (0.002 at.%) nominal composition; prepared from Royal Canadian Mint "proof plate" 99.99 Au with 10^3 R(4.2 K)/[R(295 K) - R(4.2 K)] = 5.5 x 10^{-3} and which showed resistance minimum; wire specimen; alloy prepared by melting Au and pure Fe in graphite crucible, heated in sealed evacuated tube, homogenized by annealing at high temperature, drawn, re-annealed to 773 to 823 K (if danger of precipitation existed, specimen instead was annealed and quenched from higher temperatures); data points extracted from figure with estimated extraction error ± 0.02 K in temperature and ± 0.00006 x 10^{-8} Ω m in resistivity.
40	115	MacDonald, D.K.C., et al.	1962		0.03–4.2		Similar to the above specimen and conditions except 0.0017 Fe (0.006 at.%) nominal composition.
41	115	MacDonald, D.K.C., et al.	1962		1.2–4.2		Similar to the above specimen and conditions except 0.0057 Fe (0.02 at.%) nominal composition.
42	115	MacDonald, D.K.C., et al.	1962		0.04–4.2		Similar to the above specimen and conditions except 0.028 Fe (0.1 at.%) nominal composition.
43	115	MacDonald, D.K.C., et al.	1962		1.8–23		Similar to the above specimen and conditions except estimated extraction error ± 0.1 K in temperature and ± 0.002 x 10^{-8} Ω m in resistivity.
44	115	MacDonald, D.K.C., et al.	1962		1.8–17		Similar to the above specimen and conditions except 0.14 Fe (0.5 at.%) nominal composition.
45	54	Otter, F.A., Jr.	1956	A	75–736		99.99+ pure; source of material, Handy and Harman; high temperature experiments performed in vacuum; data extracted from figure
46	101	Das, K.E. and Dawson, H.I.	1971	A	4–295		99.9999 nominal purity (6N), 0.0001 Al, 0.0001 Fe, 0.00007 Ca, 0.00005 Cu, 0.00003 Ag, 0.00003 Si, and 0.00002 Mg, total impurities 0.00087; wire specimen 0.25 mm in diam; wires supplied by Cominco Products, Inc.; annealed for 1 h at 723 K in air; residual resistance ratios R(295 K)/R(4 K) between 600 and 900; average resistivity values reported; data from table; reported error ± 2%.
47	101	Das, K.E. and Dawson, H.I.	1971	A	4–295		99.99 nominal purity (4N), 0.0005 Na, 0.0003 Ag, 0.0003 Cu, 0.0003 Fe, 0.0003 Si, 0.0001 Al, 0.0001 Ca, 0.0001 In, 0.00005 Ge, and 0.00005 Mg, total impurities 0.00021; wire specimen 0.25 mm in diam; wires supplied by Cominco Products, Inc.; annealed for 1 h at 723 K in air; residual resistance ratios R(295 K)/R(4 K) around 200; average resistivity values reported; data extracted from table; reported error ± 2%.
48	29	Kapitza, P.	1929		88	Au_I	99.99 pure; wire specimen 0.2 mm in diam; material from Heraeus; already drawn, soft; residual resistance ratio R(290 K)/R(88 K) = 4.63; units not explicitly given, presume they are in Ω cm; data extracted from table.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
49	29	Kapitza, P.	1929		91	Au_{II}	Spectroscopically compared to Au_I, found to be less pure; wire specimen 0.1 mm in diam; from Johnson and Matthey; hard; R(290 K) / R(91 K) = 3.1; units not explicitly given, presume they are in Ω cm; data from table.
50	91	White, G.K. and Woods, S.B.	1959		10-295	Au A	99.999 pure; wire specimen 0.13 mm in diam and 6-8 cm long; from Johnson Matthey Ltd., London; vacuum annealed 803 K; residual resistance ratio R(295)/(residual resistance) = 316; error in reading galvanometer amplifier 1 in 400; $\rho = \rho_0 + \rho_i$, smoothed values of ideal resistivity given in tabular form as 0.0006, 0.0037, 0.0125, 0.027, 0.050, 0.12, 0.20, 0.29, 0.38, 0.460, 0.545, 0.630, 0.790, 0.955, 1.12, 1.28, 1.44, 1.60, 1.83, 2.01, and 2.20 x 10^{-8} Ω m at 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 220, 250, 273, and 295 K, respectively; ρ_0 obtained from resistance ratio and assuming ρ(295 K) = ρ_i(295 K).
51	44	Mikryukov, V.E.	1957		331-964		99.99 pure; polycrystalline; data extracted from table.
52	45	Mikryukov, V.E.	1958		332-886		Pure; polycrystalline; data points extracted from figure.
53	102	Fenton, E.W.	1962	→	2.0-11	3	Wire specimen; bar obtained from Engelhard Industries (Toronto); bar 3 mm in diam and 8 cm long rolled to square cross section 1 mm on a side, immersed in aqua region, drawn through diamond dies to round wire, cut from wire, etched in aqua region; annealed; residual resistivity ratio in original condition ρ(room temperature)/ρ(4.2 K) = 40; voltage difference across specimen measured by a galvanometer amplifier; ℓ/A is 2030, calculated using known resistivity of pure metal at room temperature and measured resistance; specimen history not exactly specified, possibly it is sponge gold from National Research Council, Ottawa, melted in quartz boat under vacuum of at least 10^{-6} mmHg, solid rolled to sheet approx 0.025 cm thick, cut, etched in aqua regia, drawn through diamond die, etched; data from table; reported error 1%.
54	102	Fenton, E.W.	1962	→	2.0-9.5	4	Similar to the above specimen except ℓ/A = 1700; reported error 1%.
55	102	Fenton, E.W.	1962	→	2.0-7.9	5	Similar to the above specimen except ℓ/A = 2400 and residual resistivity is 9.47 x 10^{-9} Ω cm; reported error 1%.
56	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	13-273	Au 1-1	99.999+ pure, 0.00005 Ag, <0.000032 each of Cu, Fe, and Mg; no measurable impurity gradient found; wire specimen approx 0.1016 cm in diam and approx 17 cm long; supplied by Johnson Matthey and Co., Ltd.; cold rolled, drawn annealed for 36 h at 873 K; data extracted from table for temperatures of 4.2 K and above; below 4.2 K data of temperature dependent resistivity extracted from table and small contribution of resistivity due to phonon scattering ρ_i added in where $\rho_i = 0.711 \times 10^{-7} T^{4.2}$ μΩ cm from de Haas, W.J. and van der Berg, G.J. (Physica, 3, 440, 1936); reported error approx 1%.
57	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 2-1	0.00289 Fe, 0.00016 Ag, 0.000032 Cu, <0.000028 Mn, 0.000014 Si, and <0.000012 Mg; no measurable impurity gradient found; wire specimen approx 0.1016 cm in diam and approx 17 cm long; supplied by Johnson Matthey and Co., Ltd.; starting material 99.999+ pure melted with iron in high purity graphite crucible, cold rolled, drawn, and annealed twice for 36 h at 873 K; data extracted from table for temperatures 4.2 K and above; below 4.2 K data of temperature dependent resistivity extracted from table and small contribution of resistivity due to phonon scattering ρ_i added in where $\rho_i = 0.711 \times 10^{-7} T^{4.2}$ μΩ cm from deHaas, W.J. and van der Berg, G.J. (Physica, 3, 440, 1936); reported error approx 1%.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (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	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 3-1	0.00797 Fe, 0.00016 Ag, 0.000065 Cu, 0.000029 Si, 0.000028 Mn, and 0.000012 Mg; wire specimen approx 0.1016 cm in diam and approx 17 cm long; supplied by Johnson-Matthey and Co., Ltd.; starting material 99.999+ pure melted with iron in high purity graphite crucible, cold rolled, drawn and annealed for 36 h at 873 K; data extracted from tables; reported error approx 1%.
59	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.2-273	Au 3-2	Specimen cut from the same piece as the above specimen and similar to the above specimen and conditions except unannealed.
60	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 4-1	0.0102 Fe, 0.00042 Pb, 0.000065 Cu, 0.000055 Ag, 0.000054 Pd, < 0.000028 Mn, < 0.000014 Si, and < 0.000012 Mg; wire specimen approx 0.1016 cm in diam and approx 17 cm long; supplied by Johnson Matthey and Co., Ltd.; starting material 99.999+ pure melted with iron in high purity graphite crucible, cold rolled, drawn, and annealed for 36 h at 873 K; data extracted from tables; reported error approx 1%.
61	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 5-1	Similar to the above specimen and conditions except impurities 0.0249 Fe, 0.00042 Pb, 0.000065 Cu, 0.000055 Ag, 0.000054 Pd, < 0.000028 Mn, < 0.000014 Si, and < 0.000012 Mg.
62	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 6-1	Similar to the above specimen and conditions except impurities are 0.0279 Fe, 0.00042 Pb, 0.000065 Cu, 0.000055 Ag, 0.000054 Pd, < 0.000028 Mn, < 0.000014 Si, and < 0.000012 Mg and annealed twice for 36 h at 873 K.
63	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 7-1	Similar to the above specimen and conditions except impurities are 0.0354 Fe, 0.00042 Pb, 0.00016 Ag, 0.000054 Pd, 0.000032 Cu, < 0.000028 Mn, < 0.000014 Si, and < 0.000012 Mg, and annealed once for 36 h at 873 K.
64	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 8-1	Similar to the above specimen and conditions except impurities are 0.0680 Fe, 0.00042 Pb, 0.00016 Ag, 0.000054 Pd, 0.000032 Cu, < 0.000028 Mn, < 0.000014 Si, and < 0.000012 Mg.
65	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 9-1	Similar to the above specimen and conditions except impurities are 0.0879 Fe, 0.00042 Pb, 0.00011 Ag, 0.000054 Pd, 0.000032 Cu, < 0.000028 Mn, < 0.000014 Si, and < 0.000012 Mg.
66	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au 10-1	Similar to the above specimen and conditions except impurities are 0.111 Fe, 0.00042 Pb, 0.00011 Ag, 0.000054 Pd, 0.000032 Cu, < 0.000028 Mn, < 0.000014 Si, and < 0.000012 Mg.
67	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au_b 1-1	0.142 Fe, 0.0012 Mg, and 0.0014 Si; wire specimen approx 0.0254 cm in diam and approx 17 cm long; made at the Lawrence Radiation Laboratory by R.J. Borg and supplied by T.A. Kitchens of Brookhaven National Laboratory; prepared from starting material of unknown purity in argon arc furnace and drawn into wire, annealed for 36 h at 873 K; data extracted from tables; reported error approx 1%.
68	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au_b 4-1	Similar to the above specimen and conditions except impurity is 0.015 Fe.
69	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-273	Au_b 5-1	Similar to the above specimen and conditions except impurities are 0.030 Fe, 0.0062 Mg, and 0.0014 Si.
70	104, 105	Garbarino, P.L. and Reynolds, C.A.	1969, 1971	A	1.1-9.2	Au_b 6-1	Similar to the above specimen and conditions except impurities are 0.0604 Fe, 0.0032 Cu, 0.0055 Ag, 0.0012 Mg, and 0.0014 Si.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
71	119	Northrup, E. F.	1914	B	293-1740		Chemically pure; purchased from Baker and Company, Inc., Newark, N.J.; for measurements from 293 K to 1336 K, i.e., melting point, wire specimen 0.10133 cm in diam and wound on helix of about 1.5 cm long with turns well separated; liquid state measurements made after preheating container to approx 1873 K; error in molten state measurements 0.25 of 1%; data points manually read from figure except data point at 293 K from text of article.
72	119	Northrup, E. F.	1914	B	1413-1773		Chemically pure; purchased from Baker and Company, Inc., Newark, N.J.; liquid state measurements made after preheating container to 1523 K; data manually read from figure.
73	93	Barratt, T.	1913/1914	A	290, 372		Highest purity; specimen 0.1004 cm in diam and distance between knife edges 28.14 cm; from Johnson, Matthey and Co.; temperature coefficient of resistivity $\alpha(273, 373\ K) = 0.00356$; data extracted from table.
74	27	Jaeger, W. and Diesselhorst, H.	1900		291, 373	Gold I	99.8 Au, 0.1 Cu, 0.1 Fe, and trace of Ag; specimen 1.2078 cm in diam and 27.7 cm long; drawn; density 19.21 g cm^{-3} at 291 K; data extracted from table.
75	27	Jaeger, W. and Diesselhorst, H.	1900		291, 373	Gold II	Pure; specimen 1.1545 cm in diam and 27.7 cm long; drawn; density 19.22 g cm^{-3} at 291 K; data extracted from table.
76	42	Meissner, W.	1915		22-374		Impurities < 0.001; rod specimen with average diam of 0.1008 cm and average length 6.305 cm; from Mylius; melted in an electric oven, cast into a rod, then turned and polished; resistivities calculated from resistance ratio $r = R(T)/R(273.1\ K)$ and resistivity at 273.1 K; temperature coefficient of resistance ratio $r^{-1}(dr/dT) = 0.0153$, 0.0151, 0.00398, 0.00368, and 0.00293 at 21.5, 91.5, 273.1, 294.6, and 373.7 K, respectively.
77	120	Otter, F.A., Jr., Flanders, P.J., and Klokholm, E.	1955		162-737		Pure; data from figure.
78	121	Powell, R.W., Ho, C.Y., and Liley, P.E.	1966		293-1273		No details reported; data extracted from text.
79	2	Ascoli, A., Guarini, G., and Queirolo, G. T.	1970	A	507-1290		99.9995+ pure; supplied by Johnson, Matthey, and Co., Ltd., London; well-annealed; measurements made in vacuum of 10^{-5} mmHg; temperature known better than ± 0.1 K; five samples used, each went through several up-temperature and down-temperature curves; data of $\ln(\rho/T)$ versus T extracted from figure for typical curve with estimated extraction error ± 4.1 K in temperature and ± 0.0011 in $\ln(10^3\rho/T)$; resistivity reported in paper calculated from $\rho(T) = R(T, \text{measured}) (\rho(293\ K)/R(293\ K, \text{measured})) (1 + \bar{\alpha}(T - 293\ K))$, $\rho(293\ K) = 2.3 \times 10^{-8}\ \Omega\ m$ from p. 685 of C.J. Smithells (Metals Reference Book, Vol. III, 4th ed., Butterworths, London, 1967) and $\bar{\alpha}$ is average linear expansion coeff between T and 293 K from Leksina, I.E. and Novikova, S.I. (Sov. Phys. Solid State, 5, 798, 1963).
80*	110	Kopp, J.	1974	→	1.7-5.6	A	No traces of metal impurities down to 5 ppm found by using spectroscopic analysis; wire specimen 0.5 mm in diam; specimen from the Canadian Mint; before oxidation; four-probe network used in measurement; data points extracted from figure with estimated extraction error ± 0.52% in temperature and $\pm 0.000000006 \times 10^{-8}\ \Omega$ m in resistivity.
81*	110	Kopp, J.	1974	→	1.6-5.6	A	The above specimen except oxidized in air at about 1073 K for a few hours.

* Not shown on either figure.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
82*	110	Kopp, J.	1974	→	1.6–5.8	B	No traces of metal impurities down to 5 ppm found by using spectroscopic analysis; wire specimen 0.5 mm in diam; specimen from Johnson Matthey Metals; before oxidation; four-probe network used in measurement; data points extracted from figure with estimated extraction error ±0.52% in temperature and ±0.000000006 x 10^{-8} Ω m in resistivity.
83*	110	Kopp, J.	1974	→	1.6–5.6	B	The above specimen except oxidized in air at about 1073 K for a few hours.
84	108	Iyer, V.K. and Asimow, R.M.	1967		292–1175		99.999 pure; wire specimen; probably annealed; resistance measured in vacuum and between measurements, to prevent evaporation, specimen maintained in argon for temperatures above 673 K; corrected for linear expansion using the factor $[1 + \bar{\alpha}(T - T_0)]$ with values of $\bar{\alpha}$ obtained from p. 102 of Wise, E.M. (Gold: Recovery, Properties, and Applications, D. Van Nostrand Co., Inc., Princeton, N.J., 1964); estimated average specimen temperature reported to accuracy of ±0.3% T (T in °C); standard deviation of points from best fitting curve of a single run less than 0.5% of mean value; data points extracted from figure with estimated extraction error ±5 K in temperature and ±0.05 x 10^{-8} Ω m in resistivity; second specimen used to obtain data between 273 and 303 K and was annealed in argon; data for 300 K probably from average of the two specimens at 300 K.
85	64	Roll, A. and Motz, H.	1957	→	1242–1461		99.95 pure; in solid and liquid states, mp 1336 K; rotating field method used in liquid state with thermal expansion correction carried out; accuracy of temperature measurements ±1 K; maximum measurement uncertainty in resistivity in liquid state ±0.7% for errors in frequency, current density, torsional deviation, and sample temperature; accuracy of rotating field method, in liquid state, about 1% on basis of reproduced experiments on same metals under most diverse conditions; data points extracted from figure with estimated extraction error ±1.6 K in temperature and ±0.16 x 10^{-8} Ω m in resistivity.
86	10	Coltman, R.R., Klabunde, C.E., and Redman, J.K.	1967		3.2		High purity; wire specimen 0.025 cm (0.010 in) diam x 10.16 cm (4 in) long; annealed at 1273 K for 10 h in 1 atm air, furnace cooled; data from table.
87	125	Sharma, J.K.N.	1967		1.5, 293		99.999 pure; polycrystalline wire specimen obtained from Johnson Matthey Co., Ltd.; data extracted from table.
88*	116	Masumoto, H.	1927		297.2		4 mm diam x 20 cm long; forged and machined; data extracted from table.
89*	116	Masumoto, H.	1927		297.2		The above specimen annealed at 893 K for 1 h; data extracted from table.
90	95	Brown, H.M.	1927		273.2		99.9 pure; 0.318 cm diam x 10 cm long; from Baker and Co.; data from table.
91	87	Van Witzenburg, W. and Laubitz, M.J.	1968		4.2, 273		99.9999 pure; 1.6 mm thick wire supplied by Cominco; annealed in 10^{-5} mmHg vacuum at 890 K for 14 h; data extracted from table.
92	96	Brown, H.M.	1928		282		Bar specimen of area 0.0779 cm^2 and length 10 cm; data from table.
93	19	Fletcher, R. and Friedman, A.J. and Stott, M.J.	1972		4.2, 273		Plate specimen 0.24 mm thick; supplied by National Research Council, Ottawa; fabricated from Cominco "69" grade gold; rolled, etched, and annealed in vacuum at 773 K for 18 h; data extracted from table.
94	103	Fitzer, E.	1973		7–280		99.999 pure; supplied by Degussa, West Germany; cast, rolled or drawn to final diam, no subsequent heat treatment applied; data extracted from table; data supplied by participant no. 34 in an AGARD program of comparative measurements.

* Not shown on either figure.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
95	117	Misek, K. and Polak, J.	1963	→	273-1201		99.999 pure; wire specimen 0.1 mm in diam and about 25 cm long; supplied by Johnson and Matthey, London; annealed for some hours in nitrogen at 1273 K; resistance 0.42566, 0.46206, 0.51501, 0.56117, 0.60146, 0.64221, 0.69236, 0.73440, 0.77833, 0.82149, 0.86765, 0.91153, 1.00220, 1.11888, 1.21012, 1.28861, 1.41862, 1.53166, 1.64684, 1.78654, 1.89483, 2.06499, 2.18686, and 2.34725 Ω at 273.2, 295.5, 327.3, 354.5, 377.9, 401.7, 430.1, 454.0, 478.5, 502.6, 528.2, 551.6, 600.7, 662.1, 708.3, 747.6, 811.0, 864.3, 916.8, 978.3, 1024.1, 1093.5, 1140.8, and 1200.6 K, respectively; before measurement R(273 K) was 0.42566 Ω while after measurement it was 0.42641 Ω; specimen wound bifillarly on 4-hole capillary tube made of Degussit and placed in tube of sintered corundum within an electrically heated furnace; potential and current leads made of same material as specimen; oxygen free nitrogen or argon steadily flowed through tube with the specimen; measurements up to 523 K made in a stirred silicon oil bath; resistance measured by comparison using 5-dial Diesselhorst type precision potentiometer; specimen temperature determined by using Pt/Pt, Rh 10% thermocouple; 2.25 x 10^{-8} Ω m adopted by authors for resistivity at 273.2 K; resistivity data extracted from table; data corrected for thermal linear expansion; values of α_T derived from Simmons, R.O. and Balluffi, R.W., (Phys. Rev., 125(3), 862-72, 1962) used in dilatation correction; resistance extracted from table.
96	122	Rowland, T., Cusack, N.E., and Ross, R.G.	1974	→	4.2-1200		Spectroscopically pure, impurities 0.0003 Ag and 0.0002 Fe, not stated explicitly whether impurities in at.% or wt%; wire specimen between 0.31 and 0.38 mm in diam; supplied by Johnson Matthey; annealed at 1073 K in vacuum for a few hours, slowly furnace cooled before taking measurements; residual resistivity ratio ρ(273 K)/ρ(4.2 K) = 333; resistivity measured using standard four terminal technique; temperature below 300 K measured with Au/0.03 at.% Fe-chromel thermocouple, above 300 K by Pt-Pt 13% Rh thermocouple; data in tabular form supplied by authors except ρ(4.2 K) from table and ρ(273 K) deduced from resistivity ratio; reported error ± 5%.
97	41	Meechan, C.J. and Eggleston, R.R.	1954	→	290-1214		99.999 pure; wire specimen 0.30 cm (0.012 in) in diam; specimen furnished by Johnson and Matthey Company; drawn; resistance 0.07993, 0.11302, 0.12992, 0.14106, 0.18490, 0.19125, 0.19677, 0.20993, 0.22305, 0.23516, 0.24706, 0.25916, 0.27206, 0.29325, 0.31459, 0.32470, 0.34563, 0.36391, 0.38655, and 0.40637 Ω at 290.5, 406.9, 464.8, 503.4, 642.7, 662.4, 679.0, 718.3, 756.7, 791.3, 824.8, 858.4, 893.6, 949.6, 1003.6, 1028.7, 1079.0, 1121.5, 1172.3, and 1214.4 K, respectively; pressure maintained below 10^{-4} mmHg; electrical leads made of commercial purity wires of same material as specimen and spot welded; resistance measurements made using Rubicon Type "B" potentiometer; precision of temperature measurements within 0.5 K; resistivity at 293 K of 2.35 x 10^{-8} Ω m from Metals Handbook, p. 1116, 1948; resistivity ρ(T) calculated using ρ(293 K) [R(T)/R(293 K)]; R(293 K) calculated using equation given by author, R(T) = 0.007440 + 2.2856 x 10^{-4} T + 0.742 x 10^{-7} T^2 where T is in kelvins and R is in ohms, R(293 K) = 0.08078 Ω; resistance extracted from table.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
98	13	Dewar, J. and Fleming, J.A.	1893	B	76–468		99.9 degrees of fineness; wire specimen 0.0078653 cm mean diam and 100 cm long; prepared by and drawn into wire by Messrs. Johnson and Matthey; resistance 1.4022, 2.8131, 3.1870, 3.8056, 4.5296, 4.7208, 4.7636, 4.7726, 4.7882, 4.8319, 4.7882, 6.0538, 6.7068, and 7.8048 at 76.1, 167.1, 191.3, 229, 244.20, 285.10, 287.5, 288.6, 289.45, 291.9, 323.2, 363.5, 405.4, and 467.7 K, respectively; mean temperature coefficient between 273 and 373 K 0.00377; Wheatstone bridge used to measure resistance; temperature measured using platinum resistance thermometer; data uncorrected for thermal expansion, length and mean diam measured at 288 K; data extracted from table; resistivity at 273 K $2.197 \times 10^{-8}\ \Omega$ m; temperatures of 76.1 (in liquid oxygen), 167.1 (in liquid ethylene), 191.3 (in CO_2 and ether), and 229 K are "platinum" temperatures arrived at using standard platinum wire with all other temperatures corrected Celsius temperatures.
99	12	Dewar, J. and Fleming, J.A.	1892	B	91–370		Purest soft gold, 999.9 degrees of fineness; wire specimen of probable dimensions 0.0076 cm (0.003 in) in diam and 50 or 100 cm long; specimen provided by J.S. Sellon and G. Matthey of Messrs. Johnson and Matthey of Hatton Garden drawn; experiment carried out with ambient temperature approx constant at 293 K; mean diam of wire measured to nearest ten-thousandth of an inch; resistance measured on Wheatstone bridge; measurement of resistance repeated several times, mean observed specific resistance reported; data uncorrected for thermal expansion; data points extracted from table.
100*	123	Schulze, F.A.	1911		298		100 Au; data point extracted from table.
101*	123	Schulze, F.A.	1911		298		100 Au; data point extracted from table.
102	107	Howe, R.A. and Enderby, J.E.	1967		1408		99.999 pure (reported as grade 5N); supplied by Koch-Light; in liquid state; fused quartz sample holder used to contain the liquid; data point extracted from figure.
103	52	Niccolai, G.	1908	B	84–673		Pure; material from C.A.F. Kahlbaum, Berlin; wire specimen about 0.5 mm in diam and approx 8 m long; resistance measured using a Wheatstone Bridge; data points extracted from table.
104	55	Ozelton, M.W., Wilson, J.R., and Pratt, J.N.	1967	R	1373		In liquid state; data point at zero at.% Ge extracted from figure with estimated extraction error ± 0.3 at.% Ge in concentration and $\pm 0.6 \times 10^{-8}\ \Omega$ m in resistivity.
105	97	Busch, G. and Güntherodt, H.J.	1967	-	1340, 1358		99.999 pure; in liquid state; from Degussa, Hanau; resistivity measured by an ac current-ac magnetic field method; data points extracted from figure with estimated extraction error ± 1.7 K in temperature and $\pm 0.08 \times 10^{-8}\ \Omega$ m in resistivity; the absolute accuracy of measurement of electrical resistivity was about 3%.
106	11	Dawson, H.I.	1965		78		99.999 pure; polycrystalline; approx grain size 0.1–0.2 mm; wire specimen 0.20 or 0.25 mm in diam; from Johnson Matthey; annealed for 1 h at 723 K in air; data point extracted from table.

* Not shown on either figure.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
107	113	Lebedev, S.V., Savvatimskii, A.I., and Smirnov, Yu.B.	1973	→	293-1338		99.99 pure (according to specification), 99.999 purity indicated by correspondence to $\rho(293\ K) = 2.235 \times 10^{-8}\ \Omega$ m according to Espe, W. (Technology of Vacuum Electronic Devices [Russian Translation], Vol. 1, GEI, 1962); measured in solid and liquid states; 0.1 mm diam wire specimen approx 1 to 6 cm long; exploding wire method used, wires heated by single current pulse with current density of 4×10^{D} A M^{-2} and almost rectangular in shape; data points extracted from table; arithmetic mean error 1.2%, possible systematic error of resistivity of solid and liquid specimens is 1.5%; mp and "room temperature" not explicitly given in paper, assigned 1337.58 K (Metrologia 5(2), 35-44, 1969) and 293 K respectively.
108	114	Logie, H.J., Jackson, J., Anderson, J.C., and Nabarro, F.R.N.	1961	→	77.34		Spectographically pure, < 0.002 impurity concentration; polycrystalline wire, 0.2 mm diam and 10 cm in length; melted under vacuum and drawn to required diam; annealed at 1173 K for 3 h and furnace-cooled; resistivity measured with Diesselhorst potentiometer; data point at zero at.% Pd extracted from figure with estimated extraction error of ± 0.4 at.% in concentration and $\pm 0.07 \times 10^{-8}$ Ω m in resistivity; measurement temperature specified as liquid nitrogen temperature, 77.34 K assigned.
109	106	Hau, N.H.	1966	→	4.2-298	A100	99.999+ pure; spectrographic analysis by manufacturer reveals 0.0002 Ag, 0.0001 Fe, and Mg, Si, and Cu < 0.0001 each; made by American Smelting and Refining Co.; wire specimen 0.07 cm in diam and approx 16 cm in length; homogenized in argon gas at 1123 K for 6.8 d; slowly cooled, swaged and drawn; intermediately annealed in argon gas at 723 K for 24 h and a final anneal in 10^{-6} mmHg vacuum at 973 K for 24 h; measurements conducted with sample holder surrounded by He gas; gold-cobalt vs. copper thermocouples from Sigmund Cohn used between 10-400 K; conventional dc method used; cross-sectional area determined from density (computed from lattice parameter obtained by x-ray analysis) and weight of a known length of wire; to correct for spurious effects the current was reversed and voltage readings averaged for final value; data points extracted from table; T accurate to 0.01 K for T > 16 K; max error of voltage measurement due to thermal emfs is estimated at 0.02 μV; at high temperature the error in cross-sectional measurement is approx 1%.
110	82	Teixeira, J.	1974	→	1.3-292		99.999 pure (reported as 5N) with < 0.0005 magnetic impurities as indicated by manufacturer; wire specimen 0.2787 mm in diam, calculated from specimen mass taking the density of Au as 19.3 and 80.068 cm between voltage probes; furnished by Johnson Matthey; specimen prepared from 1 mm diam wire, melted and cooled during casting then rolled to a diam of 1.4 mm and annealed in vacuum at 823 K for 4 h then slowly cooled; presence of impurities prevents exact value for residual resistivity, author reports ρ_0 as of the order of 8 nΩ cm, ideal resistivity at 273.15 K $\rho_i(273) \simeq 2021$ nΩ cm and $\rho(273)/\rho_0 \approx 240$; author estimates impurity concentration at 0.0003; resistance measured using four-probe dc method; resistivity ρ derived from resistance R by $\rho = RM/d\ell^2$ where M is specimen mass, ℓ is specimen length, and d is density of Au as stated above; data extracted from table and text; uncertainty in voltage measurements is 10^{-4} in worst case but usually 10^{-6}; imprecision of ℓ and M are $\Delta\ell/\ell \simeq 2 \times 10^{-3}$ and $\Delta M/M \simeq 10^{-4}$; uncertainty in temperature of 0.1 K but relative uncertainty of 0.001 K; author fits data to $\rho = A - DT^5J_5(\theta/T)(1 + 2\alpha\gamma T)$ with an absolute quadratical average error of 0.467 nΩ cm where $J_5(\theta/T)$ is the integral of Grüneisen evaluated at temperature T, A = 0.11275 nΩ cm, D = 3.09327 in nΩ cm K^{-5}, $2\alpha\gamma = 1.5841$, $\theta = 175.0$ K and T is in kelvins.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
111	127	Stewart, R. G.	1966	A	1.6-297	MR3-1	Pure with 0.14 (0.25 at.%) Ag determined by wet chemical and fire assays, minor constituents approx 2 ppm; polycrystalline wire specimen 254 μm (10 mil) in diam; annealed by joule heating in air using dc according to a schedule starting at about 1223 K and ending 24 h later at 1023 K then cooled to room temperature within 1 h; specimen rinsed in dilute nitric acid for 20 min, distilled water, and pure alcohol prior to spotwelding into sample frame; residual resistivity $\rho(0)$ = 0.0805 x 10^{-8} Ωm; geometric factor G = ℓ/A where ℓ is wire length and A is cross-sectional area, ℓ determined by measuring length of wire between potential probes with a travelling microscope and A found by weighing out sections of wire where the density was computed from known values of lattice constants and the chemical assay of concentration of the solute; G accurate to approx 1%; resistance measurements taken in vacuum of approx 10^{-3} Torr; conventional potentiometric techniques used; effects of thermal emf's eliminated by current reversal; potential contacts 50.8 μm (2 mil) diam pure Au wires spotwelded to sample; 30 mA sample current with less than 4 ppm drift over several days; data uncorrected for thermal expansion; data extracted from table; absolute value of temperature believed accurate within 1 K for T > 30 K and within 0.25 K for T < 30 K with a temperature stability approaching 0.001 K achieved in cryostat; low temperature slope of 2.9.
112	127	Stewart, R. G.	1966	A	1.6-297	MR3-2	Similar to the above specimen and conditions except comp pure with no solute, $\rho(0)$ = 0.00158 x 10^{-8} Ωm, and low temperature slope of 3.9.
113	127	Stewart, R. G.	1966	A	1.6-297	MR3-3	Similar to the above specimen and conditions except comp pure with 0.10 (0.10 at.%) Pt, $\rho(0)$ = 0.111 x 10^{-8} Ωm, and low temperature slope of 2.8.
114	127	Stewart, R. G.	1966	A	3.3-372	MR4-2	Similar to the above specimen and conditions except comp pure with no solute, $\rho(0)$ = 0.00196 x 10^{-8} Ωm, and low temperature slope of 4.1.
115	127	Stewart, R. G.	1966	A	3.3-372	MR4-3	Similar to the above specimen and conditions except composition pure with 0.032 (0.10 at.%) Cu, $\rho(0)$ = 0.0340 x 10^{-8} Ωm, and low temperature slope of 3.2.
116	127	Stewart, R. G.	1966	A	3.3-372	MR4-5	Similar to the above specimen and conditions except comp pure with 0.049 (0.09 at.%) Ag, $\rho(0)$ = 0.0320 x 10^{-8} Ωm, and low temperature slope of 3.0.
117	118	Mydosh, J.A., Ford, P.J., Kawatra, M.P., and Whall, T.E.	1974	A	10-290		Pure; tape specimens 2 mm wide, 0.008 cm thick, and 6-7 cm long; resistivity measurements made using standard four-point-probe potentiometric technique; voltage accurate to better than 1 part in 10^4, precision of a few nanovolts; dc current constant to about 1 part in 10^5, uncertainty in temperature below 4.2 K did not exceed a few millidegrees, above 4.2 K known to within 0.5% of given temperature; sample dimensions determined by direct measurement to accuracy of ± 2%, by length measurement and weighing procedure to accuracy within ± 0.5%; measurements of 3 experimental runs on pure gold made during course of work and summarized as intrinsic resistivity in tabular form; one run made on 99.999 pure Cominco specimen with estimated 0.5 ppm Fe and prepared using a copper boat levitation furnace; other two runs made on specimen of spectroscopically pure gold with estimated 5 ppm Fe; in general, homogenizing anneal done at 1173 K for 6 h in vacuum followed by rapid quench into iced water, on some occasions strain-relieving anneal made at 823 K for 1 h in vacuum followed by slow cooling; phonon resistivity not affected by different annealing techniques but residual resistance was affected; intrinsic resistivity extracted from table; additional information supplied by an author.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
118*	111	Hust, J. G. and Sparks, L. L.	1971		7-280	AGARD gold (1)	99.999 pure, indicated by supplier; grain size 0.0044 mm; cylindrical rod specimen 23 cm long; specimen supplied by Advisory Group for Aerospace Research and Development (AGARD); as received specimen swaged from 4.0 mm to 3.6 mm, a 19% reduction in area, specimen in work-hardened state; density for as received specimen 19.28 ± 0.01 g cm^{-3}; DP hardness 58.4; residual resistivity ratio ρ (273 K) / ρ (4 K) = 98 ± 2; experimental data represented by $$\rho = \sum_{i=1}^{m} b_i \, [\ln T]^{i-1}$$ with ρ in Ω m and b_i's determined using a least-squares criterion; parameters stated as 1.28194052 x 10^{-7}, -3.74247727 x 10^{-7}, 4.84323112 x 10^{-7}, -3.63942509 x 10^{-7}, 1.74605577 x 10^{-7}, -5.52414226 x 10^{-8}, 1.14679247 x 10^{-8}, -1.49913542 x 10^{-9}, 1.11637318 x 10^{-10}, and -3.60211265 x 10^{-12}; data, calculated from above equation, extracted from table; uncertainty estimates, with 95% confidence, 0.25% at 300 K to 50 K and increasing inversely with temperature to 2% 4 K; above 20 K temperature based on IPTS - 68 temperature scale and below 20 K based on NBS P2-20 (1965) scale.
119	111	Hust, J. G. and Sparks, L. L.	1971		6-170	AGARD gold (2)	The above specimen and conditions except in work-hardened condition after swaging to 1.9 mm, a 72% reduction in area; grain size 0.0090 mm; DP hardness 57.6; residual resistivity ratio ρ (273 K) / ρ (4 K) = 57 ± 1; and parameters stated as 1.20562901 x 10^{-7}, -4.06129794 x 10^{-7}, 5.95441316 x 10^{-7}, -4.96918541 x 10^{-7}, 2.59934639 x 10^{-7}, -8.83008294 x 10^{-8}, 1.94621083 x 10^{-8}, -2.68241017 x 10^{-9}, 2.09889879 x 10^{-10}, and -7.11154715 x 10^{-12}.
120	111	Hust, J. G. and Sparks, L. L.	1971		7-170	AGARD gold (3)	The above specimen and conditions except in annealed condition with annealing done by heating to 673 K for 2 h and then furnace cooling to room temperature; grain size 0.013 mm; DP hardness 29.2; residual resistivity ratio 289 ± 6; parameters stated as -3.91448814 x 10^{-8}, 1.07108920 x 10^{-7}, -1.21444299 x 10^{-7}, 7.40065999 x 10^{-8}, -2.61218503 x 10^{-8}, 5.32621370 x 10^{-9}, -5.79365841 x 10^{-10}, and 2.61310864 x 10^{-11}, ninth and tenth coefficients for electrical resistivity of AGARD gold (3) on p. 29 of NBS Rept. 9785, ref. [111], appear inadvertently according to information supplied by an author; intrinsic resistivity reported in tabular form as 0.0003, 0.0006, 0.0014, 0.0028, 0.0051, 0.0082, 0.0124, 0.0278, 0.0510, 0.0821, 0.1198, 0.1621, 0.2060, 0.2893, 0.3769, 0.4639, 0.550, 0.636, 0.804, 0.968, 1.128, 1.287, 1.444, 1.602, 1.760, 1.920, 2.083, and 2.248 x 10^{-8}, Ωm at 8, 10, 12, 14, 16, 18, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, and 300 K, respectively; intrinsic resistivity arrived at by assuming Matthiessen's Rule, starting with data for gold (3), above 170 K using data from gold (1) adjusted to match smoothly, and transition made at 130 K to obtain sufficient overlap.

* Not shown on either figure.

TABLE 6. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF GOLD Au (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	38	Loram, J.W., Whall, T.E., and Ford, P.J.	1970		0.49-3.4	No. 1	99.999 pure; analyzed Fe content 0.0005; from Cominco; induction melted in copper-boat levitation furnace, rolled to tape 0.008 cm thick, cut in form of a strip 2 mm wide and 12 cm long, etched in aqua regia, annealed at 1173 K for 6 h in vacuum, and quenched rapidly in iced water; ρ (1 K) = 0.0029 x 10^{-8} Ωm; resistance measured potentiometrically; data points extracted from figure with estimated extraction error ± 0.87% in temperature and ± 0.000015 x 10^{-8} Ωm in resistivity; length to area ratio determined to within ± 0.3%; uncertainty in temperature below 4 K does not exceed 4 millidegree, above 4 K always less than 0.5% and over much of the range considerably less than this.
122	38	Loram, J.W., Whall, T.E., and Ford, P.J.	1970		0.50-3.4	No. 2	Pure; analyzed Fe concentration 0.0010; swaged, drawn, etched in aqua regia, annealed at 1173 K for 6 h in vacuum, and quenched rapidly in iced water; ρ (1 K) = 0.0105 x 10^{-8} Ωm; resistance measured potentiometrically; data points extracted from figure with estimated extraction error ± 0.87% in temperature and ± 0.000015 x 10^{-8} Ωm in resistivity; length to area ratio determined to within ± 0.3%; uncertainty in temperature below 4 K does not exceed 4 millidegree, above 4 K always less than 0.5% and over much of the range considerably less than this.
123	38	Loram, J.W., Whall, T.E., and Ford, P.J.	1970		0.50-3.4	No. 3	Analyzed Fe concentration 0.0010; alloy made by induction melting pure Au (estimated Fe content 0.0005) and an Au (0.01 at. % Fe) master alloy in alumina crucible, swaged in brass down to 0.15 cm diam, drawn through steel dies to 0.025 cm diam, etched in aqua regia, annealed at 1173 K for 6 h in vacuum, and quenched rapidly in iced water; ρ (1 K) = 0.0182 x 10^{-8} Ωm; resistance measured potentiometrically; data points extracted from figure with estimated extraction error ± 0.87% in temperature and ± 0.000015 x 10^{-8} Ωm in resistivity; length to area ratio determined to within ± 0.3%; uncertainty in temperature below 4 K does not exceed 4 millidegree, above 4 K always less than 0.5% and over much of the range considerably less than this.
124*	38	Loram, J.W., Whall, T.E., and Ford, P.J.	1970		0.52-3.5	No. 4	Similar to the above specimen and conditions except analyzed Fe concentration 0.0028 and ρ (1 K) = 0.0343 x 10^{-8} Ωm.
125	38	Loram, J.W., Whall, T.E., and Ford, P.J.	1970		0.49-3.5	No. 5	Similar to the above specimen and conditions except analyzed Fe concentration 0.0037 and ρ (1 K) = 0.0388 x 10^{-8} Ωm.

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF GOLD Au

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

T	ρ
DATA SET 1	
21.2	0.0142
83.2	0.488
273.2	2.04
DATA SET 2	
21.2	0.0160
83.2	0.490
273.2	2.04*
DATA SET 3	
21.2	0.0147
83.2	0.489*
273.2	2.04*
DATA SET 4	
21.2	0.1174
83.2	0.599
273.2	2.16
DATA SET 5	
21.2	0.0941
83.2	0.575
273.2	2.14
DATA SET 6	
21.2	1.919
83.2	2.486
273.2	4.100
DATA SET 7	
273.15	2.051*
282	2.125
282	2.122*
307	2.329
348	2.667
352	2.702
418	3.256
446	3.498
479	3.783
539	4.310
DATA SET 7 (cont.)	
545	4.360
549	4.402
621	5.058
691	5.697
726	6.026
730	6.072
730	6.061*
731	6.076*
761	6.366
795	6.708
873	7.497
892	7.698
920	7.993
973	8.576
994	8.818
1024	9.155
1070	9.702
1124	10.355
DATA SET 8	
278	2.093
281	2.120*
284	2.142*
290	2.192
300	2.273
307	2.330*
347	2.660
351	2.695*
418	3.258*
446	3.496*
479	3.782*
538	4.300
546	4.372*
550	4.402*
552	4.425*
556	4.453
622	5.061*
690	5.697*
726	6.037*
729	6.071*
729	6.069*
732	6.094*
737	6.137
763	6.397
795	6.719*
DATA SET 8 (cont.)	
842	7.183
874	7.526*
891	7.701*
920	8.015*
974	8.602
1024	9.168*
1028	9.209
1071	9.717*
1089	9.933
1120	10.307
1124	10.371*
1171	10.945
DATA SET 9	
4	0.0221
20	0.036
30	0.073
40	0.141
50	0.222
60	0.308
70	0.395
80	0.4810
100	0.6504
120	0.8165
140	0.9787
160	1.141
180	1.302
200	1.462
220	1.622
240	1.783
260	1.945
273.15	2.052*
280	2.108*
300	2.271*
320	2.434
340	2.598
DATA SET 10	
4.2	0.0091*
80	0.457
100	0.626
120	0.795
140	0.960
160	1.124
DATA SET 10 (cont.)	
180	1.286
200	1.444*
220	1.603*
240	1.763*
260	1.924*
273.2	2.032*
280	2.085*
300	2.247
320	2.410*
340	2.574*
360	2.739
380	2.905
400	3.073
420	3.243
440	3.413
460	3.584
480	3.757
DATA SET 11	
4	0.0070
14	0.0099
20	0.0202
80	0.452*
273	2.02*
DATA SET 12	
2	0.0448
4	0.0444
14	0.0479
20	0.0592
80	0.504
273	2.05*
DATA SET 13	
10.0	0.00840
11.0	0.00871
12.0	0.00917
13.0	0.00975
14.0	0.01051
16.0	0.01259
18.0	0.01559
20.0	0.01984
22.0	0.02534
DATA SET 13 (cont.)	
25.0	0.03604
30.0	0.05989
35.0	0.0917
40.0	0.1278
80	0.4562*
100	0.6252*
120	0.7937*
140	0.9588
160	1.123*
180	1.285*
200	1.443*
220	1.602*
240	1.762*
260	1.923*
280	2.084*
300	2.246
320	2.409
340	2.573*
360	2.738*
380	2.904*
400	3.072*
420	3.242*
440	3.412*
460	3.583*
480	3.756*
DATA SET 14	
10.0	0.00971
11.0	0.01002
12.0	0.01048
13.0	0.01106
14.0	0.01182
16.0	0.01390
18.0	0.01690
20.0	0.02115
22.0	0.02665
25.0	0.03735
30.0	0.06120
35.0	0.0930
40.0	0.1291*
80	0.4575*
100	0.6265*
120	0.7950*
140	0.9601*
160	1.124*
DATA SET 14 (cont.)	
180	1.286*
200	1.444*
220	1.603*
240	1.763*
260	1.924*
280	2.085*
300	2.247*
320	2.410*
340	2.574*
360	2.739*
380	2.905*
400	3.073*
420	3.243*
440	3.413*
460	3.584*
480	3.759*
DATA SET 15*	
10.0	0.00968
11.0	0.00999
12.0	0.01045
13.0	0.01103
14.0	0.01179
16.0	0.01387
18.0	0.01687
20.0	0.02112
22.0	0.02662
25.0	0.03732
30.0	0.06117
35.0	0.0930
40.0	0.1291
80	0.4575
100	0.6265
120	0.7950
140	0.9601
160	1.124
180	1.286
200	1.444
220	1.603
240	1.763
260	1.924
280	2.085
300	2.247
320	2.410
340	2.574

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

DATA SET 15 (cont.)*

T	ρ
360	2.739
380	2.905
400	3.073
420	3.243
440	3.413
460	3.584
480	3.757

DATA SET 16

T	ρ
7.3	0.3311
7.6	0.3312
8.4	0.3312
8.7	0.3315
10.2	0.3318
12.2	0.3330
14.2	0.3355
16.2	0.3388
18.2	0.3432
20.1	0.3488
22.2	0.3562
25.8	0.3724
30.5	0.3993
34.7	0.4284
40.5	0.469

DATA SET 17

T	ρ
5	0.04
14	0.04
21	0.06
36	0.13
43	0.18
53	0.25
70	0.39*
475	3.73
503	4.00
559	4.52
646	5.30
737	6.22
845	7.29
931	8.24
934	8.29
939	8.30
958	8.53

DATA SET 18

T	ρ
5	0.00*
14	0.02
22	0.03
36	0.10
44	0.15
53	0.22
70	0.36
79	0.46
196	1.45
199	1.45*
200	1.49
228	1.70
288	2.19*
294	2.25
294	2.30
298	2.29*
299	2.33
302	2.30*
388	3.05
394	3.09
400	3.07*
400	3.12
400	3.07*
440	3.42*
446	3.44
483	3.76*
502	3.95
555	4.40
555	4.43*
556	4.49*
651	5.34
664	5.40
729	6.15
736	6.12*
739	6.17
755	6.38
838	7.14
858	7.42
867	7.47
924	8.14
925	8.10
928	8.13
935	8.21
935	8.26*
953	8.48
955	8.46
959	8.49
986	8.81

DATA SET 18 (cont.)

T	ρ
993	8.87
997	8.92
1017	9.19
1022	9.20
1060	9.66

DATA SET 19*

T	ρ
273	2.13

DATA SET 20

T	ρ
1.35	0.3302
1.82	0.3300*
2.25	0.3298*
2.51	0.3298
2.69	0.3295*
2.99	0.3296*
3.33	0.3296*
3.60	0.3296*
3.94	0.3296*
4.18	0.3296*
4.20	0.3294*
4.78	0.3296
5.47	0.3294*
5.98	0.3294*
6.49	0.3294*
8.40	0.3292*
8.88	0.3295*
9.98	0.3299
10.68	0.3303
11.76	0.3313
12.87	0.3322
13.99	0.3337*
15.27	0.3358
16.97	0.3395
18.98	0.3453

DATA SET 21

T	ρ
4.2	1.557

DATA SET 22

T	ρ
1.24	0.0069
1.36	0.0068*
1.52	0.0068*
1.73	0.0068*

DATA SET 22 (cont.)

T	ρ
1.98	0.0068
2.55	0.0067*
2.81	0.0067*
2.99	0.0067*
3.30	0.0067
3.55	0.0066*
3.89	0.0067*
4.11	0.0067
4.20	0.0066*
4.39	0.0067*
4.78	0.0067*
5.17	0.0067*
6.08	0.0067*
7.06	0.0067
7.50	0.0068
8.39	0.0070
9.36	0.0071
10.32	0.0074
11.10	0.0077
11.98	0.0080
12.77	0.0086
13.75	0.0093
14.98	0.0104
18.29	0.0152
20.31	0.0195*

DATA SET 23

T	ρ
1.24	0.2802
2.09	0.2758
3.11	0.2727
4.36	0.2696
5.62	0.2668
7.40	0.2649
8.97	0.2641
11.0	0.2638
13.5	0.2650
15.8	0.2681
18.7	0.2739
21.6	0.2847
24.2	0.2943
78.3	0.769
298.5	2.62

DATA SET 24

T	ρ
304	2.34*
324	2.51

DATA SET 24 (cont.)

T	ρ
349	2.73
372	2.90
394	3.05*
456	3.59
475	3.76*
500	3.94*
520	4.13
544	4.37*
562	4.55
586	4.73
625	5.08*
653	5.34*
683	5.62
705	5.85
749	6.25
777	6.51
798	6.74*
823	6.98
848	7.22*
881	7.49
904	7.80
929	8.11*
949	8.30*
974	8.55*
997	8.81*
1024	9.16*
1047	9.35
1078	9.71
1102	10.06*
1126	10.33*
1149	10.61
1179	10.99
1200	11.30
1226	11.67

DATA SET 25

T	ρ
300	2.23*
333	2.47
357	2.71*
404	3.09*
426	3.31
449	3.49*
495	3.86
544	4.30*
594	4.76
635	5.13
679	5.54

DATA SET 25 (cont.)

T	ρ
733	6.07*
782	6.51
841	7.10*
893	7.67*
936	8.11
1033	9.17*
1041	9.28
1083	9.79*
1135	10.41
1183	11.07

DATA SET 26

T	ρ
298	2.36*
363	2.90
384	3.07
410	3.33
432	3.52
461	3.75
482	3.95
504	4.14
519	4.25
555	4.62*
577	4.79
607	5.07
630	5.26*
656	5.49*
680	5.78
707	6.02
729	6.26
754	6.47
783	6.75*
808	6.99
832	7.21*
860	7.53*
885	7.74
905	8.00*
932	8.30*
961	8.58*
982	8.89
1008	9.12
1033	9.39*
1059	9.75*
1082	10.02
1109	10.34
1133	10.67*
1157	10.98
1182	11.34
1205	11.63

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY CF GOLD Au (continued)

T	ρ
DATA SET 27	
300	3.72
313	3.85
352	4.16
392	4.41
432	4.81
485	5.24
534	5.61
559	5.78
609	6.30
655	6.67
698	7.08
745	7.49
795	7.84
842	8.45
887	8.98
934	9.35
985	9.97
1033	10.45
1082	11.08
1133	11.67
1185	12.12
1235	12.65
DATA SET 28	
568	4.72
DATA SET 29	
1.74	0.1452
2.42	0.1444
2.92	0.1410
2.95	0.1426*
3.84	0.1373
4.17	0.1384
5.09	0.1360
5.65	0.1342
6.66	0.1328
8.29	0.1309
9.73	0.1296
11.60	0.1292
14.82	0.1311
16.84	0.1335
DATA SET 30	
1.83	0.9710
2.35	0.9764

T	ρ
DATA SET 30 (cont.)	
2.99	0.9799
3.69	0.9840
4.17	0.9859
5.18	0.9868
5.61	0.9875
6.23	0.9880
6.94	0.9875
7.93	0.9845
9.26	0.9830
11.40	0.9785
13.62	0.9765
16.85	0.9772
DATA SET 31	
1.21	0.0132
2.05	0.0130
2.65	0.0129
3.06	0.0128
4.24	0.0127
DATA SET 32	
1.20	0.0362
2.10	0.0356
2.33	0.0355
2.65	0.0352
3.05	0.0351
4.24	0.0347
DATA SET 33	
1.23	0.0520
2.11	0.0510
2.32	0.0506
2.65	0.0505
3.07	0.0503
4.24	0.0497
DATA SET 34	
0.03	0.1366*
0.04	0.1381*
0.17	0.1396
0.26	0.1409
0.44	0.1426
0.72	0.1440
1.06	0.1446

T	ρ
DATA SET 34 (cont.)	
1.22	0.1447
1.64	0.1447
2.02	0.1446
2.22	0.1446
2.32	0.1446
2.66	0.1444
3.06	0.1440
3.60	0.1437
4.24	0.1434
DATA SET 35	
1.24	0.2297
1.63	0.2306
2.05	0.2310
2.30	0.2310
2.63	0.2315
3.05	0.2312
3.62	0.2309
4.24	0.2306
DATA SET 36	
1.8	0.268
2.4	0.270
3.1	0.270*
4.1	0.270
5.1	0.268
6.0	0.269
6.7	0.267
7.4	0.268*
9.3	0.267
11.3	0.267
12.9	0.269
15.3	0.272
18.9	0.281
23.1	0.300
DATA SET 37	
1.8	0.486
2.4	0.488
3.0	0.490
3.6	0.490
4.2	0.492
5.2	0.492
5.6	0.492
6.2	0.491

T	ρ
DATA SET 37 (cont.)	
7.0	0.491
7.9	0.491
9.3	0.491
11.5	0.490
13.6	0.491
16.9	0.494
DATA SET 38	
1.8	1.188
2.4	1.205*
3.2	1.212*
3.7	1.221*
4.2	1.225
5.2	1.227
5.8	1.229
6.7	1.231
7.7	1.231
9.3	1.230
11.2	1.232
13.0	1.231
15.4	1.235
18.9	1.243
23.1	1.263
DATA SET 39	
1.24	0.0336
2.04	0.0328*
2.29	0.0326
2.64	0.0323
3.04	0.0322
3.60	0.0320
4.21	0.0320
DATA SET 40	
0.03	0.08691*
0.10	0.08480
0.13	0.08436
0.27	0.08226
0.66	0.07835
1.22	0.07621
1.61	0.07458
2.05	0.07384
2.05	0.07384
2.24	0.07335
2.31	0.07363

T	ρ
DATA SET 40 (cont.)	
2.58	0.07299
2.64	0.07299*
3.05	0.07235
3.57	0.07199
4.25	0.07165
DATA SET 41	
1.23	0.19456
2.04	0.19074
2.29	0.18947
2.65	0.18886
3.04	0.18753
4.25	0.18574
DATA SET 42	
0.04	0.77873*
0.23	0.78121
0.39	0.78295
0.85	0.78791
1.14	0.78964
1.18	0.79122*
1.60	0.79278
1.98	0.79356
2.23	0.79356
2.60	0.79356
2.98	0.79356
3.55	0.79279
4.22	0.79201
DATA SET 43	
1.76	0.833
2.41	0.833
3.07	0.835
3.76	0.843
4.22	0.841
5.12	0.844
5.97	0.844
6.69	0.840
7.56	0.837
9.25	0.835
11.29	0.835
12.99	0.837
15.41	0.838
18.91	0.850
23.22	0.867

T	ρ
DATA SET 44	
1.78	3.802
2.33	3.816
2.95	3.821
3.63	3.845
4.17	3.850
5.14	3.857
5.56	3.862
6.26	3.869
6.89	3.873
7.85	3.877
9.27	3.885
11.41	3.895
13.62	3.905
16.84	3.916
DATA SET 45	
75	0.53
158	1.21
194	1.56
246	1.96
304	2.41
460	3.69
580	4.75
679	5.72
736	6.27
DATA SET 46	
4	0.002775
77	0.427
295	2.145
DATA SET 47	
4	0.009519
77	0.434*
295	2.161*
DATA SET 48	
88	0.487
DATA SET 49	
91	0.520

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

DATA SET 50

T	ρ
10	0.00757
15	0.0107
20	0.0195
25	0.0340
30	0.0570
40	0.127*
50	0.207
60	0.297
70	0.387
80	0.467
90	0.552
100	0.637*
120	0.797
140	0.962*
160	1.13*
180	1.29*
200	1.45*
220	1.61*
250	1.83
273	2.01*
295	2.21

DATA SET 51

T	ρ
330.7	2.64
396.2	3.31
471.5	4.10
569.5	5.03
636.5	5.78
716.5	6.54
797.8	7.53
888.8	8.55
963.8	9.72

DATA SET 52

T	ρ
332	2.74
394	3.37
469	4.20
566	5.15
635	5.94
712	6.73
795	7.73
886	8.75

DATA SET 53

T	ρ
2.03	0.0281
2.49	0.0281
2.97	0.0281
3.43	0.0281
4.13	0.0281
5.31	0.0281
7.97	0.0284
10.75	0.0290

DATA SET 54

T	ρ
2.04	0.0328
2.58	0.0328
2.99	0.0328
3.50	0.0328
4.13	0.0327
5.21	0.0329
5.24	0.0330*
7.94	0.0333
9.45	0.0337

DATA SET 55

T	ρ
2.00	0.00950
2.54	0.00951
2.95	0.00950
3.45	0.00953
4.14	0.00964
6.06	0.00977
7.88	0.00995

DATA SET 56

T	ρ
1.2607	0.003902
1.5009	0.003838
1.8403	0.003823
2.0405	0.003862
2.3356	0.003823
2.5654	0.003847
2.7558	0.003855
2.9256	0.003798
3.2355	0.003807
3.4202	0.003883
3.6257	0.003839
3.8253	0.003799
4.0351	0.003807
4.2	0.0038
77	0.440
273	2.045*

DATA SET 57

T	ρ
1.0859	0.09071
1.0948	0.09071*
1.3448	0.08973*
1.4291	0.08948*
1.5351	0.08914
1.6427	0.08885*
1.6991	0.08868*
1.8202	0.08841*
1.9013	0.08822
2.0015	0.08811*
2.1180	0.08772*
2.1615	0.08766*
2.3300	0.08738*
2.3644	0.08733
2.5198	0.08704*
2.6230	0.08691*
2.7101	0.08679*
2.8165	0.08664*
2.8968	0.08652*
2.9747	0.08638
3.0861	0.08631*
3.1973	0.08617*
3.3323	0.08602*
3.3907	0.08596*
3.5551	0.08583*
3.5928	0.08577
3.7124	0.08566*
3.8155	0.08553*
3.9149	0.08550*
3.9892	0.08539*
4.0900	0.08535
4.1932	0.08526*
4.1999	0.08522*
4.2	0.0852
77	0.527
273	2.109

DATA SET 58

T	ρ
1.0905	0.25990
1.3729	0.25829*
1.5113	0.25755
1.6829	0.25666*
1.8045	0.25609
1.8699	0.25573*
1.9694	0.25534
2.1237	0.25467*
2.3286	0.25384
2.5158	0.25318*
2.6280	0.25279
2.7117	0.25219*
2.8951	0.25193
3.0940	0.25134*
3.3426	0.25066
3.4449	0.25038*
3.5472	0.25015
3.7115	0.24974*
3.9148	0.24929
4.0955	0.24887
4.2	0.24710
4.2131	0.24868*
77	0.695
273	2.269

DATA SET 59

T	ρ
1.1617	0.31140
1.3677	0.30974*
1.5113	0.30887
1.6831	0.30804*
1.8020	0.30743
1.8876	0.30709*
1.9667	0.30664
2.1055	0.30616*
2.3374	0.30516
2.5315	0.30455*
2.6352	0.30411
2.7125	0.30377*
2.8852	0.30334
3.1129	0.30274*
3.3303	0.30209*
3.4508	0.30179
3.5604	0.30170*
3.6855	0.30129*
3.9112	0.30070
4.0996	0.30029
4.2	0.30000
4.2033	0.30003*
77	0.732
273	2.295

DATA SET 60

T	ρ
1.0804	0.41832
1.3283	0.41757
1.5157	0.41686
1.6891	0.41618
1.7409	0.41594
1.8540	0.41555
1.9954	0.41496
2.1072	0.41454
2.1367	0.41435*
2.1628	0.41430
2.3129	0.41370
2.5123	0.41292
2.6141	0.41258
2.7036	0.41229
2.8829	0.41159
3.0954	0.41090
3.3472	0.41018
3.5467	0.40955
3.7098	0.40910
3.8276	0.40878
3.9243	0.40854
4.0630	0.40814
4.1846	0.4078*
4.2	0.408
77	0.862
273	2.435

DATA SET 61

T	ρ
1.0859	0.76547
1.2892	0.76676*
1.4071	0.76727*
1.5406	0.76765
1.6882	0.76801*
1.8806	0.76823*
2.0164	0.76813
2.2198	0.76825*
2.4215	0.76799*
2.5894	0.76787
2.7485	0.76753*
2.8780	0.76730*
3.0338	0.76697
3.1966	0.76667*
3.3825	0.76625
3.5238	0.76603*
3.6488	0.76570*
3.7698	0.76554
3.9179	0.76515*
4.0932	0.76477
4.2	0.76500
4.2062	0.76456*
77	1.231
273	2.812

DATA SET [illegible]

T	ρ
1.0690	[illegible]
1.3445	[illegible]
1.5041	[illegible]
1.6143	[illegible]
1.7002	[illegible]
1.7991	[illegible]
1.8925	[illegible]
1.9851	[illegible]
2.0700	[illegible]
2.1502	[illegible]
2.3215	[illegible]
2.5179	[illegible]
2.7135	[illegible]
2.9034	[illegible]
3.0923	[illegible]
3.3404	0.78758
3.5052	0.78734*
3.6367	0.78701*
3.7571	0.78690
3.9113	0.78639*
4.0945	0.76598*
4.2	0.78600
4.2043	0.78557*
77	1.251
273	2.828*

DATA SET 63

T	ρ
1.0905	1.2000
1.0936	1.2000*
1.2970	1.2018
1.3556	1.2025
1.3980	1.2029
1.4989	1.2038
1.5139	1.2037*
1.5770	1.2044
1.6995	1.2054
1.7004	1.2054*
1.8451	1.2063
1.8974	1.2066
2.0098	1.2075
2.1163	1.2078
2.2401	1.2087
2.3196	1.2089
2.4172	1.2093
2.5066	1.2095
2.6226	1.2100
2.7034	1.2101
2.8323	1.2105

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

T	ρ
DATA SET 63 (cont.)	
2.8988	1.2106
3.0162	1.2108
3.0873	1.2109*
3.1533	1.2110
3.3315	1.2112
3.3425	1.2112*
3.4027	1.2113*
3.5297	1.2114
3.5451	1.2114*
3.5933	1.2114*
3.6943	1.2114
3.7130	1.2115*
3.8081	1.2115
3.9168	1.2116
3.9957	1.2116*
4.0744	1.2115
4.1898	1.2114*
4.2	1.212*
77	1.692
273	3.280
DATA SET 64	
1.0939	1.5043
1.2940	1.5065
1.3602	1.5072
1.3887	1.5076*
1.4559	1.5082
1.4947	1.5088*
1.5421	1.5092
1.6082	1.5098
1.6505	1.5102
1.6833	1.5106*
1.7770	1.5115
1.8678	1.5123
1.9658	1.5132
2.0805	1.5138
2.1587	1.5145
2.2938	1.5156
2.4769	1.5169
2.6172	1.5177
2.7459	1.5184
2.9126	1.5192
3.1051	1.5201
3.3402	1.5208
3.5512	1.5215
3.7163	1.5220
3.8622	1.5223

T	ρ
DATA SET 64 (cont.)	
3.9973	1.5224
4.0937	1.5226
4.1972	1.5228*
4.2	1.523
77	2.016
273	3.602
DATA SET 65	
1.0729	2.1268
1.2649	2.1280
1.3493	2.1285
1.3820	2.1287
1.4619	2.1292
1.5162	2.1295
1.5774	2.1299
1.6615	2.1304
1.7597	2.1311
1.8512	2.1315
1.9391	2.1321
2.0650	2.1327
2.1445	2.1331
2.2575	2.1338
2.4021	2.1345
2.5250	2.1352
2.6911	2.1360
2.8802	2.1369
3.0861	2.1378
3.3150	2.1388
3.5087	2.1394
3.6115	2.1397
3.7432	2.1400
3.9293	2.1407
4.0867	2.1411
4.2	2.1500
4.2014	2.1413*
77	2.664
273	4.25
DATA SET 66	
1.0859	3.3889
1.3313	3.3920
1.3790	3.3929
1.5365	3.3949
1.6675	3.3966
1.7680	3.3980
1.8644	3.3995

T	ρ
DATA SET 66 (cont.)	
2.0190	3.4008
2.1107	3.4024
2.2821	3.4044
2.4175	3.4062
2.5653	3.4079
2.7208	3.4099
2.8649	3.4115
3.0032	3.4128
3.1226	3.4139
3.3556	3.4164
3.5447	3.4181
3.6707	3.4193
3.7889	3.4202
3.9278	3.4223
4.0949	3.4239
4.2	3.4200
4.2118	3.4248*
77	4.003
273	5.60
DATA SET 67	
1.0651	3.7280
1.3580	3.7302
1.5210	3.7323
1.7071	3.7246
1.8963	3.7371
2.1170	3.7395
2.3258	3.7426
2.5223	3.7449
2.6951	3.7471
2.8958	3.7493
3.0942	3.7513
3.3398	3.7541
3.5427	3.7561
3.7117	3.7580
3.9207	3.7599
4.2	3.760
77	4.39
273	5.99
DATA SET 68	
1.0690	0.49612
1.3283	0.49603
1.4995	0.49573
1.7036	0.49521
1.8974	0.49468

T	ρ
DATA SET 68 (cont.)	
2.1220	0.49396
2.3005	0.49334
2.5150	0.49265
2.7082	0.49202
2.9004	0.49142
3.0914	0.49083
3.3413	0.49004
3.5483	0.48938
3.7058	0.48858
3.9220	0.48836
4.0962	0.48289
4.2	0.4870
4.2037	0.4876*
77	0.938
273	2.48
DATA SET 69	
1.0938	0.87550
1.3564	0.87784*
1.5289	0.87900*
1.7029	0.87983
1.8995	0.88071*
2.1205	0.88134*
2.3288	0.88205
2.5191	0.88248*
2.7121	0.88282*
2.9067	0.88304
3.0868	0.88317*
3.3428	0.88312*
3.5450	0.88299
3.6980	0.88284*
3.9233	0.88259*
4.0927	0.88233
4.2	0.8822
4.2008	0.88216*
77	1.356
273	2.92
DATA SET 70	
1.0753	1.7447
1.3585	1.7480
1.8948	1.7535
2.1203	1.7556
2.3303	1.7577
2.5086	1.7591
2.7039	1.7603

T	ρ
DATA SET 70 (cont.)	
2.8914	1.7619
3.0932	1.7627
3.3473	1.7639
3.5433	1.7648
3.7108	1.7655
3.9237	1.7662
4.0886	1.7668
4.1993	1.7670
DATA SET 71	
293	2.3166*
587	4.82
688	5.68
818	7.01
913	8.05
987	8.90
1051	9.70
1118	10.55
1195	11.45
1243	12.05
1311	13.05
1336	13.40
1336	14.00
1343	15.60
1333	21.00
1335	26.00
1339	28.00
1351	30.99
1384	31.49
1402	31.75
1413	32.00
1457	32.50
1476	32.80
1491	33.00
1500	33.12
1527	33.50
1546	33.75
1632	35.01
1668	35.51
1699	36.00
1740	36.55
DATA SET 72	
1413	32.00*
1491	33.00*
1605	35.00

T	ρ
DATA SET 72 (cont.)	
1643	36.00
1668	37.00
1703	38.05
1745	39.00
1773	40.00
DATA SET 73	
290.09	2.405
372.24	3.069
DATA SET 74	
291	4.05
373	4.72
DATA SET 75	
291	2.42*
373	3.12
DATA SET 76	
21.5	0.01726
91.5	0.5708
273.1	2.065*
291.1	2.213*
294.6	2.243*
373.7	2.895*
DATA SET 77	
162	1.24
199	1.36
252	1.84*
307	2.29*
461	3.48
580	4.66
679	5.73*
737	6.14*
DATA SET 78	
293	2.20*
473	3.71
673	5.52
873	7.47*
1073	9.65
1273	12.64

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

DATA SET 79

T	ρ
507	4.29
554	4.74
708	6.26
722	6.41
774	6.96
798	7.22
834	7.62
865	7.96
892	8.28
914	8.53
949	8.93
978	9.29
1011	9.70
1068	10.42
1096	10.78
1124	11.16
1150	11.53
1183	11.98
1204	12.29
1228	12.63
1260	13.13
1290	13.62

DATA SET 80*

T	ρ
1.70	0.000071863
1.94	0.000071880
2.21	0.000071859
2.68	0.000071873
2.80	0.000071853
3.35	0.000071836
3.78	0.000071862
3.96	0.000071869
4.38	0.000071912
5.11	0.000071964
5.62	0.000072064

DATA SET 81*

T	ρ
1.62	0.000071764
1.83	0.000071729
2.09	0.000071693
2.54	0.000071647
2.75	0.000071574
3.13	0.000071545
3.47	0.000071554
3.97	0.000071502

DATA SET 81 (cont.)*

T	ρ
4.38	0.000071571
5.04	0.000071660
5.64	0.000071800

DATA SET 82*

T	ρ
1.61	0.000055150
1.80	0.000055128
2.00	0.000055128
2.29	0.000055164
2.56	0.000055176
2.89	0.000055142
3.58	0.000055146
3.97	0.000055174
4.91	0.000055271
5.81	0.000055427

DATA SET 83*

T	ρ
1.62	0.000055383
1.86	0.000055372
2.10	0.000055344
2.34	0.000055304
2.82	0.000055285
3.28	0.000055244
3.69	0.000055244
3.97	0.000055228
4.47	0.000055282
5.02	0.000055360
5.63	0.000055412

DATA SET 84

T	ρ
292	2.34
300	2.30*
389	3.10
477	3.82
524	4.19
595	4.84
635	5.26
713	6.01
802	6.90
823	7.12
888	7.85
945	8.55
1013	9.33
1065	9.96

DATA SET 84 (cont.)

T	ρ
1102	10.39
1175	11.35

DATA SET 85

T	ρ
1243	12.35
1263	12.51
1285	12.84
1305	13.16
1323	13.48
1334	13.49
1343	31.21
1364	31.38
1381	31.70
1403	32.02
1425	32.35
1443	32.67
1465	32.84

DATA SET 86

T	ρ
3.2	0.00278

DATA SET 87

T	ρ
1.5	0.0166
293	2.42*

DATA SET 88*

T	ρ
297.2	2.44

DATA SET 89*

T	ρ
297.2	2.44

DATA SET 90

T	ρ
273.2	2.214

DATA SET 91

T	ρ
4.2	0.0023
273.2	2.000

DATA SET 92

T	ρ
281.62	2.219

DATA SET 93

T	ρ
4.2	0.00205
273.2	2.009*

DATA SET 94

T	ρ
7	0.02057
8	0.02121
9	0.02210
10	0.02290
12	0.02422
14	0.02567
16	0.02782
18	0.03103
20	0.03550*
25	0.05249
30	0.07721
35	0.1082
40	0.1438
45	0.1831
50	0.2245*
55	0.2674
60	0.3112*
65	0.3554
70	0.3998*
75	0.4441
80	0.4881*
85	0.5318
90	0.5751*
95	0.6181
100	0.6607*
110	0.7447
120	0.8274*
130	0.9091
140	0.9902*
150	1.071
160	1.151*
170	1.231
180	1.311*
190	1.392
200	1.473*
220	1.635*
240	1.797*
260	1.960
280	2.123

DATA SET 95

T	ρ
273.2	2.2500*
295.5	2.4424
327.3	2.7237
354.4	2.9690
377.9	3.1831
401.7	3.4001
430.1	3.6671
454.0	3.8909
478.5	4.1253
502.6	4.3558
528.2	4.6029
551.6	4.8365
600.7	5.3219
662.1	5.9474
708.3	6.4369
747.6	6.8592
811.0	7.5587
864.3	8.1691
916.8	8.7912
978.3	9.5474
1024.1	10.1351
1093.5	11.0594
1140.8	11.7236
1200.6	12.5971

DATA SET 96

T	ρ
4.2	0.006
90	0.54
200	1.40
273	2.00
300	2.25*
500	3.97
600	4.83
700	5.79
800	6.76
900	7.79
1000	8.89
1100	10.06
1200	11.32*

DATA SET 97

T	ρ
290.5	2.33*
406.9	3.29
464.8	3.78
503.4	4.10

DATA SET 97 (cont.)

T	ρ
642.7	5.38
662.4	5.56
679.0	5.72*
718.3	6.11
756.7	6.49
791.3	6.84
824.8	7.19
858.4	7.54
893.6	7.91
949.6	8.53
1003.6	9.16
1028.7	9.45
1079.0	10.05
1121.5	10.59
1172.3	11.25
1214.4	11.82

DATA SET 98

T	ρ
76.1	0.6813
167.1	1.3668
191.3	1.5485
229	1.8490
273	2.1970*
274.20	2.2008*
285.10	2.2937
287.5	2.3145
288.6	2.3188*
289.45	2.3264*
291.9	2.3477*
323.2	2.6065
363.5	2.9413
405.4	3.2586
467.7	3.7921*

DATA SET 99

T	ρ
91	0.604
173	1.207
193	1.400*
273.8	1.952
295.5	2.096
369.7	2.639

DATA SET 100*

T	ρ
298	2.270

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

T	ρ
DATA SET 101*	
298	2.288
DATA SET 102	
1408	32.0
DATA SET 103	
84	0.688
98	0.795
123	0.992
148	1.191
173	1.400
198	1.607
223	1.818
248	2.029
273	2.245*
298	2.462*
323	2.675*
348	2.891
373	3.102*
398	3.317*
423	3.529*
448	3.745*
473	3.956
498	4.178*
523	4.402*
548	4.623*
573	4.853
598	5.084*
623	5.320*
648	5.561
673	5.818
DATA SET 104	
1373	31.7
DATA SET 105	
1340	31.2
1358	31.5
DATA SET 106	
78	0.45

T	ρ
DATA SET 107	
293	2.235*
1337.58	13.1
1337.58	29.1
DATA SET 108	
77.34	0.79
DATA SET 109	
4.2	0.0075
77.3	0.444*
298.0	2.235*
DATA SET 110	
1.281	0.008524
1.531	0.008483*
1.755	0.008454*
1.950	0.008433*
2.117	0.008416
2.290	0.008402*
2.504	0.008388*
2.724	0.008376*
2.871	0.008368*
3.012	0.008355
3.185	0.008357*
3.289	0.008344*
3.465	0.008341*
3.652	0.008334*
3.891	0.008329*
4.063	0.008322
4.182	0.008318*
4.283	0.008318*
4.369	0.008314*
4.450	0.008313*
4.471	0.008312*
4.553	0.008309*
4.645	0.008308*
4.761	0.008306*
4.861	0.008306*
4.968	0.008305*
5.100	0.008303
5.230	0.008306*
5.349	0.008305*
5.473	0.008310*
5.601	0.008314*
5.743	0.008311*

T	ρ
DATA SET 110 (cont.)	
5.997	0.008318*
6.388	0.008331
6.821	0.008356*
7.365	0.008397
8.112	0.008469
9.389	0.008684
10.175	0.008880
10.929	0.009136*
11.785	0.009487*
12.222	0.009725
13.197	0.010259*
14.235	0.011063*
14.886	0.011688*
15.697	0.012571
16.526	0.013657*
17.505	0.015111*
18.605	0.017050*
19.970	0.019906*
21.643	0.024203
22.807	0.027720*
23.744	0.030845*
25.222	0.036371*
26.387	0.041260*
28.363	0.050499*
29.989	0.058945*
31.758	0.069046
33.813	0.081736*
35.031	0.089731*
37.581	0.107493*
39.822	0.123943*
44.288	0.158806
48.683	0.194837*
54.105	0.240760
60.877	0.299283*
69.740	0.376239*
75.308	0.424014
88.475	0.537190*
94.201	0.585430*
97.838	0.615885*
103.593	0.663869*
109.623	0.713418*
113.006	0.741206*
115.591	0.762371
118.745	0.788330*
121.257	0.808816*
124.823	0.837775*
130.376	0.882911*
136.333	0.931227

T	ρ
DATA SET 110 (cont.)	
147.733	1.023563
154.509	1.077907*
160.520	1.126396*
166.809	1.177116
172.854	1.225542*
178.979	1.274530*
185.019	1.322666
191.138	1.371640*
197.391	1.421695*
203.572	1.471057*
209.769	1.520675
215.936	1.569809
222.148	1.619663*
228.727	1.672842*
234.783	1.720887
240.969	1.770194*
247.348	1.821392*
253.598	1.871606
260.168	1.924557*
266.329	1.973967*
272.793	2.026343
273.150	2.0290*
279.034	2.076592*
285.433	2.128011
291.910	2.180623*
DATA SET 111	
1.59	0.0805
1.70	0.0805*
2.89	0.0804*
4.20	0.0804*
4.21	0.0804*
7.21	0.0806
10.70	0.0819
12.44	0.0843*
16.88	0.0900
20.06	0.1014
30.20	0.1472
41.26	0.2223
50.19	0.2945
59.88	0.3769
74.19	0.4997
76.97	0.5234*
89.32	0.6282
106.99	0.7765*
114.60	0.8390
127.19	0.9418*

T	ρ
DATA SET 111 (cont.)	
147.20	1.103
167.90	1.269*
192.63	1.466
217.89	1.668*
243.43	1.872
273.15	2.110*
288.45	2.232
297.11	2.301*
DATA SET 112	
1.59	0.00158
1.71	0.00158*
2.90	0.00158*
4.21	0.00158*
4.21	0.00182
7.18	0.00167
10.69	0.00228
12.47	0.00360*
16.84	0.00702
20.10	0.01528
30.21	0.05604*
41.26	0.1314
50.19	0.2054*
59.88	0.2897
74.17	0.4147*
76.97	0.4390*
89.32	0.5455*
107.01	0.6953
114.61	0.7587*
127.19	0.8626
147.18	1.026*
167.92	1.194*
192.63	1.393*
217.87	1.597
243.43	1.803
273.15	2.043*
288.45	2.166
297.11	2.236*
DATA SET 113	
1.59	0.111
1.72	0.111*
2.92	0.111*
4.20	0.112
4.21	0.112*
7.16	0.112*

T	ρ
DATA SET 113 (cont.)	
10.66	0.113
12.50	0.116
16.80	0.123
20.11	0.135
30.22	0.184
41.26	0.260
50.19	0.333
59.88	0.416
74.17	0.538*
76.97	0.563
89.32	0.668
107.02	0.816
114.60	0.879*
127.16	0.982
147.19	1.144*
167.91	1.311
192.63	1.509*
217.86	1.712
243.45	1.917
273.15	2.155*
288.45	2.278*
297.11	2.347*
DATA SET 114	
3.28	0.00196
5.16	0.00196*
6.97	0.00205
10.64	0.00268
14.26	0.00460
17.76	0.00774
20.81	0.01334
22.30	0.02191*
26.20	0.03597*
29.83	0.05367*
35.08	0.08600
44.94	0.1603*
54.24	0.2394*
65.85	0.3404
75.22	0.4220*
76.84	0.4360*
77.93	0.4454*
79.64	0.4602*
90.26	0.5512*
105.67	0.6811
113.31	0.7446*
126.32	0.8517*
146.76	1.018*

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

DATA SET 114 (cont.)

T	ρ
167.61	1.186*
192.13	1.383*
217.90	1.590*
243.42	1.795*
273.15	2.034*
277.07	2.065
286.26	2.139*
297.08	2.226*
298.03	2.233*
311.69	2.343
327.95	2.474
329.58	2.487*
342.12	2.587*
348.34	2.637*
354.47	2.687*
359.29	2.725*
372.37	2.846

DATA SET 115

T	ρ
3.28	0.0340
5.16	0.0340*
6.97	0.0342
10.57	0.0354
14.02	0.0383*
17.76	0.0423
20.81	0.0504*
22.27	0.0605
26.21	0.0759*
29.84	0.0943
35.08	0.1267*
44.93	0.2001
54.24	0.2785*
65.85	0.3784
75.22	0.4595*
76.84	0.4736
77.92	0.4822*
79.64	0.4976*
90.27	0.5881
105.67	0.7174*
113.31	0.7808
126.32	0.8875*
146.76	1.054
167.62	1.221
192.13	1.418*
217.91	1.625*
243.41	1.830*
273.15	2.068*

DATA SET 115 (cont.)

T	ρ
277.07	2.100*
286.26	2.173*
297.08	2.260*
298.03	2.267*
311.69	2.377
327.95	2.509*
329.58	2.521
342.02	2.621*
348.44	2.674*
354.45	2.722
359.29	2.760*
372.35	2.882*

DATA SET 116

T	ρ
3.28	0.0320*
5.15	0.0320
6.97	0.0322*
10.66	0.0334
13.90	0.0362*
17.92	0.0413
20.82	0.0480*
22.22	0.0576
26.19	0.0730*
29.83	0.0911
35.08	0.1237
44.93	0.1972*
54.25	0.2762
65.86	0.3768*
75.23	0.4585
76.84	0.4728*
77.91	0.4812*
79.65	0.4967*
90.27	0.5883*
105.67	0.7186
113.31	0.7825*
126.32	0.8902
146.76	1.057*
167.62	1.227*
192.11	1.424
217.94	1.631*
243.41	1.839*
273.15	2.078*
277.08	2.111*
286.26	2.185*
297.08	2.272*
298.03	2.279*
311.69	2.389

DATA SET 116 (cont.)

T	ρ
327.95	2.523*
329.58	2.536*
341.92	2.634
348.44	2.691
354.47	2.737*
359.19	2.777
372.34	2.899*

DATA SET 117

T	ρ_i
10	0.00050*
12	0.00115*
14	0.00228*
16	0.00422
18	0.00720*
20	0.01093
22	0.0162*
24	0.0228*
26	0.0304
28	0.0395*
30	0.0497*
32	0.0610
34	0.0733*
36	0.0872*
38	0.1012*
40	0.1152
42	0.1300*
44	0.1465*
46	0.1630
48	0.1795*
50	0.1960*
55	0.2400*
60	0.2840*
65	0.3290*
70	0.3725
75	0.4155*
80	0.4585*
85	0.5020*
90	0.5450*
95	0.5870
100	0.6295*
105	0.6715*
110	0.7140
115	0.7560*
120	0.7965*
125	0.8370*

DATA SET 117 (cont.)

T	ρ_i
130	0.8780*
135	0.9190
140	0.9600*
145	1.0010*
150	1.041*
155	1.082
160	1.122*
165	1.163*
170	1.204*
175	1.244*
180	1.285*
185	1.325*
190	1.365*
195	1.405*
200	1.446*
205	1.488*
210	1.528*
215	1.568*
220	1.610*
225	1.650*
230	1.690*
235	1.730*
240	1.770*
245	1.812*
250	1.852*
255	1.892*
260	1.934*
265	1.975*
270	2.015*
273.2	2.038*
275	2.056*
280	2.096*
285	2.136*
290	2.178*

DATA SET 118*

T	ρ
7	0.02057
8	0.02121
9	0.02210
10	0.02290
12	0.02422
17	0.02567
16	0.02782
18	0.03103
20	0.03550

DATA SET 118 (cont.)*

T	ρ
25	0.05249
30	0.07721
35	0.10820
40	0.14390
45	0.18310
50	0.22450
55	0.26740
60	0.31120
65	0.35540
70	0.39980
75	0.44410
80	0.48810
85	0.53180
90	0.57510
95	0.61810
100	0.66070
110	0.74470
120	0.82740
130	0.90910
140	0.99020
150	1.07100
160	1.15100
170	1.23100
180	1.31100
190	1.39200
200	1.47300
220	1.63500
240	1.79700
260	1.96000
280	2.12300

DATA SET 119

T	ρ
6	0.03618
7	0.03648*
8	0.03652
9	0.03660*
10	0.03683
12	0.03783*
14	0.03955*
16	0.04209
18	0.04564*
20	0.05035
25	0.06769
30	0.09272*
35	0.12410*
40	0.16040
45	0.20010*

DATA SET 119 (cont.)

T	ρ
50	0.24200*
55	0.28530*
60	0.32930*
65	0.37370*
70	0.41810*
75	0.46230*
80	0.50630*
85	0.55000*
90	0.59330*
95	0.63630
100	0.67910*
110	0.76380*
120	0.84760*
130	0.93080*
140	1.01400*
150	1.09600*
160	1.17700*
170	1.25800*

DATA SET 120

T	ρ
7	0.00726
8	0.00706
9	0.00729
10	0.00768*
12	0.00863
14	0.00984*
16	0.01168
18	0.01452*
20	0.01859
25	0.03466*
30	0.05875
35	0.08941*
40	0.12500
45	0.16420*
50	0.20580*
55	0.24900*
60	0.29310*
65	0.33760*
70	0.38230*
75	0.42690*
80	0.47120*
85	0.51520
90	0.55880*
95	0.60200*
100	0.64470*
110	0.72920*
120	0.81250*

* Not shown on either figure.

TABLE 7. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF GOLD Au (continued)

DATA SET 120 (cont.)

T	ρ
130	0.89500*
140	0.97720*
150	1.06000*
160	1.14300*
170	1.22700*

DATA SET 121

T	ρ
0.492	0.002911*
0.513	0.002896*
0.535	0.002881*
0.554	0.002881*
0.578	0.002881*
0.613	0.002866*
0.656	0.002881*
0.685	0.002881*
0.714	0.002866*
0.758	0.002866*
0.798	0.002880*
0.832	0.002865*
0.854	0.002865*
0.883	0.002865*
0.922	0.002865*
0.954	0.002865*
1.012	0.002865*
1.074	0.002865*
1.130	0.002865*
1.169	0.002865*
1.210	0.002879
1.295	0.002879*
1.351	0.002864*
1.421	0.002864*
1.470	0.002864*
1.547	0.002864
1.628	0.002864*
1.713	0.002864*
1.818	0.002878*
1.930	0.002878*
2.013	0.002878
2.083	0.002878*
2.173	0.002893*
2.287	0.002878*
2.406	0.002892
2.511	0.002863*
2.597	0.002877*
2.756	0.002892*
2.900	0.002892

DATA SET 121 (cont.)

T	ρ
3.001	0.002877*
3.158	0.002892*
3.351	0.002907

DATA SET 122

T	ρ
0.495	0.010823*
0.516	0.010794*
0.543	0.010780*
0.562	0.010751*
0.591	0.010751*
0.611	0.010722*
0.654	0.010693*
0.694	0.010650*
0.730	0.010635*
0.762	0.010621*
0.808	0.010592*
0.850	0.010563*
0.895	0.010549*
0.933	0.010520*
0.974	0.010505*
1.024	0.010491*
1.087	0.010477*
1.124	0.010462*
1.193	0.010448*
1.223	0.010434
1.265	0.010434*
1.320	0.010405*
1.354	0.010405*
1.413	0.010376*
1.474	0.010376*
1.550	0.010377
1.631	0.010318*
1.701	0.010304*
1.790	0.010304*
1.899	0.010305*
1.998	0.010276*
2.102	0.010247*
2.193	0.010218*
2.288	0.010203*
2.427	0.010189
2.532	0.010189*
2.619	0.010190*
2.756	0.010175*
2.899	0.010161*
3.050	0.010162
3.155	0.010147*

DATA SET 122 (cont.)

T	ρ
3.319	0.010133*
3.433	0.010133

DATA SET 123

T	ρ
0.505	0.018945*
0.522	0.018918*
0.540	0.018877*
0.568	0.018849*
0.598	0.018794*
0.619	0.018767*
0.640	0.018712*
0.662	0.018684*
0.697	0.018657*
0.727	0.018629*
0.758	0.018574*
0.805	0.018519*
0.854	0.018492*
0.891	0.018451*
0.922	0.018423*
0.962	0.018382*
1.029	0.018354
1.074	0.018299*
1.149	0.018272*
1.179	0.018244*
1.209	0.018217*
1.251	0.018176*
1.328	0.018162
1.397	0.018107*
1.445	0.018107*
1.534	0.018093*
1.628	0.018038*
1.684	0.018011*
1.772	0.017969*
1.880	0.017928
1.996	0.017901*
2.082	0.017901*
2.154	0.017846*
2.286	0.017832*
2.405	0.017791*
2.509	0.017763*
2.618	0.017749*
2.755	0.017722*
2.899	0.017694
3.025	0.017667*
3.156	0.017653*
3.293	0.017639*
3.406	0.017625

DATA SET 124*

T	ρ
0.522	0.035489
0.550	0.035401
0.583	0.035284
0.608	0.035153
0.640	0.035094
0.691	0.034948
0.733	0.034802
0.785	0.034670
0.840	0.034583
0.869	0.034509
0.922	0.034407
0.962	0.034334
1.021	0.034232
1.074	0.034144
1.120	0.034056
1.179	0.033969
1.219	0.033910
1.262	0.033866
1.350	0.033749
1.445	0.033603
1.482	0.033545
1.627	0.033442
1.697	0.033369
1.786	0.033281
1.895	0.033237
1.994	0.033150
2.081	0.033077
2.152	0.033018
2.265	0.032959
2.403	0.032843
2.507	0.032784
2.594	0.032784
2.729	0.032696
2.872	0.032609
3.022	0.032550
3.179	0.032491
3.289	0.032433
3.461	0.032404

DATA SET 125

T	ρ
0.487	0.040696*
0.500	0.040580*
0.513	0.040507*
0.540	0.040391*
0.563	0.040275*
0.588	0.040159*
0.614	0.040029*

DATA SET 125 (cont.)

T	ρ
0.640	0.039913*
0.663	0.039855*
0.691	0.039696*
0.722	0.039638*
0.760	0.039493*
0.793	0.039362*
0.849	0.039232*
0.886	0.039116*
0.932	0.039043*
0.964	0.038928*
1.015	0.038793*
1.078	0.038681*
1.134	0.038551*
1.174	0.038464*
1.214	0.038406*
1.267	0.038348*
1.345	0.038203
1.416	0.038072*
1.465	0.038014*
1.516	0.037928*
1.609	0.037797*
1.708	0.037710
1.783	0.037623*
1.909	0.037507*
2.009	0.037391*
2.079	0.037333*
2.188	0.037261*
2.303	0.037188
2.424	0.037043*
2.551	0.036971*
2.640	0.036942*
2.778	0.036826
2.899	0.036754*
3.026	0.036681*
3.185	0.036609*
3.295	0.036580*
3.468	0.036522

* Not shown on either figure.

4.3. Palladium

Palladium is a metal with a steel-white appearance. It has an atomic number of 46, a relative atomic mass of 106.4 (see table 1), and is a member of group VIII of the periodic table. There are six stable naturally-occurring isotopes with mass numbers 102, 104, 105, 106, 108, and 110, and a natural abundance of 0.96, 10.97, 22.23, 27.33, 26.71, and 11.81%, respectively [232, pp. B-334 and B-335]. The crystal structure is face-centered cubic. Palladium has a melting point of 1827 K and a normal boiling point of 3243 K [228, p. 41a]. The Debye temperature as obtained from specific heat data is 275 K at 298 K and 283±16 K at 0 K [209, table XV]. It has a density of 12.02 Mg m^{-3} at 293.2 K [228, p. 41a]. At 293 K it has a coefficient of thermal linear expansion of 11.8×10^{-6} K^{-1} [228, p. 248]. At 300 K it has a thermal conductivity of 0.718×10^{2} W m^{-1} K^{-1} for well-annealed high-purity material [211, p. I-503]. Palladium has a latent heat of fusion of 16.74 kJ mol^{-1} [214, p. 229]. Hydrogen is absorbed readily by palladium, and, in addition, hydrogen diffuses at a relatively rapid rate through the heated metal [189, p. 593].

There are 76 sets of experimental data reported in this work for the temperature dependence of the electrical resistivity of palladium. Information pertaining to the specimen characterization, measurement conditions, and method of data extraction is given in table 9 for each of the data sets. The numerical data are tabulated in table 10. The numerical data are graphically shown in figures 9 and 10; the former figure has logarithmic scales, which highlight the low-temperature region, and the latter figure has both scales linear, which emphasize the high-temperature region. Numerical data for the electrical resistivity exist over the temperature range from 1 K to 2019 K.

Out of 71 data sets that give data exclusively in the solid state and the one data set that covers both the solid and liquid states, twenty data sets were produced before 1940. Among these early measurements, the earliest is the 1893 work of Dewar and Fleming [13] (data set 26) that covered the temperature range from 76 K to 467 K. Toward the end of this period, in 1937, Conybeare [130] (data sets 40, 41) reported measurements up to 1273 K for 99.98% pure palladium. His data for a specimen with a preliminary heating to 923 K (curve 40) was considerably below his data for a specimen annealed for 3 days at 1243 to 1273 K (curve 41). The work of Grube and Knabe [138] (data set 70) that was reported in 1936 extended measurements to 1673 K, and their numerical values were below those of Conybeare. The measurements of Grube and Kästner [137] (data set 71) and of Grube et al. [136] (data set 72), both of which were reported in 1936, also were below the measurements of Conybeare.

There are several noteworthy measurements made at low temperatures. The work of Kemp et al. [143, p. 813] (data set 13) in the mid-1950's for 99.995^{+}% pure palladium showed a $T^{3.2}$ dependence below $\theta/5$, where θ is the Debye temperature. White and Woods [91] (data sets 64–6) in their 1959 paper reported smoothed ideal resistivity data down to 10 K. They also showed a $T^{3.2}$ dependence for the ideal resistivity in the range of $\theta/20<T<\theta/10$ [91, pp. 286–7]. In addition, a T^2 relationship appeared to show up in the region of very low temperatures [91, fig. 5]. Schindler and Rice [155] (data sets 27–9) reported measurements in the range of 1.9–32 K for three high-purity specimens, and, in addition, they reported measurements on three Pd-Ni alloys. For the measured resistivity minus the residual resistivity, they stated, "At the lowest temperatures, the resistances of all the samples vary as T^2" [155, p. 762], which applied to the three high-purity specimens and the three Pd-Ni alloys. Several years later, in 1968, Schriempf [158] (data set 12) reported a dependence of the form

$$\rho = \rho_0 + AT^2 + BT^5 \tag{19}$$

for pure material at low temperatures (see also data sets 11 and 17).

There are several important measurements at intermediate and high temperatures. In 1972 Laubitz and Matsumura [146] (data set 67) reported smoothed resistivity data over the temperature range of 90 K to 1300 K for a specimen of 99.99% nominal purity. It should be noted that, in addition to using a well-characterized specimen, they used two systems for the measurements and "Both systems have been extensively and satisfactorily intercompared with each other and with systems in other laboratories ..." [146, p. 197]. Rowland et al. [122] (data set 39) reported data in 1974 on spectroscopically pure palladium from below room temperature to 1300 K that agreed very well with the data of Laubitz and Matsumura [146] (data set 67). In 1975 Dupree et al. [132] (data set 68) reported measurements on a specimen with a typical batch purity of 99.95% from room temperature to very close to the melting point. In addition, they reported measurements in the liquid state for which their apparatus was optimized [132, 204, 205] (data set 69). In 1969 Jain et al. [141] (data sets 19–21) reported measurements on 99.9% pure material in the temperature range of 1109–1466 K. They used an equation of the form

$$\rho = AT + BT^3 \tag{20}$$

to fit their data as well as the data for the unannealed specimen of Conybeare (see data set 40). The constant B in eq (20) turned out to be negative.

Although they did not present original data, Birss and Dey [193] in their 1961 paper fitted the results of White and Woods and of Conybeare. They assumed the resistivity was represented by the form

$$\rho = AT\, g(\theta/T) + BT^2 + CT^3 \tag{21}$$

and found when using the data in eq (21) that $g(\theta/T)$ was not given by $F(\theta/T)$, the Grüneisen function, eq (14). They defined a new function $g'(\theta/T)$ that replaced $g(\theta/T)$ in eq (21) such that the data was brought into exact agreement. They gave a comparison of $g'(\theta/T)$ with the Grüneisen function.

There is very little information on deviations from Matthiessen's Rule (DMR) in palladium. In his review article Bass [191, p. 543] stated, "We have been unable to find any clear-cut examples of DMR in dilute Pd-based alloys which do not manifest a resistivity minimum." Referring to the work of Arajs et al. [129], Bass mentioned that Arajs et al. "... found no resistivity minimum in dilute Pd-Er alloys measured between 4 and 40 °K; but also no DMR." Only the pure palladium specimen of Arajs et al. met the impurity criterion for an element, and that is the only specimen for which resistivity data are given in this work (data set 37). The later review paper of Cimberle et al. [199], which was also concerned with deviations from Matthiessen's Rule, did not add any further information about palladium.

Our evaluated data for pure bulk palladium in the solid state were specifically based on the data of Laubitz and Matsumura [146] (data set 67), White and Woods [91] (data sets 64–6), and Schriempf [158] (data set 12). The data of White and Woods merged well into the data of Laubitz and Matsumura. In addition, the data of Schriempf merged well into the data of White and Woods.

Reasons for using the data of Laubitz and Matsumura include the well-characterized nature of their specimen, the intercomparison of their equipment, the reporting of tabular data, and confirmatory measurements by Rowland et al. In order to match the data sets and to insure smoothness, a preliminary fit to the data, reduced to nominal intrinsic resistivity, was made using eq (12) with an rms fractional deviation of 0.0031 and $A=10.968\times10^{-8}$ Ω m, $B=-6.4812\times10^{-2}$, $C=2.3854\times10^{-2}$, and $\theta=278.4$ K. A plot of the fractional deviations against temperature was smoothed, and the result added to eq (12) to obtain smoothed data from 80 K to 1300 K. In the region from 13 K to 90 K, a plot of $\rho_i(\text{nominal})/T^{3.2}$ was used for matching of data sets and to insure smoothness, while below 13 K a plot of $\rho_i(\text{nominal})/T^2$ was used. Then, the thermal expansion correction was applied to ρ_i(nominal) using eq (11) and the CINDAS recommended values for $\Delta\ell(T)/\ell(293\text{ K})$ [228, p. 248]. Finally, the residual resistivity of 0.0200×10^{-8} Ω m was added to ρ_i to obtain the reported total electrical resistivity. This value of residual resistivity is representative of the residual resistivities of the data used in developing the recommended values.

Extension of the resistivity values beyond 1200 K to the melting point was complicated by the fact that the existing data sets had either incompletely characterized specimens or too much scatter. In addition, recommended values for thermal linear expansion beyond 1200 K did not exist [228, p. 248], and a search of the CINDAS documentation files did not yield any useful information to remedy the situation. Therefore, a different approach was utilized. It was observed that the form

$$\frac{\rho_i(\text{nominal})}{T(1-AT)} \tag{22}$$

reached a constant value above 1000 K. The constants in eq (22) were determined by using the already smoothed data of nominal intrinsic resistivity at 1000 K and 1200 K resulting in

$$\rho_i(\text{nominal}) = 4.0608 \times T \times (1 - 2.1445 \times 10^{-4}\ T) \times 10^{-10}\ \Omega\text{ m}. \tag{23}$$

It was assumed that eq (23) held up to the melting point. The form

$$\frac{\rho_i(\text{nominal})}{T\,(1-CT^2)} \tag{24}$$

did not reach a constant value above 1000 K, and the form

$$\frac{\rho_i(\text{nominal})}{T\,(1-AT-CT^2)} \tag{25}$$

was slightly worse than eq (22) in reaching a constant value. These two forms were tried because they were used by Jain et al. and by Birss and Dey in their work previously mentioned. Values of the thermal linear expansion above 1200 K were calculated from

$$\frac{\Delta\ell(T)}{\ell(293\text{ K})} = 0.00975\left[\frac{1+1.400\times10^{-3}\,(T-1000.0)}{1-2.070\times10^{-4}\,(T-1000.0)}\right]. \tag{26}$$

The rational fraction, eq (26), appears to be better than a power series when both forms have their constants determined by using the CINDAS recommended values for $\Delta\ell(T)/\ell(293\text{ K})$ at 800 K, 1000 K, and 1200 K. The thermal expansion correction was applied to ρ_i(nominal) using eq (11). Finally, the residual resistivity of 0.0200×10^{-8} Ω m was added to ρ_i to obtain the reported total electrical resistivity.

The uncertainty in the recommendations in the solid state was arrived at by applying the general ideas mentioned in subsection 3.4. In addition, the uncertainty at low temperatures was increased somewhat, since no explicit statement was made that annealing took place for the material reported by Schriempf.

There are five data sets that entirely or in part give data for the liquid state. The data of Dubinin et al. [131] (data sets 45, 46) and of Vatolin et al. [163] (data set 47) are single-point values. The data of Güntherodt et al. [139, 148] (data set 53) cover both the solid and liquid states, and their data were presented in the form of a figure. The form in which data is reported is important, because CINDAS introduces an estimated extraction error when data is extracted from a figure. In the liquid state, Güntherodt et al. reported resistivity data between 1864 K and 2019 K. The authors pointed out that there is "... almost no temperature dependence ..." [139, p. 292]. In addition, the difference in the data points is within the estimated extraction error of $\pm0.8\times10^{-8}$ Ω m. These two facts suggest that the resistivity is constant up to 2019 K. Dupree et al. [132] (data set 69) reported resistivity data for palladium of 99.9% initial nominal purity and corrected for the thermal expansion of the cell. The apparatus was optimized with respect to the liquid state measurements [132, 204, 205]. The results indicated that in the liquid state $\rho=(83\pm2)\times10^{-8}$ Ω m and $d\rho/dT=(0.00\pm0.02)\times10^{-8}$ Ω m K^{-1}, which gives further support to the conclusion of a constant resistivity.

The evaluated data for the resistivity of palladium in the liquid state were based on the work of Dupree et al. [132] (data set 69) and of Güntherodt et al. [139, 148] (data set

53). A constant value of 83×10^{-8} Ω m was assigned from the melting point to 2019 K with an uncertainty of ±5%, therefore, making these values recommended values, in the usage of CINDAS. The data of Güntherodt et al. would be within this uncertainty range considering the estimated extraction error of the data set and an assumed uncertainty of 2%.

The recommended values for the temperature dependence of the electrical resistivity of palladium are tabulated in table 8. The values for the solid and liquid states are corrected for thermal expansion. The values tabulated are for the total resistivity. In addition, the intrinsic resistivity values are given for the solid state. The recommended values for the total resistivity are shown in figures 9 and 10. For the solid state, the values for the total resistivity apply to annealed 99.99% pure or purer bulk palladium and the values below 90 K are applicable to a sample obeying Matthiessen's Rule with a residual resistivity of 0.0200×10^{-8} Ω m. (The criterion for the selection of 90 K is that, at this temperature or above, the percentage error in using the intrinsic resistivity instead of the total resistivity, or vice versa, is within the uncertainty in the total resistivity given below.) The values for the intrinsic resistivity apply to pure palladium with various impurity concentrations and residual resistivities. Values for the total resistivity of samples other than one with a residual resistivity of 0.0200×10^{-8} Ω m can be obtained by adding the residual resistivity of the particular sample to the intrinsic resistivity. For the liquid state, the values apply to 99.9% pure or purer palladium. The uncertainty in the recommended values for the total electrical resistivity is negligible below 1 K, 2% from 1 K to 40 K, 1% above 40 K to 350 K, within 2% from above 350 K to 1600 K, and 2.5% above 1600 K to the melting point of 1827 K. There is negligible uncertainty below 1 K, because, in determining the uncertainty in the total resistivity, the residual resistivity is considered to be exactly specified. The percentage uncertainty in the intrinsic resistivity in the solid state is the same as that for the total resistivity down to 30 K. The uncertainty increases to 3% from below 30 K to 15 K, is 5% from below 15 K to 10 K, and is greater than 10% below 10 K. For the liquid state, the uncertainty is 5% from the melting point to 2019 K. The values in the table for the solid state have been given beyond the physically significant figures to permit linear interpolation of log ρ_i versus log T and log ρ versus log T. The maximum error introduced solely by linear interpolation of log ρ_i versus log T compared to the correct values is less than 0.1% from 293 K to the melting point of 1827 K, but increases at lower temperatures; it is less than 0.5% from 125 K to just below 293 K, less than 0.9% from 100 K to just below 125 K, less than 0.5% from 35 K to just below 100 K, less than 0.7% from 30 K to just below 35 K, less than 0.5% from 15 K to just below 30 K, and less than 2.5% from 1 K to just below 15 K. The maximum error introduced solely by linear interpolation of log ρ versus log T compared to the correct values is less than 0.14% from 225 K to just below 600 K, less than 0.1% from 600 K to the melting point of 1827 K, and increases at temperatures lower than 225 K; it is less than 0.3% from 175 K to just below 225 K, less than 0.5% from 125 K to just below 175 K, less than 1% from 25 K to just below 125 K, less than 2.5% from 15 K to just below 25 K, less than 4.5% from 10 K to just below 15 K, and less than 1% from 1 K to just below 10 K.

TABLE 8. RECOMMENDED VALUES FOR THE ELECTRICAL RESISTIVITY OF PALLADIUM

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

Solid

T	ρ_i [a]	ρ [a,b]	T	ρ_i [a]	ρ [a,b]
1	0.0000309*	0.0200	225	7.87	7.89
4	0.000505*	0.0205	250	8.86	8.88
7	0.00170*	0.0217	273.15	9.76	9.78
10	0.00421*	0.0242	293	10.52	10.54
15	0.0145	0.0345	300	10.78	10.80
20	0.0363	0.0563	350	12.65	12.67
25	0.0736	0.0936	400	14.46	14.48
30	0.130	0.150	500	17.92	17.94
35	0.210	0.230	600	21.16	21.18
40	0.314	0.334	700	24.21	24.23
45	0.440	0.460	800	27.05	27.07
50	0.586	0.606	900	29.72	29.74
55	0.745	0.765	1000	32.21	32.23
60	0.918	0.938	1100	34.52	34.54
70	1.30	1.32	1200	36.66	36.68
80	1.73	1.75	1300	38.64	38.66
90	2.17	2.19	1400	40.44	40.46
100	2.60	2.62	1500	42.08	42.10
125	3.71	3.73	1600	43.55	43.57
150	4.78	4.80	1700	44.86	44.88
175	5.83	5.85	1800	45.99	46.01
200	6.86	6.88	1827	46.27	46.29

Liquid

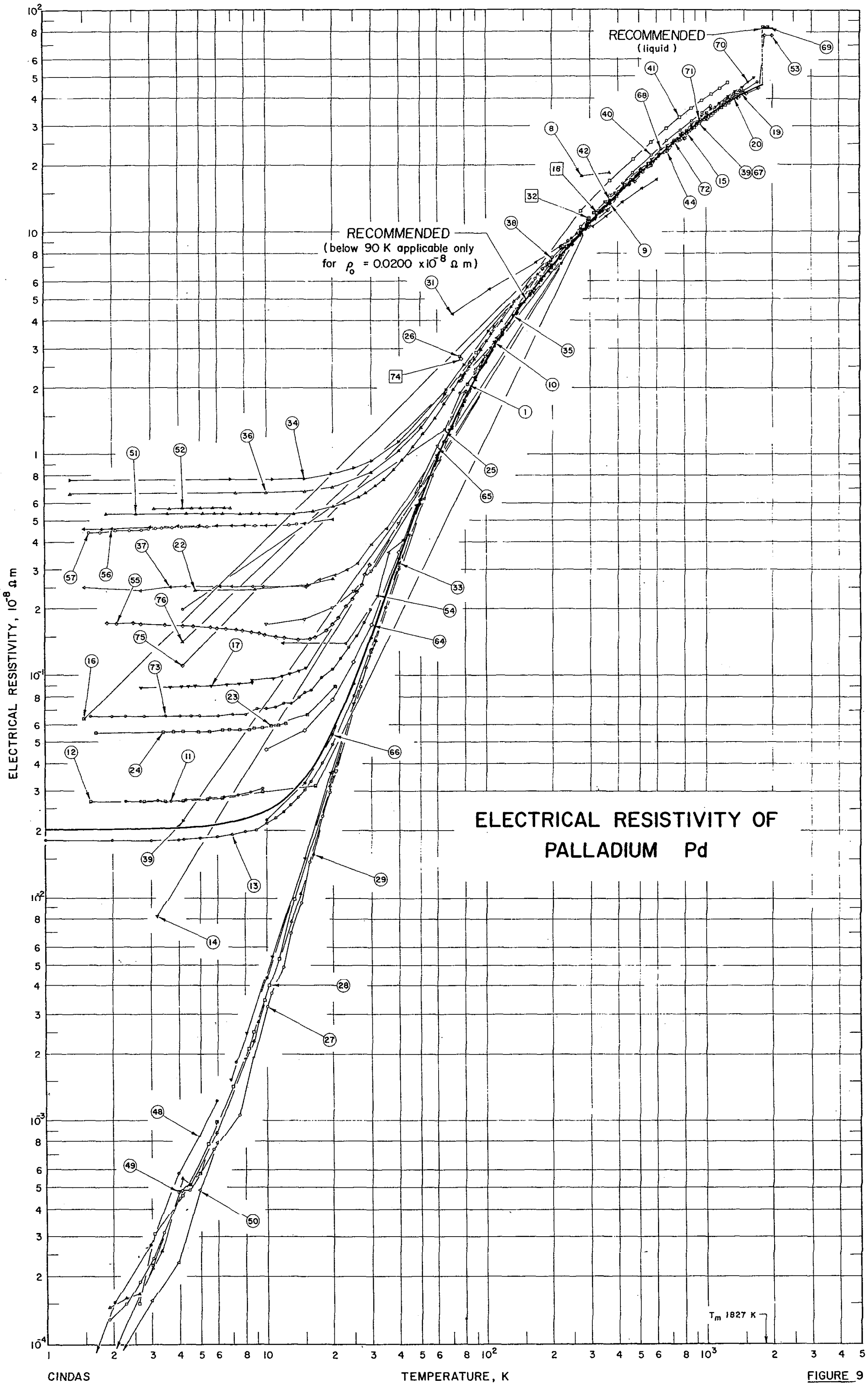
T	ρ [a,c]
1827	83
1900	83
2000	83
2019	83

[a] The values are corrected for thermal expansion. See text for the uncertainty of the values. See text for an indication of the determination of values between those given in this table (interpolation scheme in the solid state).

[b] In the solid state, the values for the total electrical resistivity apply to annealed 99.99% pure or purer bulk palladium and the values below 90 K are applicable to a sample obeying Matthiessen's Rule with a residual resistivity of 0.0200 x 10^{-8} Ωm.

[c] In the liquid state, the values apply to 99.9% pure or purer palladium.

* Provisional values.


ELECTRICAL RESISTIVITY OF PALLADIUM Pd
RECOMMENDED (liquid)
RECOMMENDED (below 90 K applicable only for ρ_0 = 0.0200 x 10^{-8} Ω m)
ELECTRICAL RESISTIVITY, 10^{-8} Ω m
TEMPERATURE, K
T_m 1827 K
CINDAS
FIGURE 9

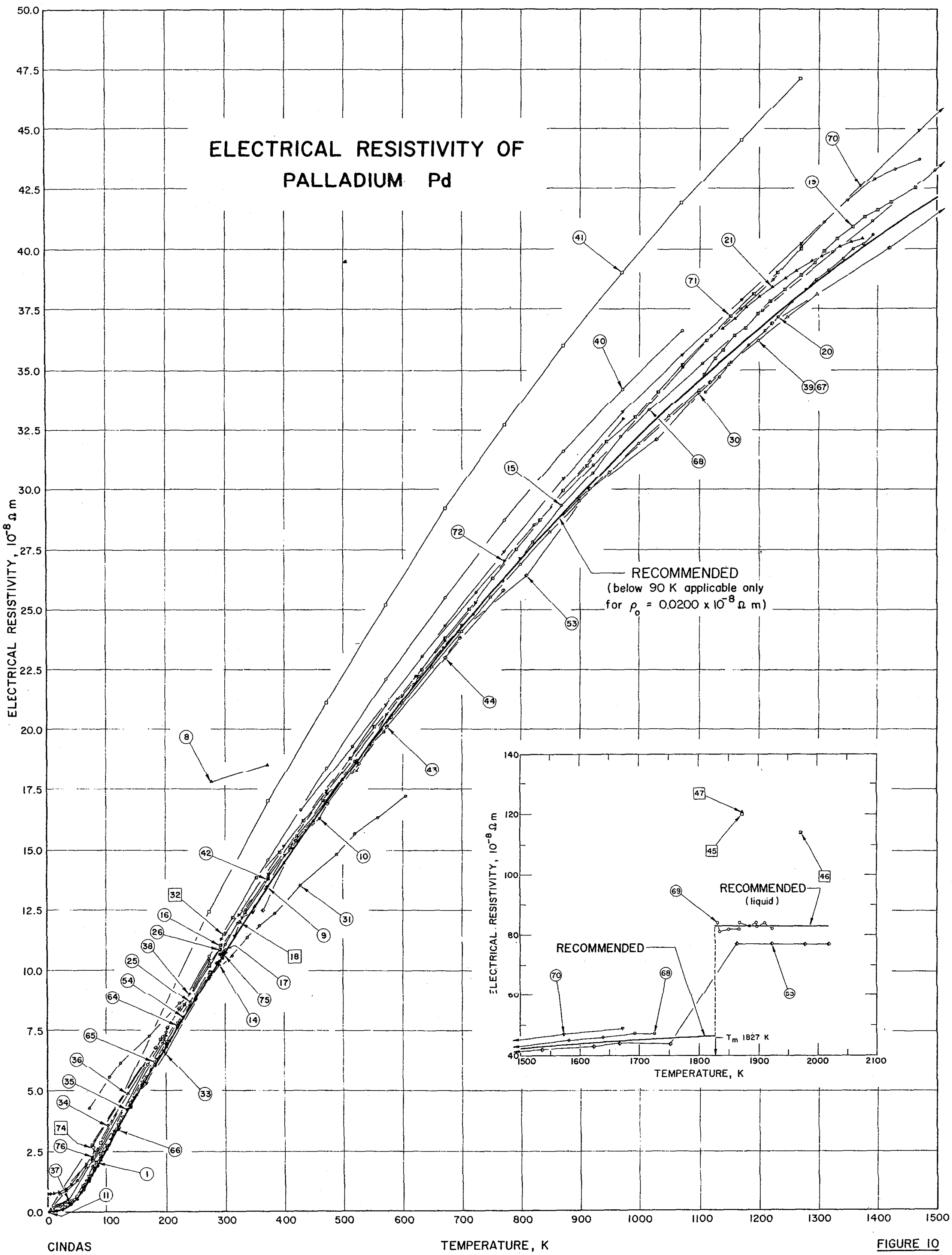

ELECTRICAL RESISTIVITY OF
PALLADIUM Pd
ELECTRICAL RESISTIVITY, 10^{-8} Ω m
TEMPERATURE, K
RECOMMENDED
(below 90 K applicable only
for ρ_0 = 0.0200 x 10^{-8} Ω m)
RECOMMENDED
RECOMMENDED
(liquid)
T_m 1827 K
CINDAS

FIGURE 10

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	22	Grüneisen, E. and Reddemann, H.	1934		83, 273	Pd I	Moderately pure; from Heraeus 1928; unannealed; data extracted from tables.
2*	22	Grüneisen, E. and Reddemann, H.	1934		22-273	Pd I	The above specimen and conditions measured after 5.5 months.
3*	22	Grüneisen, E. and Reddemann, H.	1934		22-273	Pd II	Very pure; from Heraeus 1932; drawn; unannealed; data extracted from tables.
4*	22	Grüneisen, E. and Reddemann, H.	1934		22-273	Pd II	The above specimen and conditions except annealed at 633 K for 2 h in vacuum.
5*	147	Meissner, W. and Voigt, B.	1930		1.3-273	Pd 1	Specimen 0.6 mm in diam and 27.0 mm long; obtained from Heraeus 1921; annealed at 773 K for 2.5 h; resistance ratio R(T)/R(273 K) reported in tabular form as 0.0245, 0.0247, 0.0303, 0.1916, and 1 at 1.27, 4.22, 20.42, 77.73, and 273.16 K, respectively; resistivity ρ(273 K) of 9.77 x 10^{-8} Ω m from Grüneisen, E. and Reddemann, H. (Ann. Physik, 20(5), 843-77, 1934), see data set 4; resistivity ρ(T) calculated using ρ(273 K) [R(T)/R(273 K)].
6*	147	Meissner, W. and Voigt, B.	1930		1.2-273	Pd 2	Specimen 0.5 mm in diam and 60.0 mm long; obtained from Heraeus, 1924; annealed at 773 K for 2.5 h; resistance ratio R(T)/R(273 K) reported in tabular form as 0.005595, 0.005595, 0.005595, 0.005625, 0.005656, 0.009588, 0.1730, 0.2220 and 1 at 1.17, 1.27, 1.45, 3.16, 4.20, 20.46, 77.82, 88.90, and 273.16 K, respectively; resistivity ρ(273 K) of 9.77 x 10^{-8} Ω m from Grüneisen, E. and Reddemann, H. (Ann. Physik, 20(5), 843-77, 1934); see data set 4; resistivity calculated using ρ(273 K) [R(T)/R(273 K)].
7*	147	Meissner, W. and Voigt, B.	1930		1.4-273	Pd 3	No impurities with elements of at. no. 22 to 92, perhaps contaminated with carbides and oxides; specimen 1.8 mm in diam and 34 mm long; obtained from Heraeus, 1927; resistance ratio R(T)/R(273 K) reported in tabular form as 0.0764, 0.0760, 0.0804, 0.2398, 0.2798, and 1 at 1.36, 4.22, 20.45, 78.30, 88.16, and 273.16 K, respectively; resistivity ρ(273 K) of 9.81 x 10^{-8} Ω m from Grüneisen, E. and Reddemann, H. (Ann. Physik, 20(5), 843-77, 1934), see data set 3; resistivity calculated using ρ(273 K) [R(T)/R(273 K)].
8	93	Barratt, T.	1913, 1914	A	278, 373	Commercial	Of highest purity obtainable; specimen 0.1010 cm in diam and distance between knife edges 28.14 cm; from Johnson, Matthey and Co.; temperature coeff of resistivity α(273, 373 K) = 0.000427; data extracted from table.
9	93	Barratt, T.	1913, 1914	A	286, 372	Pure	Of highest purity obtainable; specimen 0.0905 cm in diam and distance between knife edges 28.14 cm; from Johnson, Matthey and Co.; temperature coeff of resistivity α(273, 373 K) = 0.000374; data extracted from table.
10	153	Powell, R.W., Tye, R.P., and Woodman, M.J.	1962		2.7-500		0.005 Rh, 0.0005 Au, 0.0005 Fe, 0.0002 Pt, 0.0001 Cu, and < 0.0001 Ag; rod specimen 0.636 cm in diam and 6.1 cm long; supplied by Johnson, Matthey and Co., Ltd., density 12.02 g cm^{-3}; ρ(273 K)/ρ(4.2 K) = 69 for as received condition; data points extracted from figure.
11	157	Schriempf, J.T.	1967		2.3-9.7		Pure; polycrystalline; rod specimen about 2.4 mm in diam; ratio of room temperature electrical resistivity to that at helium temperature roughly 400; data points extracted from figure of ρ versus T^2; straight line through data reported as $\rho = (2.68 + 0.0033 T^2) \times 10^{-6}$ Ω cm.

* Not shown on either figure.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
12	158	Schriempf, J. T.	1968		1.6-297		Data reported in previous publication by Schriempf, J. T. (Phys. Rev. Letters, 19(19), 1131-3, 1967), see immediately above data set, reanalyzed because of refinements in calibration of germanium-resistor temperature standard; data extracted from figure of $(\rho-\rho_0)/T^2$ versus T^3, $\rho_0 = 26.87 \times 10^{-9}\ \Omega$ cm; 0.1% uncertainty in resistivity; least squares fit through data reported as $\rho = (26.87 \times 10^{-9} + 3.1 \times 10^{-11} T^2 + 1.1 \times 10^{-14} T^5)\ \Omega$ cm, T in K; resistivity at 297 K reported in Table 1, p. 14 by Schriempf, J. T., Schindler, A.I., and Mills, D. L. (Naval Research Laboratory Report NRL-6949, 32 pp., 1969).
13	143, 144	Kemp, W.R.G., Klemens, P.G., Sreedhar, A.K., and White, G.K.	1955, 1956	→	1.0-50	Specimen Pd 6	99.995+ Pd, spectroscopic analysis showed strong Ag lines and faintly visible lines of Ca, Cu, Mg, and Si; rod specimen 2 mm in diam; JM2928; Pd 6 was Pd 5 drawn to 2 mm, annealed at 723 K in vacuum for about 4 h, Pd 5 was Pd 4 after annealing at 1273 K in vacuum for about 4 h, Pd 4 was Pd 3 after annealing at 923 K in vacuum for about 4 h, Pd 3 was Pd 2 after annealing at 723 K in vacuum for about 4 h, Pd 2 was Pd 1 after annealing at 523 K in vacuum for about 4 h, and Pd 1 was strained 3 mm rod in as received condition; residual resistivity ratio $\rho_{293}/\rho_0 = 588$; resistance measurements made with galvanometer amplifier; data presented as the equation $\rho = 1.82 \times 10^{-8} + 2.12 \times T^{3.2}\ \Omega$ cm with T in K and valid for $T < \theta/5$, $\theta = 275$ K, note second term in equation in error; data calculated assuming $\rho = 1.82 \times 10^{-8} + 2.12 \times 10^{-12} T^{3.2}\ \Omega$ cm.
14	10	Coltman, R.R., Klabunde, C.E., and Redman, J.K.	1967		3.2, 290		99.999 pure (reported as 5N nominal purity); polycrystalline; fcc crystal structure; wire specimen 0.051 cm by 5.1 cm (0.020 in by 2 in); annealed at 1023 K in 15 mTorr air for 24 h furnace cooled; residual resistance ratio R(290 K)/R(3.2 K) = 1240, data of ρ(3.2 K) extracted from table; ρ(290 K) obtained by using ρ(3.2 K) and residual resistance ratio.
15	133	Gimpl, M.L., Fuschillo, N., and Zwilsky, K.M.	1965		293-1473		Melting point 1825 K; smooth data extracted from figure except point at 293 K from table.
16	125	Sharma, J.K.N.	1967		1.5, 293		99.999 pure (manufacturers purity), spectroscopically pure; polycrystalline; wire specimen; manufacturer Johnson Matthey, Lab. No. 36949; residual resistivity ratio ρ(293 K)/ρ(1.5 K) = 171; ρ(1.5 K) extracted from table; ρ(293 K) calculated using ρ(1.5 K) and residual resistivity ratio.
17	159	Schriempf, J. T., Schindler, A.I., and Mills, D. L.	1969	→	2.7-297		0.116 Ni (0.21 at.%, nominal composition) and 0.0002 Fe; rod specimen 0.318 cm (0.125 in) in diam and 15.2 cm (6 in) long; x-ray fluorescence indicated Ni concentration uniform to ± 0.1 at.%, wet chemical analysis ± 0.02 at.%; prepared from Johnson-Matthey Pd sponge and Johnson-Matthey Ni rod of 99.999 nominal purity; materials induction melted in quartz crucibles and argon gas which was purified by trapping, swaged; annealed at 1173 K in 10^{-5} Torr vacuum for 4.5 h; resistivity determined by four-probe potentiometric system; data points extracted from figure of $(\rho-\rho_0)/T^2$ versus T^3 except resistivity at 297 K from table; reported error ± 0.2%.
18	24	Holgersson, S. and Sedström, E.	1924		323		100 at.% Pd; from Heraeus; calculated density 11.97 g cm^{-3}; data point extracted from figure.
19	141	Jain, S.C., Sinha, V., and Reddy, B.K.	1969		1109-1466	Specimen 2	99.9 pure; rod specimen 0.3 cm in diam and 20 cm long; obtained from H.A.N. Mehra, Calcutta; annealed at 1450 K for about 8 h; smooth data extracted from figure; deviations of observed data points within 2% of smooth curve; evaporation effect (decrease in diam after annealing) did not occur for this specimen.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
20	141	Jain, S.C., Sinha, V., and Reddy, B.K.	1969		1114-1394	Specimen 3	99.9 pure; tubular specimen 0.54 cm O.D., 0.025 cm wall thickness, and 18.5 cm long; obtained from H.A.N. Mehra, Calcutta; smooth data extracted from figure; deviations of observed data points within 2% of smooth curve; data taken with increasing temperature; evaporation effect (decrease in diam after annealing) did not occur for this specimen.
21	141	Jain, S.C., et al.	1969		1140-1394	Specimen 3	Same as the above specimen except data taken with decreasing temperature.
22	152	Olsen-Bär, M.	1956		4.8-20		Specimen prepared from spectroscopically pure Pd; wire specimen 3 to 5 cm long; wire obtained from Johnson Matthey Ltd., Laboratory Number 2928Ax; unannealed; Simon expansion liquifier provided temperature bath; galvanometer amplifier used to measure changes in resistance; data points of resistance ratio as a function of temperature $R(T)/R(90.2\ K) = R_t/Ro_2$ extracted from figure and are 0.1115, 0.1119, 0.1119, 0.1122, 0.1127, 0.1128, 0.1133, 0.1139, 0.1145, 0.1149, 0.1156, 0.1173, 0.1179, 0.1192, 0.1208, 0.1229, and 0.1250 at 4.80, 8.93, 9.40, 9.98, 10.32, 11.04, 11.54, 12.79, 13.33, 13.89, 14.60, 15.56, 16.28, 17.42, 18.36, 19.60, and 20.28 K, respectively; $\rho(T)$ arrived by using $\rho(90.2\ K)$ $[R(T)/R(90.2\ K)]$ with $\rho(90.2\ K)$, uncorrected for thermal expansion, assumed to be $2.19 \times 10^{-8}\ \Omega$ m; temperature could be determined to a few hundredths of a degree.
23	152	Olsen-Bär, M.	1956		11-20		Specimen from the same batch of wire as the above specimen with the same conditions except (1) annealed for several hours in vacuum at approx two-thirds of the melting temperature by passing a current through the specimen, (2) residual resistance ratio $Ro_2/R_r = 39.5$, (3) resistance ratio as a function of temperature 0.02736, 0.02770, 0.02809, 0.02850, 0.02889, 0.02964, 0.03061, 0.03204, 0.03385, 0.03596, and 0.03864 at 10.61, 11.28, 11.91, 12.53, 13.18, 14.19, 15.05, 16.36, 17.73, 18.98, and 20.16 K, respectively, and (4) for first controlled expansion of compressed helium gas.
24	152	Olsen-Bär, M.	1956		1.7-12		Same as the above specimen and conditions except (1) for second controlled expansion of the compressed helium gas and (2) resistance ratio as a function of temperature 0.02552, 0.02556, 0.02564, 0.02567, 0.02581, 0.02585, 0.02605, 0.02605, 0.02607, 0.02630, 0.02631, 0.02634, 0.02655, 0.02679, 0.02739, and 0.02794 at 1.70, 3.41, 3.84, 4.22, 4.95, 5.57, 6.33, 6.89, 7.29, 7.60, 7.96, 8.40, 8.87, 9.62, 11.55, and 12.33 K, respectively.
25	156	Schindler, A.I., Smith, R.J., and Salkovitz, E.I.	1956	B	4.2-322		99.9 pure; strip specimen 0.1 cm by 0.1 cm by 42 cm; vacuum annealed at 1073 K for 2 h then gradually cooled for 24 h; using modified Kelvin bridge, resistance could be measured to 1 part in 10,000; temperature measured using copper-constantan thermocouples; data points extracted from figures.
26	13	Dewar, J. and Fleming, J.A.	1893	B	76-467		Highest degree of purity; wire specimen 0.024478 cm mean diam and 100 cm long; prepared by Mr. George Matthey using greatest care; resistance 0.5913, 1.5226, 1.8259, 2.1786, 2.3106, 2.3115, 2.3176, 2.6405, 2.9304, 3.2069, and 3.6173 ohms at 76.1, 191.3, 230, 273.8, 290.4, 291.20, 291.50, 333.3, 371.7, 410.4, and 467.4 K, respectively; mean temperature coeff between 273 and 373 K = 0.00354; Wheatstone bridge used to measure resistance; temperature measured using platinum resistance thermometer; data uncorrected for thermal expansion, length and mean diam measured at 288 K; data extracted from table; resistivity at 273 K = $10.219 \times 10^{-8}\ \Omega$m; temperatures of 76.1, 191.3, and 230 K are "platinum" temperatures arrived at using standard platinum wire with all other temperatures corrected Celsius temperatures.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
27	155	Schindler, A.I. and Rice, M.J.	1967	A	1.9-27		High purity; specimen dimensions 0.5 cm^2 cross sectional area and approx 2 cm long; spark cut from cylindrical ingot; Tinsley-Diesselhorst potentiometer and galvanometer with noise level of nV used; below 4.2 K (1) specimen directly immersed in pumped liquid helium, and (2) temperature related to helium vapor pressure above bath; above 4.2 K (1) liquid helium level allowed to drop below bottom of specimen holder and measurement made during slow warm up (< 10 K h^{-1} up to 30 K) and (2) temperatures measured with calibrated Au-0.03% Fe vs Ag-0.37% Au thermocouple; data extracted from figure; ideal resistivity, defined as measured resistivity minus residual resistivity, reported.
28	155	Schindler, A.I. and Rice, M.J.	1967	A	2.6-21		Similar to the above specimen and conditions.
29	155	Schindler, A.I. and Rice, M.J.	1967	A	1.9-32		Similar to the above specimen and conditions.
30	154	Ricker, T. and Pflüger, E.	1966		47-1100		Pure; wire specimen with diam in range 0.35 to 0.5 mm and length in range of 50 to 100 cm; specimen annealed for 30 min at 1073 K in argon and quenched in water; resistance change recorded on Philips-Wolf-Kanal recorder with absolute values determined at beginning and the end of the measurements with Wheatstone bridge; measurement undertaken in a vacuum of 10^{-5} Torr and with highest temperature at least 10^{-4} Torr; data points extracted from figure.
31	162	Vasil'eva, R.P., Cheremushkina, A.V., Ivanova, N.N., and Olefirenko, P.P.	1973		71-606		Pure; polycrystalline; specimen 10 x 4 x 1 mm in size; potentiometer method used; measurements made in vacuum of 10^{-3} mmHg; temperature measured with copper-constantan thermocouple below 273 K and with chromel-alumel thermocouple above 273 K; data points extracted from figure.
32	123	Schulze, F.A.	1911		298		100 Pd; data extracted from table.
33	135	Greig, D. and Rowlands, J.A.	1974		20-273		Pure; from Engelhard Industries, Ltd.; specimen 2 mm in diam and about 10 cm long; measurements taken with specimen surrounded by helium exchange gas; data extracted from table; temperature dependent resistivity ρ_T = (ρ_{meas}-ρ_0) reported; reported error ±0.1%, temperature measured to ±0.1 K, and estimate of length to area ratio known to ±0.1%; additional information and data at 6.9, 8.1, 10.7, 15.0, 19.8, and 25.0 K supplied by authors.
34	135	Greig, D. and Rowlands, J.A.	1974		1.3-273		0.095 Ru (0.1 at.%), nominal concentration; rod specimen 2 mm in diam and 12 cm long; specimen made in Physics Dept. of University of Leeds, UK, by Mr. M.J. Walker from Pd loaned by Engelhard Industries and minor constituent purchased from Johnson-Matthey, weighed mixture of pure metals melted in argon furnace, homogenized by turning ingot over and remelting it 5 times, pressed, rolled, swaged, and annealed in vacuum for 24 h at 1123 K; residual resistivity ρ_0(1.3 K) = 0.773 x 10^{-8} Ω m; measurements taken with specimen surrounded by helium exchange gas; temperature dependent resistivity ρ_T reported in table as 0.0400, 0.0880, 0.1570, 0.3673, 1.204, 1.775, 2.811, 6.562, and 9.735 x 10^{-8} Ω m at 19.8, 25.0, 30.1, 40.0, 66.0, 79.7, 103.7, 199.0, and 273.0 K, respectively; $\rho_{meas} = \rho_T + \rho_0$(1.3 K); reported error ±0.1%, temperature measured to ±0.1 K, estimate of length to area ratio known to ±0.1%; data taken in same experimental run as above specimen; questionable resistance minimum; additional information and data at 6.9, 8.1, 10.7, and 15.0 K supplied by authors.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
35	135	Greig, D. and Rowlands, J. A.	1974		20-273		Pure; from Engelhard Industries Ltd.; specimen 2 mm in diam and about 10 cm long; measurements taken with specimen surrounded by helium exchange gas; data extracted from table; temperature dependent resistivity $\rho_T = (\rho_{meas} - \rho_0)$ reported; reported error ±0.1%, temperature measured to ±0.1 K, and estimate of length to area ratio known to ±0.1%; same specimen as reported in data set 33 but different series of experiments; additional information and data at 7.3, 10.0, 15.0, 20.0, and 30.0 K supplied by authors.
36	135	Greig, D. and Rowlands, J. A.	1974		1.3-273		0.194 Rh (0.2 at.%), nominal concentration; rod specimen 2 mm in diam and 12 cm long; specimen made in Physics Dept. of University of Leeds, UK, by M. J. Walker from Pd loaned by Engelhard Industries and minor constituent purchased from Johnson-Matthey, weighed mixture of pure metals melted in argon furnace, homogenized by turning ingot over and remelting it 5 times, pressed, rolled, swaged, and annealed in vacuum for 24 h at 1123 K; residual resistivity $\rho_0(1.3\ K) = 0.661 \times 10^{-8}\ \Omega$ m; temperature dependent resistivity ρ_T reported in table as 0.0458, 0.1611, 0.3750, 0.6649, 1.220, 1.976, 3.099, 4.224, 6.658, and 9.700 x $10^{-8}\ \Omega$ m at 20.0, 30.0, 40.0, 50.0, 66.5, 84.5, 110, 135, 195, and 273 K, respectively; measurements taken with specimen surrounded by helium exchange gas; $\rho_{meas} = \rho_T + \rho_0(1.3\ K)$; reported error ±0.1%, temperature measured to ±0.1 K, and estimate of length to area ratio known to ±0.1%; data taken in same experimental run as above specimen; no resistance min; additional information and data at 7.3, 10.0, and 15.0 K supplied by authors.
37	129	Arajs, S., Dunmyre, G. R., and Dechter, S. J.	1966	A	1.5-297		If Pd specimen made from same material as Pd-Er alloys studied in the document, then it has following characteristics: 99.95 pure, spectrographic analysis by supplier indicated 0.0102 B, 0.0086 Si, 0.0082 Fe, 0.0072 Pt, 0.0033 Au, 0.0029 Cu, 0.0025 Rh, 0.0024 Ag, 0.0016 Al, 0.0014 Ca, <0.0010 Ir, <0.0010 Ru, <0.0010 Sn, 0.0004 Mg, <0.0004 Pb, <0.0003 Ni, <0.0001 Mn, <0.0001 Mo, and <0.0001 Ti with the following impurities not detected: As, Bi, Cd, Co, Os, Sb, and Zn; material purchased from Engelhard Industries, Inc.; residual resistivity ratio $\rho(297.0\ K)/\rho(4.2\ K) = 46.7$; data points extracted from table except points at 4.2 and 297.0 K from table.
38	161	Szafranski, A. W.	1973	A	181-239		Zero hydrogen content; foil specimen 0.01 mm x 1 mm x 10 mm (probably); cold-rolled to final thickness and not annealed thereafter (probably); measurements carried out with rising temperature at rate of 0.3 to 1 degree per min; data points of resistance ratio R(T)/R(298 K) extracted from figure; $\rho(T)$ determined by using $\rho(298\ K)$ [R(T)/R(298 K)] with $\rho(298\ K)$ assumed to be 10.72 x $10^{-8}\ \Omega$ m.
39	122	Rowland, T., Cusack, N. E., and Ross, R. G.	1974	→	4.2-1300		Spectroscopically pure, impurities 0.0010 Pt and 0.0001 Fe, not stated explicitly whether impurities in at. or wt%; wire specimen between 0.31 and 0.38 mm in diam; supplied by Johnson Matthey; annealed at 1073 K in vacuum for a few h, slowly furnace cooled before taking measurements; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 452$; resistivity measured using standard four-terminal technique; temperature below 300 K measured with Au/0.03 at.% Fe-chromel thermocouple, above 300 K by Pt-Pt 13% Rh thermocouple; data in tabular form supplied by authors except $\rho(4.2\ K)$ from table and $\rho(273\ K)$ deduced from residual resistivity ratio; reported error ± 5%.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
40	130	Conybeare, J. G. G.	1937	A	90.2-1073		99.98 pure; rod specimen 2 mm in diam and 18 cm long; obtained from Johnson Matthey and Co.; resistivity at 273 K=ρ(273 K), after preliminary heating to 923 K, was 10.63 x 10^{-8} Ω m; resistance ratio R(T)/R(273.2 K) originally reported in a table as 0.2283, 0.5788, 0.6840, 1.0000, 1.372, 1.730, 2.078, 2.395, 2.704, 2.972, 3.220, and 3.449 at 90.2, 169.3, 194.6, 273.2, 373, 473, 573, 673, 773, 873, 973, and 1073 K, respectively; potential difference measured with Tinsley potentiometer; measurements made with pressure less than 10^{-6} mm except at highest temperatures where occasionally it rose to 10^{-4} mm; resistivity ρ(T) calculated by using ρ(273 K) [R(T)/R(273.2 K)].
41	130	Conybeare, J. G. G.	1937	A	90.2-1273		Similar to the above specimen except resistivity at 273 K, after annealing to 1243 to 1273 K for 3 days was 12.38 x 10^{-8} Ω m; resistance ratio reported as 0.2327, 1.000, 1.370, 1.708, 2.039, 2.357, 2.645, 2.907, 3.152, 3.382, 3.597, and 3.803 at 90.2, 273.2, 373, 473, 573, 673, 773, 873, 973, 1073, 1173, and 1273 K, respectively.
42	27	Jaeger, W. and Diesselhorst, H.	1900		291, 373		Chemically pure; 1.610 cm diam and 27.0 cm long; cast; density 11.96 g cm^{-3} at 291 K; data extracted from table.
43	140	Holborn, L.	1919		81-698	Pd_1	Every contamination of the sample avoided; wire specimen 0.1 mm in diam; from the firm of W. C. Heraeus; annealed; measured in air; resistance measured with a compensation apparatus; resistance ratio R(T)/R(273 K) reported in tabular form as 0.1844, 0.6851, 1.3770, 1.7276, 2.0616, and 2.4416 at 80.5, 195.1, 373.2, 473.0, 574.2, and 698.0 K, respectively; resistivity ρ(273 K) of 9.81 x 10^{-8} Ω m from Grüneisen, E. and Reddemann, H. (Ann. Physik, 20(5), 843-77, 1934), see data set 3; resistivity calculated using ρ(273 K) [R(T)/R(273 K)].
44	140	Holborn, L.	1919		81-772	Pd_2	Similar to the above specimen and conditions except R(T)/R(273 K) = 0.1963, 0.6881, 1.3726, 1.7216, 2.0691, 2.3553, and 2.6373 at 81.0, 194.8, 373.2, 473.1, 579.2, 672.5, and 771.5 K, respectively.
45	131	Dubinin, E. L., Esin, O. A., and Vatolin, N. A.	1969	R	1873		Presumably pure, technical grade; liquid state; measurement conducted in purified helium gas; data point extracted from figure; relative error of the measurements ± 5%.
46	131	Dubinin, E. L., Esin, O. A., and Vatolin, N. A.	1969	R	1973		Similar to the above specimen and conditions.
47	163	Vatolin, N. A., Esin, O. A., and Dubinin, E. L.	1967	R	1873		Presumably technically pure; liquid state; data point extracted from figure.
48	134	Greig, D. and Rowlands, J. A.	1974	→	1.5-5.9		Pure; not more than 10 ppm metallic impurities; loaned by Englehard Industries; measured with specimen surrounded by helium exchange gas; voltages measured with Tinsley Diesselhorst potentiometer and a galvanometer amplifier null detector; data points of temperature dependent resistivity $\rho_T = (\rho_M - \rho_0)$ extracted from figure where ρ_M is the measured resistivity; estimated extraction error ± 0.78% in temperature and ± 1.6% in ρ_T; error in geometrical factor estimated at ± 0.1%; uncertainty in temperature ± 100 mK.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
49	134	Greig, D. and Rowlands, J.A.	1974	→	1.5-6.0		0.19 Rh (0.20 at.% nominal concentration); made from Pd, loaned by Englehard Industries, having no more than 10 ppm metallic impurities and Rh purchased from Johnson Matthey, Ltd.; specimen 2 mm in diam and 12 cm long; weighed amounts of material melted together in argon arc furnace, initial melt cooled, turned over and remelted five times; pressed, rolled, and swaged; annealed at 1123 K for 24 h in vacuum and then slowly cooled; residual resistivity $\rho_0 = 0.661 \times 10^{-8}\ \Omega$ m; measured with specimen surrounded by helium exchange gas; voltages measured with Tinsley Diesselhorst potentiometer and a galvanometer amplifier null detector; data points of temperature dependent resistivity $\rho_T = (\rho_M - \rho_0)$ extracted from figure where ρ_M is the measured resistivity; estimated extraction error ± 0.78% in temperature and ± 1.6% in ρ_T; error in geometrical factor estimated at ± 0.1%; uncertainty in temperature ± 100 mK.
50	134	Greig, D. and Rowlands, J. A.	1974	→	1.5-6.0		Similar to the above specimen and conditions except 0.095 Ru (0.10 at.% nominal concentration) and residual resistivity $\rho_0 = 0.773 \times 10^{-8}\ \Omega$ m.
51	142	Kao, F.C.C., Colp, M.E., and Williams, G.	1973	→	1.9-296		0.072 V (0.15 at.%); prepared from 99.999 pure Pd and 99.9 pure V with the latter having principle impurities of 0.02 Fe and 0.02 Si, both Pd and V from Johnson Matthey and Co. (London); alloy prepared by successive dilution of 0.48 wt% (1 at.%) alloy with pure Pd; cold rolled, washed, dried, and annealed in vacuum at 1273 K for 30 h; specimen dimensions approx 10 cm x 0.2 cm x 0.015 cm; resistance measured using a four-probe technique; data points extracted from figure with estimated extraction error ± 0.7 K in temperature and ± 0.03 x $10^{-8}\ \Omega$ m in resistivity; area to length ratio determined to ± 0.3%; temperature in range 1.4 to 4.2 K measured to ± 5 mK and above 4.2 K to better than ± 5%.
52	160	Ström-Olsen, J.O. and Williams, G.	1975	→	3.1-7.0		0.072 V (0.15 at.%), specimen selected from those investigated in Kao, F.C.C. Colp, M.E., and Williams, G. (Phys. Rev. B, 8(3), 1228-38, 1973), see immediately above data set; resistivity measured by a four-terminal ac technique; data points of resistivity versus temperature squared extracted from figure with estimated extraction error ± 0.04 K at 3.11 K and ± 0.02 K at 5.46 K and 6.99 K and ± 0.0000006 x $10^{-8}\ \Omega$ m in resistivity.
53	139, 148	Güntherodt, H.J., Hauser, E., Künzi, H.U., and Müller, R.	1975, 1976		364-2019		In solid and liquid states; data points extracted from figure with estimated extraction error ± 6 K in temperature and ± 0.8 x $10^{-8}\ \Omega$ m in resistivity, in liquid state, resistivity showed almost no temperature dependence; change in resistivity at melting point is by a factor of two.
54	128	Abramova, L.I., Fedorov, G.V., and Volkenshteyn, N.V.	1972	A	0-292		99.98 pure; fcc crystal structure; wire specimen 1 mm in diam and about 100 mm long; resistivity measured by four-contact method and dc potentiometer U309 with response of 2 x 10^{-8} V; data points extracted from figure with estimated extraction error ± 1 K in temperature and ± 0.05 x $10^{-8}\ \Omega$ m in resistivity.
55	150	Nagasawa, H.	1970		1.9-29		99.98 pure; obtained from Johnson and Massey (sic) Co.; data points extracted from figure with estimated extraction error ± 0.1 K in temperature and ± 0.001 x $10^{-8}\ \Omega$ m in resistivity.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
56	149	Mydosh, J.A.	1974	→	1.5-20		0.11 Fe (0.2 at.%); fabricated by arc melting and rolled into thin foils 0.1-0.2 mm thick; Curie temperature about 2.5 K; measured by standard four-point probe method with photoamplifier, digital voltmeter, voltage-compensation technique; relative accuracy a few parts in 100,000 attained; data points extracted from figure with estimated extraction error ± 0.1 K in temperature and ± 0.0003 x 10^{-8} Ω m in resistivity.
57	145	Koon, N.C., Schindler, A.I., and Mills, D.L.	1972		1.6-14		0.12 Fe (0.23 at.%, determined by wet chemical analysis); wire specimen 0.4 mm in diam and 10 cm long; master alloy of 1 at.% Fe prepared and desired concentration obtained by diluting with pure Pd; alloys prepared by induction melting in quartz crucibles under clean argon; swaged into wires, given a homogenizing anneal at 1473 K for 20 h in argon; Curie temperature 3.75 K; measurements made in zero magnetic field; data points extracted from figure with estimated extraction error ± 0.09 K in temperature and ± 0.0004 x 10^{-8} Ω m in resistivity, resistance measured by standard four-point potentiometric technique with accuracy and resolution approx 2 parts in 10^5; accuracy of resistivity approx 2% due to uncertainty in form factor; temperature stabilized to better than 0.001 K.
58*	145	Koon, N.C., et al.	1972		1.6-14		The above specimen and conditions except measurements made in longitudinal magnetic field of 1 kOe, accuracy of temperature measurement ± 1% in magnetic field, and Curie temperature not applicable in this context.
59*	145	Koon, N.C., et al.	1972		1.6-12		The above specimen and conditions except measurements made in longitudinal magnetic field of 3 kOe.
60*	145	Koon, N.C., et al.	1972		1.6-15		The above specimen and conditions except measurements made in longitudinal magnetic field of 9.7 kOe.
61*	145	Koon, N.C., et al.	1972		1.5-13		The above specimen and conditions except measurements made in longitudinal magnetic field of 20 kOe.
62*	145	Koon, N.C., et al.	1972		1.5-14		The above specimen and conditions except measurements made in longitudinal magnetic field of 40 kOe.
63*	145	Koon, N.C., et al.	1972		1.6-14		The above specimen and conditions except measurements made in longitudinal magnetic field of 60 kOe.
64	91	White, G.K. and Woods, S.B.	1959		10-295	Pd 7	99.995 pure, analysis of JM2928 gave strong Ag lines and faint lines for Ca, Cu, Mg, and Si; wire specimen 0.19 mm in diam and 6-8 cm long; obtained from Johnson Matthey Ltd., London, specimen made from JM2928; vacuum annealed at 723 K; residual resistance ratio R(295 K)/(residual resistance) = 250; error in reading galvanometer amplifier 1 in 400, probable error in ℓ/A seldom exceeded 1%; $\rho = \rho_0 + \rho_i$; smoothed values of ρ_i extracted from table with ρ_0 obtained from residual resistance ratio and assuming $\rho(295\ K) = \rho_i(295\ K)$, $\rho_0 = 0.0422 \times 10^{-8}$ Ω m; ideal resistivity 0.004, 0.0145, 0.036, 0.074, 0.13, 0.32, 0.58, 0.92, 1.30, 1.72, 2.17, 2.60, 3.46, 4.33, 5.19, 6.06, 6.90, 7.66, 8.82, 9.70, and 10.55 x 10^{-8} Ω m at 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 220, 250, 273, and 295 K respectively.

* Not shown on either figure.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
65	91	White, G.K. and Woods, S.B.	1959		10-295	Pd 8	Similar to the above specimen except (1) vacuum annealed at 773 K, (2) residual resistance ratio R(295 K)/(residual resistance) = 63.8, (3) ρ_i(295 K) = 10.34 x 10^{-8} Ω m, because of slight uncertainty in ℓ/A, ρ_i normalizes to value of 10.55 x 10^{-8} Ω m which came from other specimens where ℓ, A more accurately known, and (4) ρ_0 = 0.1656 x 10^{-8} Ω m.
66	91	White, G.K. and Woods, S.B.	1959		10-295	Pd 9	99.999 pure, suppliers analysis gave 0.0002 Cu, 0.0001 each of Ca, Fe, and Na, <0.0001 of Ag, Mg, and Si; wire specimen 0.28 mm in diam and 6-8 cm long; supplied by Johnson Matthey Ltd., London, JM9401; vacuum annealed at 1173 K; residual resistance ratio R(295 K)/(residual resistance) = 578; error in reading galvanometer amplifier 1 in 400, probable error in ℓ/A seldom exceeded 1%; $\rho = \rho_0 + \rho_i$; smoothed values of ρ_i extracted from table with ρ_0 obtained from residual resistance ratio and assuming ρ(295 K) = ρ_i(295 K), ρ_0 = 0.01825 x 10^{-8} Ω m; ρ_i(295 K) = 10.84 x 10^{-8} Ω m, because of slight uncertainty in ℓ/ρ, ρ_i normalized to 10.55 x 10^{-8} Ω m which came from other specimens where ℓ, A more accurately known; ideal resistivity as 0.004, 0.0145, 0.036, 0.074, 0.13, 0.32, 0.58, 0.92, 1.30, 1.72, 2.17, 2.60, 3.46, 4.33, 5.19, 6.06, 6.90, 7.66, 8.82, 9.70, and 10.55 x 10^{-8} Ω m at 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 220, 250, 273, and 295 K, respectively.
67	146	Laubitz, M.J. and Matsumura, T.	1972	→	90-1300		99.99 nominal purity, 0.00903 O_2, 0.0055 Pt, 0.0038 F, 0.00203 B, 0.0019 Fe, 0.0019 Rh, 0.00181 C, 0.0018 Si, 0.0011 K, 0.00102 Ag, 0.00067 Ru, 0.0065 Na, 0.00062 Zn, 0.00052 W, 0.00051 Zr, 0.00022 Sn, 0.00019 Ca, 0.00019 Au, 0.00019 Pb, 0.00018 Al, 0.00015 S, 0.00018 Ti, 0.00014 Ir, 0.00012 Cu, 0.00009 Mo, 0.000079 N_2, 0.000078 Mn, 0.000055 Ni, <0.000078 V, 0.000026 Nb, <0.000024 Cr, 0.000022 In, 0.000020 Ga, 0.000018 P, 0.000011 Ca, 0.000009 Mg, and 0.000007 As (impurities originally reported in atomic ppm as 300 O_2, 200 B, 160 C, 70 Si, 36 Fe, 30 Na, 30 Pt, 30 K, 20 Rh, 10 Ag, 7 Al, 7 Ru, 6 Zr, 5 Ca, 5 S, 4 Ti, 3 N_2, 3 W, 2 Cu, 2 F, 2 Sn, 1.5 Mn, 1 Au, 1 Mo, 1 Ni, 1 Pb, 1 Zn, <1 V, 0.8 Ir, 0.6 P, <0.5 Cr, 0.4 Mg, 0.3 Ga, 0.3 Nb, 0.2 Co, 0.2 In, and 0.1 As) impurities determined by mass spectrographic analysis by Analytic Chemistry Section of Division of Chemistry of NRCC, except Cr, Mn, and V which were determined by emission spectrography; bar specimen nominally 2 cm in diam and 20 cm long; purchased from Engelhard Industries; annealed for 7 d at 1300 K in oxygen and after anneal the residual resistance ratio was 250 and density at 293 K = 12.002 g cm^{-3}; between 80 and 360 K AC comparator used to measure resistivity; estimate of max error for low temperature system ± 0.15% between 80 and 360 K; for high temperature system estimate of max error ± 0.2% at 300 K to ± 0.5% at 1300 K; smoothed data for several runs extracted from table.
68	132	Dupree, B.C., Van Zytveld, J.R., and Enderby, J.E.	1975		293-1726		99.9 initial nominal purity, 99.95 typical batch purity reported by manufacturer; material obtained from Johnson Matthey; mp 1825 K; estimate of accuracy of sample dimensions ± 2%; original data of uncorrected resistivity, in tabular form, with dimensional measurements made at 293 K, and additional information supplied by authors.

TABLE 9. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
69	132	Dupree, B.C., Van Zytveld, J.B., and Enderby, J.E.	1975	→	1832–1924		99.9 initial nominal purity, 99.95 typical batch purity reported by manufacturer, impurities introduced by measurement method < 0.01 at.%; in liquid state; material obtained from Johnson Matthey; mp 1825 K; at melting temperature $\rho = (83 \pm 2) \times 10^{-8}\ \Omega$ m, $d\rho/dT = (0.00 \pm 0.02) \times 10^{-8}\ \Omega\ mK^{-1}$ and $(\rho_L - \rho_S)/\rho_S = 0.70 \pm 0.05$ where ρ_L is the resistivity in the liquid state at the melting temperature and ρ_S is the resistivity in the solid state at the melting temperature; standard four-probe dc technique used; liquid specimen held in a cylindrical cell of high-grade alumina whose constant was found by reference to doubly distilled liquid mercury at room temperature assuming the value of $95.746 \times 10^{-8}\ \Omega$ m at 293 K; cell constant at temperature of liquid state experiment found by making allowance for expansion of the alumina of the cell, with the coeff of linear expansion of alumina taken as $8 \times 10^{-6}\ K^{-1}$; original data in tabular form and additional information supplied by authors.
70	138	Grube, G. and Knabe, R.	1936	B	373–1673		100 wt% (reported as 100 at.%); data extracted from table; measured in Ar gas.
71	137	Grube, G. and Kästner, H.	1936		313–1273		Pure; data extracted from table; measured in vacuum.
72	136	Grube, G., Bayer, K., and Bumm, H.	1936		293–973		Chemically pure; data extracted from table.
73	151	Nellis, W.J. and Brodsky, M.B.	1971	→	1.6–30		99.997 pure, contained a total of 0.001 Fe, Ni, Co.; sheet specimen 10 x 1 x 0.1 mm; annealed at 723 K for 4 h; residual resistance ratio 170; four-probe technique used; absolute resistance accuracy approx ± 3%; data extracted from figure with estimated extraction error of ± 0.19 K in temperature and ± 0.005 $\mu\Omega$ cm in resistivity.
74	114	Logie, H.J., Jackson, J., Anderson, J.C., and Nabarro, F.R.N.	1961	→	77.34		Spectrographically pure, < 0.002 impurity concentration; polycrystalline wire, 0.2 mm in diam and 10 cm in length; melted under vacuum and drawn to required diam; annealed at 1173 K for 3 h and furnace-cooled; resistivity measured with Diesselhorst potentiometer; data extracted from figure; data point at 100 at.% Pd extracted from figure with estimated extraction error ± 0.37 at.% in concentration and ± 0.075 $\mu\Omega$ cm in resistivity; measurement temperature specified as liquid nitrogen temperature, 77.34 K assigned.
75	106	Hau, N.H.	1966	→	4.2–298	PdI	99.99+ pure, contains no Fe; made by Engelhard Industries, Inc.; wire specimen 0.07 cm in diam and approx 16 cm in length; two heatings required to melt, oxidation feared therefore PdII was made; homogenized in argon gas at 1123 K for 7.7 d; slowly cooled, swaged and drawn; intermediately annealed in argon gas at 973, 723, and 723 K for 4 h, 24 h, and 4 d respectively; final anneal in 10^{-3} mm Hg vacuum at 973 K for 24 h; measurements conducted with sample holder surrounded by He gas; gold-cobalt vs. copper thermocouples from Sigmund Cohn used between 10–400 K; conventional dc method used; cross-sectional area determined from density (computed from lattice parameter obtained by x-ray analysis) and weight of a known length of wire; to correct for spurious effects the current was reversed and voltage readings averaged for final value; data extracted from table; T accurate to 0.01 K for T > 16 K; maximum error of voltage measurement to thermal emfs estimated at 0.02 μV; at high temperature the error in cross-sectional measurement is approx 1%.
76	106	Hau, N.H.	1966	→	4.2–298	PdII	Similar to the above specimen and conditions except only one heating required to melt.

TABLE 10. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd

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

T	ρ
DATA SET 1	
83	2.074
273	9.98
DATA SET 2*	
22	0.2027
83	2.023
273	9.93
DATA SET 3*	
22	0.0844
83	1.899
273	9.81
DATA SET 4*	
22	0.0664
83	1.877
273	9.77
DATA SET 5*	
1.27	0.239
4.22	0.241
20.42	0.296
77.73	1.87
273.16	9.77
DATA SET 6*	
1.17	0.0547
1.27	0.0547
1.45	0.0547
3.16	0.0550
4.20	0.0553
20.46	0.0937
77.82	1.69
88.90	2.17
273.16	9.77
DATA SET 7*	
1.36	0.749
4.22	0.746
20.45	0.789
DATA SET 7 (cont.)*	
78.30	2.35
88.16	2.74
273.16	9.81
DATA SET 8	
278.11	17.815
372.72	18.532
DATA SET 9	
286.41	10.334
372.29	13.497
DATA SET 10	
80	2.3
110	3.2
145	4.7
166	5.3
182	6.2
223	7.2
249	8.8*
271	9.8*
279	10.3
317	11.4
328	12.2
334	12.3*
346	12.4
369	13.4
402	14.8
414	15.1
437	15.8
460	16.3
475	16.9*
DATA SET 11	
2.3	0.0271
2.68	0.0271
3.23	0.0273
3.67	0.0273
4.32	0.0275
5.54	0.0280
6.42	0.0283
7.42	0.0289
8.54	0.0297
9.70	0.0308
DATA SET 12	
1.6	0.0270
2.80	0.02711
3.50	0.02725
4.25	0.02744
4.31	0.02747*
5.47	0.02786
6.37	0.02824
7.36	0.02880*
8.51	0.02964*
9.71	0.03076
10.69	0.03196
297	10.63*
DATA SET 13	
1.0	0.0182
2.0	0.0182
3.0	0.0183
4.0	0.0184
4.22	0.0184
5.0	0.0186
6.0	0.0189
7.0	0.0193
8.0	0.0198
9.0	0.0201
10.0	0.0216
11.0	0.0228
12.0	0.0242
13.0	0.0260
14.0	0.0281
15.0	0.0305
16.0	0.0333
18.0	0.0402
20.0	0.0491
25.0	0.0813
30.0	0.131
35.0	0.203
40.0	0.302
45.0	0.432
50.0	0.598*
DATA SET 14	
3.2	0.00829
290	10.28
DATA SET 15	
293	11.0
334	12.5
373	13.9
422	15.6
471	17.0
520	18.7
569	19.9
620	21.9
670	23.4
720	24.8
770	26.2
821	27.8
870	29.3
922	30.7
969	32.2
1019	33.6
1073	35.1
1121	36.4
1171	37.5
1226	38.7
1273	40.1
1312	41.1
1351	42.0
1396	42.9
1432	43.3
1473	43.7
DATA SET 16	
1.5	0.0647
293	11.06
DATA SET 17	
2.7	0.08906
2.7	0.08908*
2.7	0.08910*
2.7	0.08906*
3.68	0.08948
3.91	0.08963*
3.91	0.08956*
4.12	0.08981
4.48	0.08990
4.79	0.09011
4.83	0.09018*
5.64	0.09063
DATA SET 17 (cont.)	
6.62	0.09145
7.55	0.09231
8.66	0.09371
9.73	0.09536
10.91	0.09741
11.93	0.09963
12.99	0.10224
14.08	0.10523
15.04	0.10820
297	10.84
DATA SET 18	
323	12.0
DATA SET 19	
1109	34.8
1129	35.5
1141	35.8
1159	36.4
1178	36.7
1200	37.3
1222	37.8
1245	38.3
1273	38.9
1297	39.4
1312	39.9
1339	40.4
1360	40.9
1381	41.3
1403	41.6
1425	41.9
1447	42.2
1466	42.5
DATA SET 20	
1114	34.1
1134	34.7
1154	35.3
1184	36.0
1210	36.6
1234	37.2
1258	37.8
1281	38.3
DATA SET 20 (cont.)	
1298	38.7
1319	39.1
1343	39.6
1360	40.0
1377	40.2
1394	40.6
DATA SET 21	
1140	36.7
1160	37.1
1180	37.6
1202	38.0
1225	38.4
1247	38.8
1265	39.1
1292	39.5
1309	39.7
1338	40.1
1357	40.3
1376	40.4
1394	40.6*
DATA SET 22	
4.80	0.2442
8.93	0.2451
9.40	0.2451*
9.98	0.2457*
10.32	0.2468*
11.04	0.2470*
11.54	0.2481*
12.79	0.2494*
13.33	0.2508*
13.89	0.2516*
14.60	0.2532*
15.56	0.2569
16.28	0.2582*
17.42	0.2610*
18.36	0.2646*
19.60	0.2692*
20.28	0.2738
DATA SET 23	
10.61	0.0599
11.28	0.0607*

* Not shown on either figure.

TABLE 10. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

DATA SET 23 (cont.)

T	ρ
11.91	0.06152*
12.53	0.06242*
13.18	0.06327*
14.19	0.06491*
15.05	0.06704
16.36	0.07017*
17.73	0.07413*
18.98	0.07875*
20.16	0.08462

DATA SET 24

T	ρ
1.70	0.05589
3.41	0.05598
3.84	0.05615
4.22	0.05622
4.95	0.05652
5.57	0.05661
6.33	0.05705
6.89	0.05705
7.29	0.05709*
7.60	0.05760
7.96	0.05762*
8.40	0.05768
8.87	0.05814
9.62	0.05867
11.55	0.05998
12.33	0.06119

DATA SET 25

T	ρ
4.2	0.2
65	1.3
77	1.9
194	7.0
240	8.7
300	11.1
322	11.9

DATA SET 26

T	ρ
76.1	2.783
191.3	7.166
230	8.593
273	10.219
273.8	10.253*
290.4	10.874
291.20	10.878
291.50	10.907
333.3	12.426
371.7	13.791
410.4	15.092
467.4	17.023

DATA SET 27

T	ρ_i
1.93	0.000129
2.29	0.000151
2.65	0.000191
3.05	0.000242
3.40	0.000315
4.15	0.000491
4.47	0.000491
5.77	0.000741
7.53	0.00107
8.71	0.00193
10.2	0.00325
10.6	0.00372
12.0	0.00491
13.0	0.00693
14.4	0.00944
15.8	0.0146
18.0	0.0233
19.5	0.0296
25.1	0.0750*
26.7	0.0893

DATA SET 28

T	ρ_i
2.61	0.000151
3.09	0.000310
4.17	0.000465
5.43	0.000787
7.03	0.00143
8.34	0.00213
8.79	0.00253
9.82	0.00349
10.4	0.00405
11.5	0.00536
13.5	0.00993
20.6	0.0373

DATA SET 29

T	ρ_i
1.92	0.000145
2.29	0.000159
2.61	0.000167
3.03	0.000220
3.35	0.000261
4.17	0.000553
4.50	0.000520
5.96	0.000891
8.04	0.00190
8.75	0.00230
9.18	0.00280
13.1	0.00785
14.4	0.0106
16.5	0.0158
19.5	0.0317
28.7	0.110
31.7	0.144

DATA SET 30

T	ρ
47	1.14*
100	2.75*
200	7.40
300	11.54
400	15.16
500	18.16
600	21.43
700	24.35
800	27.11
900	29.59
1000	31.91*
1100	34.03

DATA SET 31

T	ρ
71	4.30
105	5.56
123	6.18
171	7.30
222	8.62
242	9.04*
276	9.89*
310	10.64
337	11.39
358	11.87
384	12.36
428	13.53
489	14.84
520	15.69
558	16.34
606	17.21

DATA SET 32

T	ρ
298	11.5

DATA SET 33

T	ρ
6.9	0.00153
8.1	0.00248
10.7	0.00549
15.0	0.01517
19.8	0.03610
25.0	0.07506
30.1	0.1329
40.0	0.3222
66.0	1.149
79.7	1.730*
103.7	2.784
199.0	6.571
273.0	9.782

DATA SET 34

T	ρ
1.3	0.773
6.9	0.774
8.1	0.775*
10.7	0.777
15.0	0.788
19.8	0.8130
25.0	0.8610
30.1	0.9300
40.0	1.1403
66.0	1.977
79.7	2.548
103.7	3.584
199.0	7.335
273.0	10.508

DATA SET 35

T	ρ
7.3	0.00182
10.0	0.00441
15.0	0.01526*
20.0	0.03677
30.0	0.1282
40.0	0.3191*
50.0	0.5995*
66.5	1.159
84.5	1.931
110	3.077
135	4.220
195	6.686
273	9.752

DATA SET 36

T	ρ
1.3	0.661
7.3	0.663
10.0	0.666
15.0	0.679
20.0	0.7068
30.0	0.8221
40.0	1.036
50.0	1.3259
66.5	1.881
84.5	2.637
110	3.760
135	4.885
195	7.319*
273	10.361

DATA SET 37

T	ρ
1.5	0.25
2.7	0.24
3.7	0.25
4.2	0.235
4.3	0.25
4.8	0.25*
6.2	0.25
7.0	0.25
7.7	0.25*
8.7	0.25
9.7	0.25
10.4	0.25*
13.5	0.25*
15.2	0.25
17.5	0.27
20.5	0.28
23.2	0.30
25.9	0.32
30.5	0.39
35.5	0.46
297.0	10.961*

DATA SET 38

T	ρ
181	6.82
191	7.23*
202	7.63
212	8.04*
222	8.43
239	9.05

DATA SET 39

T	ρ
4.2	0.022
50	0.72
90	2.19
200	6.85*
273	9.95*
300	10.80
500	17.89
600	21.07*
700	24.09*
800	26.89
900	29.50
1000	31.92
1100	34.20*
1200	36.21
1300	38.09

DATA SET 40

T	ρ
90.2	2.427
169.3	6.153
194.6	7.271
273.2	10.63
373	14.58
473	18.39
573	22.09
673	25.46
773	28.74
873	31.59
973	34.23
1073	36.66

* Not shown on either figure.

TABLE 10. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

DATA SET 41

T	ρ
90.2	2.881
273.2	12.38
373	16.96
473	21.15
573	25.24
673	29.18
773	32.75
873	35.99
973	39.02
1073	41.87
1173	44.53
1273	47.08

DATA SET 42

T	ρ
291	10.7
373	13.8

DATA SET 43

T	ρ
80.5	1.80*
195.1	6.69*
373.2	13.4*
473.0	16.9
574.2	20.1
698.0	23.8

DATA SET 44

T	ρ
81.0	1.92
194.8	6.72*
373.2	13.4*
473.1	16.8
579.2	20.2
672.5	23.0
771.5	25.8

DATA SET 45

T	ρ
1873	120.4

DATA SET 46

T	ρ
1973	114.0

DATA SET 47

T	ρ
1873	121.0

DATA SET 48

T	ρ_T
1.51	0.000074*
2.01	0.000154
2.99	0.000277
3.98	0.000585
4.98	0.000859
5.94	0.00123

DATA SET 49

T	ρ_T
1.51	0.0000546*
2.01	0.0000957*
3.02	0.000216
4.00	0.000485
4.98	0.000581
5.97	0.000996

DATA SET 50

T	ρ_T
1.49	0.000408*
2.00	0.0000813*
2.99	0.000156
3.98	0.000333
4.98	0.000491
5.97	0.000793

DATA SET 51

T	ρ
1.9	0.54
2.6	0.54
3.6	0.54
4.4	0.54
5.2	0.54
5.9	0.54
6.4	0.54
7.7	0.54
8.7	0.54
9.4	0.54
10.1	0.54*
10.7	0.54*
11.3	0.54
11.9	0.54*
12.6	0.54*
13.5	0.54
15.9	0.54*
16.5	0.55
17.7	0.56*

DATA SET 51 (cont.)

T	ρ
20.2	0.58
22.6	0.60
26.2	0.64
28.3	0.67
31.2	0.72
34.4	0.77
37.7	0.85
41.3	0.94
46.4	1.08
52.2	1.25
58.9	1.46
64.7	1.70
71.2	1.97
75.7	2.15
78.1	2.22
80.6	2.33
82.2	2.41*
84.3	2.50
86.3	2.61*
88.4	2.70
90.0	2.79*
92.9	2.91*
95.1	2.99
97.8	3.11*
101.1	3.26
104.1	3.40*
107.0	3.52
110.6	3.70*
114.7	3.85*
119.0	4.07
123.0	4.21*
126.9	4.41*
131.4	4.62
136.4	4.82*
142.7	5.08*
147.6	5.31*
155.1	5.63
162.5	5.99*
173.8	6.45
183.8	6.89*
198.2	7.44*
214.9	8.11*
232.5	8.77*
248.7	9.37
262.5	9.83
274.0	10.23*
286.0	10.68*
295.5	11.01*

DATA SET 52

T	ρ
3.11	0.5699856
3.69	0.5699929
4.20	0.5700000
4.62	0.5700076
5.10	0.5700189
5.46	0.5700268*
5.79	0.5700345
6.20	0.5700438*
6.55	0.5700517
6.99	0.5700653

DATA SET 53

T	ρ
364	12.5
420	15.4
527	18.6
580	20.5
627	22.2
696	24.1
810	26.4
917	30.0
1030	32.1
1118	34.5
1223	36.9
1302	38.1*
1422	40.0
1536	42.0
1623	43.4
1668	44.4
1752	44.8
1864	77.4
1922	77.4
1979	77.4
2019	77.7

DATA SET 54

T	ρ
0	0.06*
12	0.14
23	0.14
32	0.23
36	0.36
42	0.41
48	0.59
52	0.63
57	0.80
60	0.99
68	1.30

DATA SET 54 (cont.)

T	ρ
76	1.53
79	1.76
89	2.23*
96	2.50
106	3.03
113	3.35
118	3.64*
128	3.94
139	4.46*
146	4.73
160	5.26*
167	5.59
171	5.77*
179	6.08*
185	6.37
193	6.72*
207	7.15
221	7.76*
229	8.07
240	8.56
251	8.94*
271	9.66
292	10.43

DATA SET 55

T	ρ
1.9	0.174
2.1	0.174
2.5	0.174
2.7	0.172
3.5	0.170
4.2	0.168
4.6	0.169*
4.7	0.167
5.6	0.166
6.0	0.165
6.6	0.163
6.9	0.162*
7.3	0.162
7.6	0.161*
7.8	0.160
8.6	0.158
8.7	0.158*
9.3	0.156
9.6	0.154*
9.9	0.153
10.3	0.152*
10.7	0.152*

DATA SET 55 (cont.)

T	ρ
11.2	0.150
11.6	0.149*
12.1	0.148
12.8	0.147*
13.2	0.146*
14.0	0.146
14.9	0.146*
15.8	0.147
16.8	0.150
17.9	0.154*
18.9	0.160
20.0	0.171
21.2	0.183
23.2	0.206
24.7	0.224
25.9	0.240
27.2	0.267
28.0	0.288
28.5	0.294*
29.5	0.317

DATA SET 56

T	ρ
1.5	0.4603
1.8	0.4622
2.0	0.4642
2.3	0.4659*
2.5	0.4678*
2.7	0.4694*
3.0	0.4706
3.3	0.4716*
3.5	0.4721*
3.7	0.4724*
4.0	0.4728
4.3	0.4730*
4.5	0.4732*
4.7	0.4733*
5.0	0.4735
5.6	0.4738*
6.0	0.4743
6.5	0.4746*
7.0	0.4749
7.5	0.4752*
8.0	0.4757
8.5	0.4762*
9.0	0.4766*
9.5	0.4772*
10.0	0.4778

* Not shown on either figure.

TABLE 10. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

T	ρ
DATA SET 56 (cont.)	
11.0	0.4791*
12.0	0.4808*
13.0	0.4828*
14.0	0.4853*
15.0	0.4882
16.0	0.4914*
17.0	0.4951*
18.0	0.4994*
19.0	0.5042*
20.0	0.5096
DATA SET 57	
1.58	0.4467
1.77	0.4487
1.87	0.4498*
1.97	0.4511*
2.09	0.4526
2.21	0.4537*
2.40	0.4554
2.58	0.4575*
2.74	0.4595
2.95	0.4618
3.16	0.4641
3.36	0.4661
3.59	0.4681*
3.79	0.4691
3.95	0.4696*
4.16	0.4700
4.45	0.4702*
4.94	0.4707
5.45	0.4711
6.02	0.4716*
6.97	0.4724*
7.98	0.4734*
8.96	0.4748
9.95	0.4758*
10.87	0.4770*
11.91	0.4792*
12.98	0.4812
13.97	0.4838
DATA SET 58*	
1.56	0.4411
1.73	0.4429
1.85	0.4436
1.93	0.4445

T	ρ
DATA SET 58 (cont.)*	
2.07	0.4454
2.20	0.4465
2.36	0.4480
2.54	0.4494
2.73	0.4508
2.99	0.4527
3.16	0.4541
3.58	0.4566
3.79	0.4583
4.10	0.4603
4.43	0.4622
4.99	0.4648
5.88	0.4683
7.96	0.4724
10.89	0.4767
13.76	0.4832
DATA SET 59*	
1.56	0.4384
1.93	0.4409
2.34	0.4434
2.54	0.4446
2.99	0.4472
3.38	0.4496
3.83	0.4520
4.20	0.4540
5.10	0.4584
5.66	0.4612
6.61	0.4648
8.52	0.4710
12.01	0.4783
DATA SET 60*	
1.58	0.4366
1.95	0.4376
2.38	0.4393
2.81	0.4407
3.34	0.4426
3.85	0.4446
4.75	0.4480
5.69	0.4518
6.51	0.4546
7.51	0.4582
8.39	0.4612
9.76	0.4658
11.28	0.4707

T	ρ
DATA SET 60 (cont.)*	
12.76	0.4754
14.51	0.4817
DATA SET 61*	
1.52	0.4396
2.20	0.4404
2.85	0.4418
3.83	0.4439
4.71	0.4461
5.72	0.4486
6.57	0.4511
7.57	0.4540
8.53	0.4569
10.07	0.4613
11.48	0.4660
13.38	0.4731
DATA SET 62*	
1.53	0.4492
2.22	0.4495
2.91	0.4499
3.81	0.4509
4.81	0.4523
5.82	0.4538
6.65	0.4554
8.25	0.4587
9.54	0.4618
11.07	0.4658
12.42	0.4702
13.95	0.4759
DATA SET 63*	
1.56	0.4588
2.21	0.4588
3.30	0.4593
4.69	0.4602
5.66	0.4648
6.62	0.4624
7.62	0.4637
8.52	0.4655
9.48	0.4674
10.97	0.4708
12.39	0.4750
13.89	0.4800

T	ρ
DATA SET 64	
10	0.0462
15	0.0567
20	0.078
25	0.116
30	0.17
40	0.36
50	0.62
60	0.96
70	1.34
80	1.76
90	2.21
100	2.64
120	3.50
140	4.37
160	5.23
180	6.10
200	6.94
220	7.70
250	8.86
273	9.74
295	10.59
DATA SET 65	
10	0.170
15	0.180
20	0.202
25	0.240
30	0.296
40	0.486
50	0.746
60	1.09
70	1.47
80	1.89
90	2.34
100	2.77
120	3.63
140	4.50
160	5.36
180	6.23
200	7.07
220	7.83
250	8.99
273	9.87
295	10.72

T	ρ
DATA SET 66	
10	0.0223
15	0.0328
20	0.0543
25	0.0923
30	0.148
40	0.338
50	0.598
60	0.938
70	1.32
80	1.74
90	2.19
100	2.62
120	3.48
140	4.35
160	5.21
180	6.08
200	6.92
220	7.68
250	8.84
273	9.72
295	10.57
DATA SET 67	
90	2.186
100	2.634
125	3.736
150	4.811
175	5.860
200	6.887
225	7.893
250	8.881
275	9.851
300	10.804
350	12.663
400	14.461
450	16.202
500	17.887
550	19.517
600	21.095
650	22.621
700	24.096
750	25.520
800	26.895
850	28.222
900	29.500
950	30.732
1000	31.917

T	ρ
DATA SET 67 (cont.)	
1050	33.056
1100	34.151
1150	35.201
1200	36.207
1250	37.170
1300	38.090
DATA SET 68	
293	10.99*
428	16.65
516	19.29
633	23.05
725	25.71
823	28.50
924	31.02
1018	33.30
1106	35.28
1208	37.46
1326	39.89
1394	41.14
1499	43.26
1581	45.27
1639	46.17
1694	47.12
1726	47.95
DATA SET 69	
1832	84.8
1836	81.9
1850	82.7
1867	82.2
1868	84.9
1886	83.1
1896	84.5
1898	83.1
1910	84.5
1924	82.5
DATA SET 70	
373	14.00
473	17.40
573	21.00
673	24.30
773	27.40
873	30.40

* Not shown on either figure.

TABLE 10. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF PALLADIUM Pd (continued)

T	ρ	T	ρ	T	ρ
DATA SET 70 (cont.)		DATA SET 72 (cont.)		DATA SET 76	
973	33.20	723	25.3	4.2	0.1422
1073	35.60	773	27.0	77.3	2.284
1173	37.89	823	28.5*	298.0	10.78
1273	40.19	873	29.9		
1373	42.59	923	31.4		
1473	44.90	973	32.9		
1573	47.19				
1673	49.60	DATA SET 73			
DATA SET 71		1.6	0.066		
		2.0	0.066		
313	12.2	2.3	0.066		
353	13.6	2.8	0.066		
393	14.9	3.5	0.066		
433	16.2	4.1	0.066		
473	17.4	4.6	0.066		
513	18.8	5.0	0.066		
553	20.1	6.1	0.066		
593	21.3	7.1	0.067		
633	22.5	8.1	0.067		
673	23.8	9.1	0.071		
713	25.0	10.0	0.071		
753	26.3	11.1	0.072		
793	27.5	12.0	0.075		
833	28.7	13.0	0.075		
873	29.9	14.1	0.080		
913	31.0	15.0	0.084		
953	32.0	16.0	0.086		
993	33.0	17.9	0.098		
1033	34.1	20.0	0.107		
1073	35.2	21.9	0.120		
1113	36.2	23.8	0.135		
1153	37.2	25.8	0.152		
1193	38.1	27.8	0.173		
1233	39.0	29.8	0.198		
1273	40.0				
		DATA SET 74			
DATA SET 72					
		77.34	2.70		
293	11.3				
323	12.3	DATA SET 75			
373	13.8*				
423	15.4	4.2	0.1117		
473	17.3	77.3	2.152		
523	18.9	298.0	10.73		
573	20.6				
623	22.2				
673	23.7				

* Not shown on either figure.

4.4. Silver

Silver is a metal with a gray-white lustrous appearance. It has an atomic number of 47, a relative atomic mass of 107.868 (see table 1), and is a member of subgroup IB of the periodic table. There are two stable naturally-occurring isotopes; one with mass number 107 has a natural abundance of 51.82%, and the other with mass number 109 has a natural abundance of 48.18% [232, p. B-338]. The crystal structure is face-centered cubic. Silver has a melting point of 1235.08 K and a normal boiling point of 2440 K [228, p. 42a]. At 293.2 K it has a density of 10.492 Mg m^{-3} [228, p. 42a]. At 293 K it has a coefficient of thermal linear expansion of 18.9×10^{-6} K^{-1} [228, p. 298]. The thermal conductivity at 300 K is 4.29×10^{2} W m^{-1} K^{-1} for well-annealed high-purity material [211, p. I-607]. The latent heat of fusion of silver is 11.30 kJ mol^{-1} [214, p. 230]. Silver with a purity of 99.999^{+}% is commercially available.

There are 130 sets of experimental data reported in this work for the temperature dependence of the electrical resistivity of silver. Information pertaining to the specimen characterization, measurement conditions, and method of data extraction is given in table 12 for each of the data sets. The data themselves are tabulated in table 13. The data are shown in figures 11 and 12; the former figure has logarithmic scales, which highlight the low-temperature region, and the latter figure has both scales linear, which emphasize the high-temperature region. Data for the electrical resistivity exist over the temperature range from 0.323 K to 1673 K with a gap and then an isolated point at 1873 K.

Among the data sets for the electrical resistivity of solid silver there are many sets obtained before 1940. The earliest data reported in this work is that of Dewar and Fleming [12] (data set 26) who reported in 1892 measurements on pure silver from 91 K to 373 K. In 1900 Jaeger and Diesselhorst [27] (data set 28) reported measurements on 99.98% pure silver at 291 K and 373 K. Lees [36] (data set 16) in 1908 reported data on 99.9% pure silver from 95 K to 295 K. Also in 1908, Niccolai [52] (data set 88) reported measurements on pure silver over the temperature range of 84 K to 674 K. In 1914 Northrup [178] (data sets 29, 30) reported data from 294 K to well into the molten region. In 1934 Grüneisen and Reddemann [22] (data sets 46–9) reported measurements on several pure silver specimens over the range of 22 K to 273 K.

Some noteworthy measurements at intermediate or high temperatures after 1940 are as follows. In 1966 Ascoli et al. [165] (data set 64) reported measurements on well-annealed 99.999% pure silver from 374 K to 1198 K. The data were corrected for thermal expansion and data for a typical set of results were extracted from a figure. Laubitz [112] (data sets 61, 62) in 1969 reported measurements on annealed 99.9999% pure silver. The data were presented in the form of a polynomial along with a plot of the deviation of the data points from the polynomial. Then, in the next year, Matsumura and Laubitz [176] (data set 66) reported measurements on 99.9999% pure silver from 84 K to 358 K. Their data were reported in a manner similar to that of Laubitz.

At low temperatures there is a good deal of disagreement as to the behavior of ρ_i. In 1959 White and Woods [91] (data set 63) reported measurements on vacuum-annealed 99.999% pure silver from 10 K to 295 K. They presented smoothed data of intrinsic resistivity in tabular form. They found a $T^{4.7}$ dependence for the intrinsic resistivity above 10 K [91, p. 286]. In 1962 Fenton [102] (data sets 84–6) reported data for pure silver from 2.1 K to 17 K and found a $T^{3.3}$ dependence for the intrinsic resistivity (see data set 84). In 1970 Seth and Woods [183] (data sets 10, 11) reported measurements on annealed 99.999% pure silver from 10 K to 295 K. Their data indicate a $T^{4.46}$ dependence between 10 K and 20 K. In 1972 Kos [174] (data sets 71–4) reported measurements on pure silver in the range of 1.4 K to 4.1 K. He found the form AT^3+BT^5 best fitted the data [174, pp. 392–3]. The next year, Kos [175] (data sets 75–82) reported data on very pure silver, both strained and annealed. In the range of 12 K to 20 K the intrinsic resistivity has a $T^{4.88}$ behavior, while from 2 K to 9 K it has a $T^{4.56}$ behavior [175, pp. 1608, 1610]. In 1974 Ehrlich and Schriempf [168] (data set 67) reported measurements on oxygen-annealed high-purity silver from 5.1 K to 20 K. In the region of 5 K to 20 K the intrinsic resistivity follows a T^5 behavior. In the same year, Teixeira [82] (data set 103) reported data on annealed 99.999% pure silver from 1.3 K to 292 K. After subtracting out a term of the form $C\exp(-\theta_E/T)$, he found good agreement with T^5 behavior [82, p. 29]. In 1975 Barber and Caplin [166] (data sets 104–29) reported data on iron-free 99.999% pure silver over the typical range of 1 K to 20 K. Their results indicate a T^4 dependence below 10 K. In 1976 Rumbo [66] (data sets 68–70) reported measurements on very pure silver from 1.2 K to 8.5 K. The dependence goes from $T^{3.5}$ in the upper portion of the temperature region to $T^{2.5}$ in the lower portion [66, p. 90]. These disagreements probably arise from problems in sample control, the formal difficulty of separating out the residual resistivity, and the general applicability of Matthiessen's Rule for all impurities.

Our evaluated data for the electrical resistivity of pure bulk silver in the solid state were primarily based on the data of Ascoli et al. [165] (data set 64), Laubitz [112] (data sets 61, 62), Matsumura and Laubitz [176] (data set 66), and Seth and Woods [183] (data sets 10, 11). One reason for selecting these data sets is the fact that the measurements are for pure specimens of comparable purity with specimen characterization and conditions of the measurements well stated. In the high-temperature region, the data of Ascoli et al. was shifted to match the data of Laubitz. In order to match and smooth the data sets, a preliminary fit to the data, reduced to nominal intrinsic resistivity, was made using eq (12). However, the error in the fit began to increase below 100 K, indicating the inadequacy of that form. Use of the form in eq (15) was quite adequate with an rms fractional deviation of 0.0017, $p=2.40$, $A=1.1730\times10^{-8}$ Ω m, $B=-2.0482\times10^{-3}$, $C=0.03765$, $D=-1.1987\times10^{-3}$, and $\theta=220.9$ K. A plot of the fractional deviations against temperature was smoothed, and the result added to eq (15) to obtain smoothed data from 50 K to 1200 K. Below 50 K, a plot of ρ_i(nominal)$/T^{4.46}$ was used to check and improve smoothness. Above 1200 K, values of ρ_i(nominal) were smoothed using a plot of ρ_i(nominal)/T against T. Finally, the thermal expansion correction was applied to ρ_i(nominal) using eq (11) together with the CINDAS recommended value for $\Delta\ell(T)/\ell(293\ \mathrm{K})$ [228, p. 298]. Values of the thermal linear expansion above 1200 K to the melting point were found by graphical extrapolation of the CINDAS values. A residual resistivity of 0.00100×10^{-8} Ω m was added to ρ_i to obtain the reported total electrical resistivity. This value of residual resistivity is representative of the residual resistivities of the data used in developing the recommended values.

The estimate of the uncertainty in our recommendations was arrived at by applying the general ideas mentioned in subsection 3.4. In particular, estimates of the uncertainties made by Laubitz as well as by Matsumura and Laubitz were supplemented by comparison of the results with the low-temperature results of Ehrlich and Schriempf [168] (data set 67), Teixeira [82] (data set 103), and White and Woods [91] (data set 63). A check was made to determine whether deviations from Matthiessen's Rule could be expected to be important in silver. For the residual resistivity of 0.00100×10^{-8} Ω m used here, the plots in Cimberle et al. [199, p. 652, figure 5.1] indicate no deviation from Matthiessen's Rule down to 22.4 K. Over the whole temperature range, the evaluated data qualify as recommended values, according to CINDAS usage.

Thirteen of the data sets reported here contain data on silver in the liquid state. Most of the recent data agree reasonably well. In 1957 Roll and Motz [64] (data set 83) reported measurements on 99.995% pure silver from 1243 K to 1464 K using the rotating field method. The data indicate linear behavior. They carried out the thermal expansion correction and reported accuracy figures. In 1962 Takeuchi and Endo [184] (data set 94) reported data from 1253 K to 1331 K, and they also used the rotating field method. The data show linear behavior and are close to the data of Roll and Motz. The single-point values of Howe and Enderby [107] (data set 87) and of Ozelton et al. [55] (data set 91), both reported in 1967, are close to previously mentioned data; the data of Busch and Güntherodt [97] (data set 92) on 99.999% pure material also falls close. The 1973 data of Uemura and Ikeda [186] (data set 90), who used the dc four-probe technique, falls below the other data. The earlier 1914 measurements of Bornemann and Wagenmann [8] (data set 95) show linear behavior to 1673 K.

As the best estimate for pure silver, the data of Roll and Motz were fitted by a straight line using a least squares criterion to get

$$\rho = 17.30 + 0.008447\ (T - 1235.08) \qquad (27)$$

(T in K, ρ in 10^{-8} Ω m). The reason for selecting the data of Roll and Motz is the existence of confirmatory measurements. More modern measurements are expected to have better sample control. Additional factors were the more extended range of measurements compared to Takeuchi and Endo, the explicit statement that the thermal expansion correction was carried out, and the error estimates that were given. Because the data of Bornemann and Wagenmann show linear behavior to 1673 K, the evaluated data were extended to 1673 K using eq (27).

The estimated uncertainty in the evaluated data is intended to take account of the apparent accuracy of the rotating field method of measurement, the uncertainty estimated by Roll and Motz, and the error in extracting the data from their figure. Additionally, the uncertainty is increased somewhat to take account of the data of Uemura and Ikeda who used a different method. The uncertainty is 4%, which makes these recommended values, in the usage of CINDAS.

The recommended values for the temperature dependence of the electrical resistivity of silver are tabulated in table 11. The values for the solid and liquid states are corrected for thermal expansion. The values tabulated are for the total resistivity. In addition, intrinsic resistivity values are given for the solid state. The recommended values for the total resistivity are shown in figures 11 and 12. The values for the total resistivity of the solid apply to annealed 99.999% pure or purer bulk silver and the values below 40 K are applicable to a sample obeying Matthiessen's Rule with a residual resistivity of 0.00100×10^{-8} Ω m. (The criterion for the selection of 40 K is that, at this temperature or above, the percentage error in using the intrinsic resistivity instead of the total resistivity, or vice versa, is within the uncertainty in the total resistivity given below.) The values for the intrinsic resistivity apply to pure silver with various impurity concentrations and residual resistivities. Values for the total resistivity of samples other than one with a residual resistivity of 0.00100×10^{-8} Ω m can be obtained by adding the residual resistivity of the particular sample to the intrinsic resistivity. For the liquid state, the values apply to 99.995% pure or purer silver. The uncertainty in the recommended values for the total electrical resistivity is negligible for 4 K and below, 1% from above 4 K to 10 K, 5% from above 10 K to 30 K, 2% from above 30 K to 70 K, 1% above 70 K to 400 K, and 2% above 400 K to the melting point. There is negligible uncertainty below 1 K, since, in determining the uncertainty in the total resistivity, the residual resistivity is considered to be exactly specified. The percentage uncertainty in the intrinsic resistivity is the same as that for the total resistivity down to 20 K. Below 20 K it increases to over 5% and values are not given. For the liquid state, the uncertainty is 4% from the melting point to 1673 K. The values in the table have been given beyond the physically significant figures and for values in the solid state permit linear interpolation of log ρ_i versus log T and log ρ versus log T. The maximum error introduced solely by linear interpolation of log ρ_i versus log T compared to the correct values is less than 0.1% from 200 K to the melting point of 1235.08 K, but increases at lower temperatures; it is less than 0.15% from 150 K to just below 200 K, less than 0.4% from 125 K to just below 150 K, less than 0.6% from 40 K to just below 125 K, and less than 0.9% from 20 K to just below 40 K. The maximum error introduced solely by linear interpolation of log ρ versus log T compared to the correct values is less than 0.1% from 175 K to the melting point of 1235.08 K, but increases at lower temperatures; it is less than 0.15% from 150 K to just below 175 K, less than 0.4% from 125 K to just below 150 K, less than 0.6% from 70 K to just below 125 K, less than 1% from 35 K to just below 70 K, less than 2.6% from 20 K to just below 35 K, less than 5% from 15 K to just below 20 K, less than 8.2% from 10 K to just below 15 K, less than 2% from 7 K to just below 10 K, less than 1% from just above 4 K to just below 7 K, and a negligible percentage error from 1 K to 4 K. For the liquid state, the determination of values between those given in the table can be done using eq (27).

TABLE 11. RECOMMENDED VALUES FOR THE ELECTRICAL RESISTIVITY OF SILVER

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

Solid

T	ρ_i[a, b]	ρ[a, c]	T	ρ_i[a, b]	ρ[a, c]
1		0.00100	150	0.725	0.726
4		0.00100	175	0.877	0.878
7		0.00103	200	1.028	1.029
10		0.00115	225	1.178	1.179
15		0.00189	250	1.328	1.329
20	0.00322	0.00422	273.15	1.466	1.467
25	0.00855	0.00955	293	1.586	1.587
30	0.0184	0.0194	300	1.628	1.629
35	0.0331	0.0341	350	1.931	1.932
40	0.0529	0.0539	400	2.240	2.241
45	0.0763	0.0773	500	2.874	2.875
50	0.103	0.104	600	3.530	3.531
55	0.131	0.132	700	4.208	4.209
60	0.161	0.162	800	4.911	4.912
70	0.224	0.225	900	5.637	5.638
80	0.288	0.289	1000	6.395	6.396
90	0.353	0.354	1100	7.214	7.215
100	0.417	0.418	1200	8.088	8.089
125	0.572	0.573	1235.08	8.414	8.415

Liquid

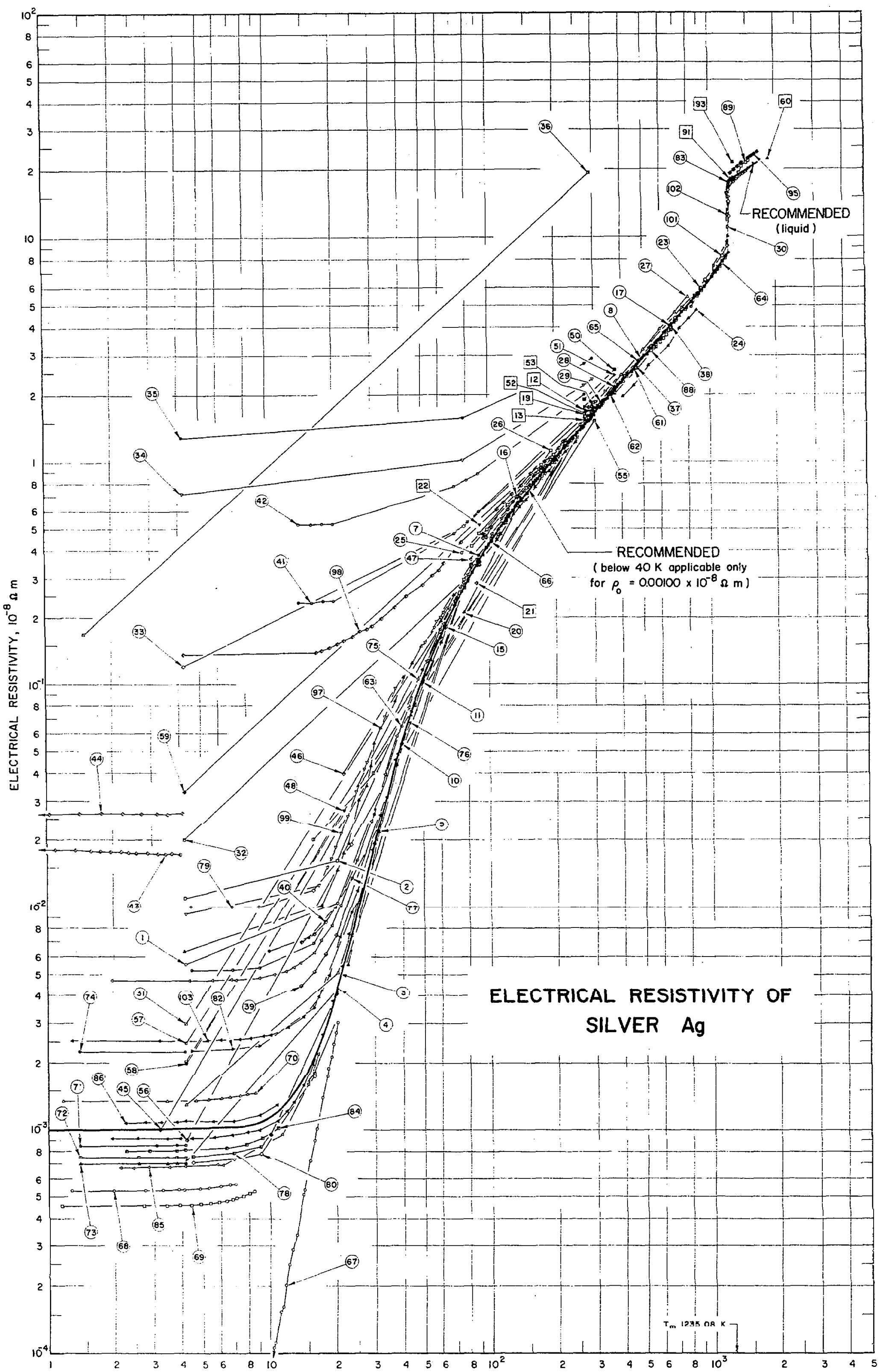
T	ρ[a, d]
1235.08	17.30
1300	17.85
1400	18.69
1500	19.54
1600	20.38
1673	21.00

[a] The recommended values are corrected for thermal expansion. See text for the uncertainty of the recommended values. See text for an indication of the determination of values between those given in this table (interpolation scheme in solid state, equation in liquid state).

[b] Values for the intrinsic resistivity are not given below 20 K because of the large uncertainty.

[c] In the solid state, the values for the total electrical resistivity apply to annealed 99.999% pure or purer bulk silver and the values below 40 K are applicable to a sample obeying Matthiessen's Rule with a residual resistivity of 0.00100 x 10^{-8} Ωm.

[d] In the liquid state, the values apply to 99.995% pure or purer silver.



CINDAS FIGURE 11

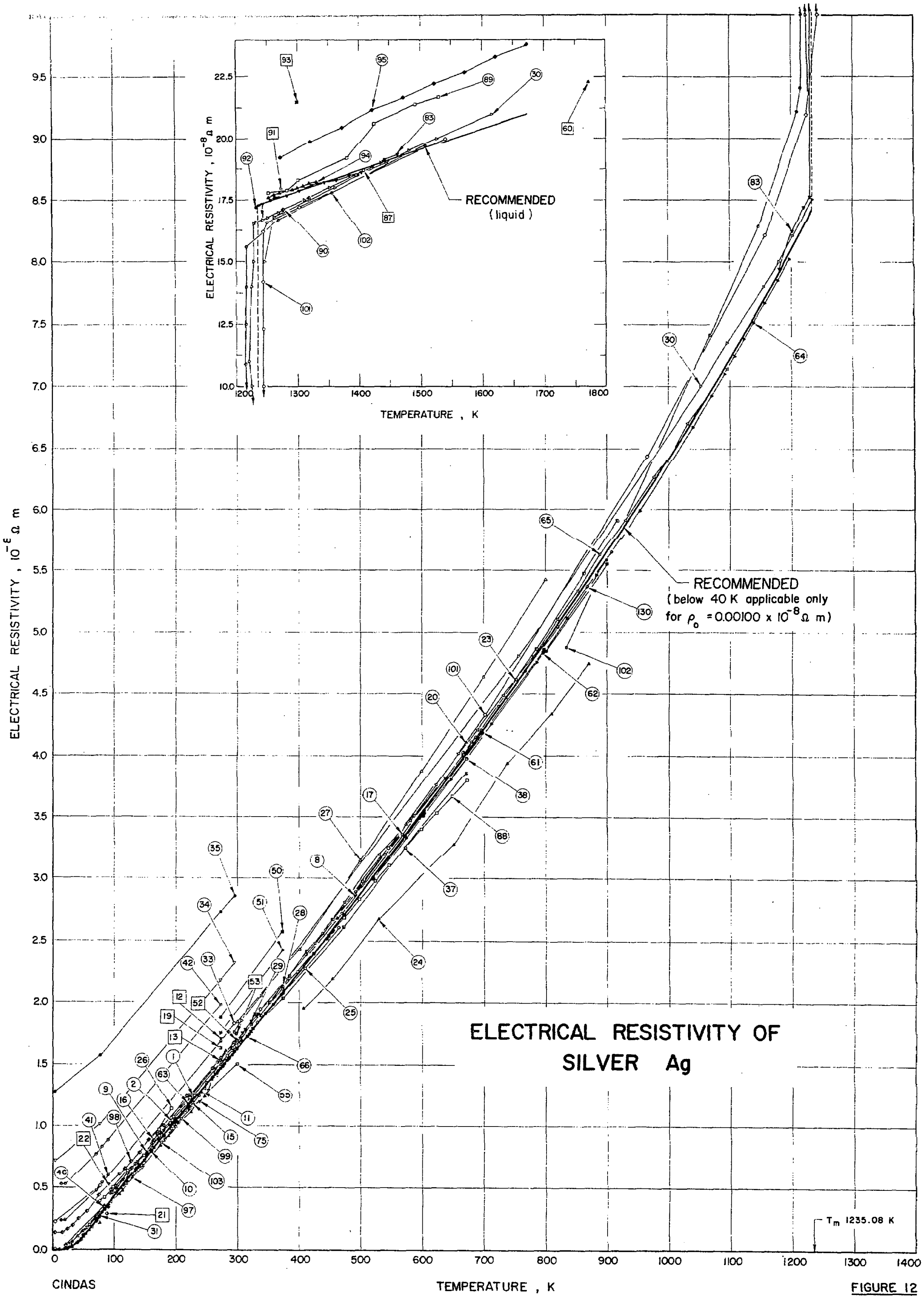

ELECTRICAL RESISTIVITY OF
SILVER Ag
ELECTRICAL RESISTIVITY, 10^{-6} Ω m
TEMPERATURE, K
RECOMMENDED
(below 40 K applicable only
for ρ_0 = 0.00100 x 10^{-8} Ω m)
ELECTRICAL RESISTIVITY, 10^{-8} Ω m
RECOMMENDED
(liquid)
T_m 1235.08 K
CINDAS

FIGURE 12

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
1	56	Pawlek, F. and Rogalla, D.	1966	→	4-298	Ag 1	About 0.0140 Cu, < 0.00125 Pd, < 0.00125 Pt, 0.0010-0.0012 Pb, 0.0005-0.0006 Fe, < 0.00015 Au, 0.0001-0.0002 Si, < 0.0001 Bi, 0.00006-0.00008 Al, < 0.00006 Sn, < 0.00002 Mn, and 0.000002 Cd; specimen 2 mm diam wire; supplied by Degussa, Frankfort/Main; annealed 1 h in argon at 773 K, cooling rate < 50 K h^{-1}; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 273$, $\rho(293\ K)/\rho(20.4\ K) = 157$; very sensitive voltmeter used for potential drop measurements; data extracted from table.
2	56	Pawlek, F. and Rogalla, D.	1966	→	4-298	Ag 2	0.0050-0.0060 Cu, 0.0012-0.0014 Pb, < 0.00125 Pd, < 0.00125 Pt, 0.0003-0.0004 Fe, 0.0002-0.0003 Si, < 0.00015 Au, < 0.0001 Bi, 0.00006-0.00008 Al, < 0.00006 Sn, < 0.00002 Mn, and 0.000005-0.00001 Cd; specimen 2 mm diam wire; supplied by Degussa, Frankfort/Main; electrolytically refined; annealed 1 h in argon at 773 K, cooling rate < 50 K h^{-1}; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 135$, $\rho(293\ K)/\rho(20.4\ K) = 100$; very sensitive voltage used for potential drop measurements; data extracted from table.
3	56	Pawlek, F. and Rogalla, D.	1966	→	4-298	Ag 3	< 0.00125 Pd, < 0.00125 Pt, 0.0002-0.0003 Fe, < 0.00015 Au, 0.0001-0.002 Cu, 0.0001-0.0002 Si, < 0.0001 Bi, < 0.0001 Pb, 0.00006-0.00008 Al, < 0.00006 Sn, < 0.00002 Mn, and 0.000005-0.00001 Cd; specimen 2 mm diam wire; supplied by Degussa, Frankfurt/Main; chemically refined; annealed 1 h in argon at 773 K cooling rate < 50 K h^{-1}; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 1170$, $\rho(293\ K)/\rho(20.4) = 322$; very sensitive voltmeter used for potential drop measurements; data extracted from table.
4	56	Pawlek, F. and Rogalla, D.	1966	→	4-298	Ag 4	99.999 pure, < 0.00125 Pd, < 0.00125 Pt, 0.0003-0.0004 Fe, < 0.00015 Au, 0.0001-0.0002 Cu, 0.0001-0.0002 Si, < 0.0001 Bi, < 0.0001 Pb, < 0.00006 Sn, 0.00004-0.00006 Al, < 0.00002 Mn, and 0.000002-0.000005 Cd; specimen 2 mm diam wire; supplied by Degussa, Frankfort/Main; annealed 1 h in argon at 773 K; cooling rate < 50 K h^{-1}; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 2040$, $\rho(293\ K)/\rho(20.4\ K) = 376$; very sensitive voltmeter used for potential drop measurements; data extracted from table.
5*	180	Powell, H. and Evans, E.J.	1943		273.0		Pure; specimen 0.4 cm x 2.5 cm x 12 cm; from Johnston Matthey; specimen annealed for two to three weeks; cooled slowly to room temperature, resistivity measured at 273 K, specimen heated in furnace and annealed at previous annealing temperature for about three weeks, cooled and measured at 273 K again, this process continued until no change in resistivity at 273 K was found upon further annealing; data point extracted from table.
6*	180	Powell, H. and Evans, E.J.	1943		273.0		Similar to the above specimen except before annealing.
7	173	Kannuluik, W.G.	1933		90-373		Only elements present were Bi, Ca, Cu, Mg, Na, Pb, and Si in amounts sufficient to give 1 or 2 ultimate lines, chemical and spectroscopic analysis by Hilger; optical spectroscopic examination by C. E. Eddy and T. H. Oddie on drawn wire showed no recognizable impurity introduced; wire specimen 0.06095 cm in diam and 9.770 cm long; drawn from a rod of "H.S." brand silver supplied by A. Hilger, Ltd.; data extracted from table.
8	173	Kannuluik, W.G.	1933		90-491		The above specimen and conditions after prolonged annealing at 773 K.
9	179	Pal, S.	1973		23-307		No details reported; data points of Dugdale and Basinski (private communication to S. Pal) extracted from figure.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (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	183	Seth, R.S. and Woods, S.B.	1970	A	10-295	Ag 1	59 grade purity; polycrystalline; obtained from Consolidated Mining and Smelting Co. of Canada; 6 mm diam rods made by melting freshly cleaned pellets in evacuated sealed quartz tubes, then drawn through steel dies to 1.5 mm diam, etched, and drawn through diamond dies to 0.5 mm diam; annealed at 823 K for 6 h in vacuum of $< 10^{-5}$ Torr (assuming line 1 in Table I applies to Ag 1); residual resistance ratio R(293 K)/R(4 K) = 2000; resistivity deduced from $\rho = \rho_i + \rho_0$, $\rho_0 = 0.0008 \times 10^{-8}\ \Omega$ m, $\rho_i(273.2\ K) = 1.471 \times 10^{-8}\ \Omega$ m, and smoothed values of $\rho_i(T)/\rho_i(273.2\ K)$ extracted from table.
11	183	Seth, R.S. and Woods, S.B.	1970	A	10-295	Ag 2	Similar to the above specimen except annealed at 873 K for 6 h in 10 Torr H_2 atmosphere (assuming line 2 in Table I applies to Ag 1); residual resistance ratio R(293 K)/R(4 K) = 2000; resistivity deduced from $\rho = \rho_i + \rho_0$, $\rho_0 = 0.0008 \times 10^{-8}\ \Omega$ m, $\rho_i(273.2\ K) = 1.469 \times 10^{-8}\ \Omega$ m, and smoothed values of $\rho_i(T)/\rho\ (273.2\ K)$ extracted from table.
12	183	Seth, R.S. and Woods, S.B.	1970	A	273.2		0.0251 Al; 6 mm diam rods made by melting freshly cleaned pellets in evacuated sealed quartz tubes, then drawn through steel dies to 1.5 mm diam, etched, and drawn through diamond dies to 0.5 mm diam; annealed at 823 K for 12 h in vacuum of $< 10^{-5}$ Torr; residual resistivity $0.1836 \times 10^{-8}\ \Omega$ m; data extracted from table.
13	183	Seth, R.S. and Woods, S.B.	1970	A	273.2		0.0158 Mg; 6 mm diam rods made by melting freshly cleaned pellets in evacuated sealed quartz tubes, then drawn through steel dies to 1.5 mm diam, etched, and drawn through diamond dies to 0.5 mm diam; annealed at 773 K for 12 h in pressure of 10 Torr H_2 using close-fitting quartz containers; residual resistivity $0.0328 \times 10^{-8}\ \Omega$ m; data extracted from table.
14*	183	Seth, R.S. and Woods, S.B.	1970	A	273.2		0.0418 Cd; 6 mm diam rods made by melting freshly cleaned pellets in evacuated sealed quartz tubes, then drawn through steel dies to 1.5 mm diam, etched, and drawn through diamond dies to 0.5 mm diam; annealed at 773 K for 12 h in vacuum of approx 10^{-6} Torr using close-fitting quartz containers; residual resistivity $0.0119 \times 10^{-8}\ \Omega$ m; data extracted from table.
15	73	Schroeder, P.A., Wolf, R., and Woollam, J.A.	1965		16-250		Wire specimen 0.2 mm in diam; specimen produced from Cominco 59 grade; specimen made by induction heating and chill casting; annealed in vacuum at 953 K; residual resistance ratio R(273 K)/R(4.2 K) = 640; data points extracted from figure.
16	36	Lees, C.H.	1908		95-295		99.9 pure; rod specimen 1.49 cm (0.585 in) in diam and approx 7.5 cm long; turned from larger rod; density 10.47 g cm^3 at 294 K; knife edges, 4 cm apart, serve as potential probes (value of resistivity $1.684 \times 10^{-8}\ \Omega$ m most likely for T = +21.3 °C, not -21.3 °C as given in paper); data extracted from table.
17	126	Sirota, N.N.	1962		199-667		No details reported; data points extracted from figure (exponent "8" by ρ is presumed to go with the "10", i.e., 10^8).
18*	109	Kannuluik, W.G.	1931	A	273	Ag I	Commercially pure electrolytic; wire specimen 0.05286 cm in diam and 17.63 cm long; temperature coeff of resistance between 273 and 373 K = 0.004060; data extracted from figure.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
19	109	Kannuluik, W. G.	1931	A	273	Ag II	Spectroscopically pure; wire specimen 0.05059 cm in diam and 17.47 cm long; wire drawn from rod; temperature coeff of resistance between 273 and 373 K = 0.003967; data extracted from figure.
20	54	Otter, F.A., Jr.	1956	A	77–736		99.99+ pure; material from Handy and Harman; high temperature experiments performed in vacuum; data points extracted from figure.
21	29	Kapitza, P.	1929		88		99.9+ pure, about 0.001 Ca; wire specimen 0.15 mm in diam and 20–30 cm long; obtained from Hartman and Braun; annealed; residual resistance ratio R(290 K)/R(88 K) = 5.52; units not explicitly given, presume they are in Ω cm; data extracted from table.
22	29	Kapitza, P.	1929		91		Similar to the above specimen except hard drawn and residual resistance ratio R(290 K)/R(91 K) = 4.5; units not explicitly given, presume they are in Ω cm; data extracted from table.
23	44	Mikryukov, V.E.	1957		338–917		99.99 pure; polycrystalline; data extracted from table.
24	45	Mikryukov, V.E.	1958	→	407–871		Pure; polycrystalline; Kohlrausch method used; data points extracted from figure; error of measurement does not exceed 1-1.5%.
25	13	Dewar, J. and Fleming, J.A.	1893	B	76–465		Wire specimen 0.025550 cm mean diam and 150 cm long; purest specimen obtained, prepared by J. W. Swan by electrolysis of silver nitrate, drawn directly from the deposit without having been melted; annealed in non-oxidizing CO_2 gas; resistance 0.1140, 0.2988, 0.3630, 0.4355, 0.4639, 0.4601, 0.4646, 0.5372, 0.6033, 0.6652, and 0.7631 Ω at 76.1, 191.3, 230.9, 273.80, 290.40, 291.35, 291.45, 333.2, 371.30, 410.4, and 465.3 K, respectively; mean temperature coefficient between 273 and 373 K = 0.00400; Wheatstone bridge used to measure resistance; temperature measured using platinum resistance thermometer; data uncorrected for thermal expansion, length and mean diam measured at 288 K; data extracted from table; resistivity at 273 K = 1.468 x 10^{-8} Ω m; temperatures of 76.1, 191.3, and 230.9 K are "platinum" temperatures arrived at using standard platinum wire with all other temperatures corrected Celsius temperatures.
26	12	Dewar, J. and Fleming, J.A.	1892	B	91–373		Pure; wire specimen of probable dimensions 0.008 cm (0.003 in) in diam and 50 or 100 cm long; specimen provided by J.S. Sellon and G. Matthey of Johnson and Matthey of Hatton Garden; drawn; experiment carried out with ambient temperature approx constant at 293 K; mean diam of wire measured to nearest ten-thousandth of an inch; resistance measured on Wheatstone bridge; measurement of resistance repeated several times, mean observed specific resistance reported; data uncorrected for thermal expansion; data extracted from table.
27	154	Ricker, T. and Pflüger, E.	1966	→	100–800		Wire specimen with diam in range 0.35 to 0.5 mm and length in range of 50 to 100 cm; specimen annealed for 30 min at 1073 K in argon and quenched in water; resistance change recorded on Philips-Wolf-Kanalrecorder with absolute values determined at beginning and the end of the measurements with Wheatstone bridge; measurement undertaken in a vacuum of 10^{-5} Torr and with highest temperature at least 10^{-4} Torr; data points extracted from figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (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	27	Jaeger, W. and Diesselhorst, H.	1900		291, 373		99.98 pure; specimen 1.1086 cm in diam and 25.2 cm long; drawn; density 10.53 g cm^{-3} at 291 K; data points manually read from figure.
29	178	Northrup, E. F.	1914	B	294-333		Soft drawn wire; data points manually read from figure.
30	178	Northrup, E. F.	1914	B	295-1617		Same silver as in above specimen; measurements made in container of 40 parts magnesite and 60 parts alundum; data points manually read from figure.
31	187	Weinberg, I.	1967	A	4.2-295		99.999 pure, obtained from Cominco; wire specimen 0.025 cm (0.010 in) in diam; vacuum melted in graphite crucible, swaged, drawn, material etched frequently during swaging and drawing process using ammonium hydroxide and hydrogen peroxide mixture, annealed in vacuum at 953 K for 24 h; standard four-point technique used: voltage drop across sample measured with Rubicon thermofree potentiometer and current determined by means of voltage drop, determined with K3 potentiometer, across a 1 Ω standard resistor placed in series with sample; data extracted from table.
32	187	Weinberg, I.	1967	A	4.2-295		0.09 Au (0.05 at.%), determined by chemical analysis; starting materials 99.999 pure Cominco silver and 99.999 pure American Smelting and Refining Co. gold, alloy constituents contained in high-purity graphite, previously outgassed, crucible, melted in a dynamic vacuum of 10^{-6} Torr using an induction heater, after becoming solid, billets inverted and melting cycle repeated, billets given an homogenized anneal at 873 K for 6 d under 10^{-6} Torr, the 0.952 cm (0.375 in) diam billets swaged to 0.178 cm (0.070 in), drawn to final diam of 0.0254 cm (0.010 in), material etched frequently during swaging and drawing with an ammonium hydroxide and hydrogen peroxide mixture, annealed in vacuum at 953 K for 24 h; standard four-point technique used; data extracted from table.
33	187	Weinberg, I.	1967	A	4.2-295		Similar to the above specimen and conditions except 0.02 Ge (0.03 at.%) and germanium starting material was Dow-Corning semiconductor-grade germanium.
34	187	Weinberg, I.	1967	A	4.2-295		Similar to the above specimen and conditions except 0.081 Ge (0.12 at.%).
35	187	Weinberg, I.	1967	A	4.2-295		Similar to the above specimen and conditions except 0.13 Ge (0.20 at.%).
36	125	Sharma, J. K. N.	1967		1.5, 293		99.999 pure (manufacturers purity), spectroscopically pure; polycrystalline; wire specimen; source of specimen Johnson Matthey, Lab. No. 24757; residual resistivity ratio $\rho(293\ K)/\rho(1.5\ K)$ = 115; $\rho(1.5\ K)$ extracted from table; $\rho(293\ K)$ calculated using $\rho(1.5\ K)$ and residual resistivity ratio.
37	181	Pravoverlov, N. L. and Tribunskaya, I. A.	1967	→	298-673	Alloy No. 18	99.99 pure; annealed in vacuum at 623 K for 0.5 h; measurements done in a vacuum of 6 x 10^{-6} mmHg; resistance determined by a bridge method; data extracted from table.
38	181	Pravoverlov, N. L. and Tribunskaya, I. A.	1967	→	298-673	Alloy No. 18	99.99 pure; annealed in vacuum at 623 K for 0.5 h; measured in air; resistance determined by a bridge method; data extracted from table.
39	171	Gerritsen, A. N. and Linde, J. O.	1956		14-273	Ag 2t	Pure; supplied by Nordiska Affiveriet, Halsingborg; etched and annealed for 4 h at 740 K in gas; $[R(273\ K)/R(T)]_{min}$ = 416; data extracted from table.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
40	171	Gerritsen, A.N. and Linde, J.O.	1956		14–273	Ag 4t	Similar to the above specimen and conditions except annealed for 4 h at 750 K in gas and $[R(273\ K)/R(T)]_{min} = 250$.
41	171	Gerritsen, A.N. and Linde, J.O.	1956		14–273	Ag-Mn 3	0.071 (0.14 at.%) Mn; rectangular rod of square cross section 2.5 x 2.5 mm; silver used in alloy from Nordiska Affiveriet, Halsingborg; alloy melted in evacuated and sealed silica tubes in high frequency furnace, rolled, and cut; annealed for a few hours at 720 K after being made and again before mounting in measuring apparatus; $[R(273\ K)/R(T)]_{min} = 7.25$; data extracted from table.
42	171	Gerritsen, A.N. and Linde, J.O.	1956		14–273	Ag-Mn 2	Similar to the above specimen and conditions except 0.163 (0.32 at.%) Mn and $[R(273\ K)/R(T)]_{min} = 3.78$.
43	172	Jha, D., Jericho, M.H., and Taylor, P.L.	1970		0.67–4.0		0.0056 Mn (0.011 at.%); strip specimen 1 x 0.2 mm cross section and approx 10 cm long; prepared from 99.9999 pure component materials; homogenized at 973 K for 24 h under high vacuum; resistivity measured using a relax modulator described by Jericho and March (Rev. Sci. Instrum., 38, 428, 1967); data points extracted from figure except value at 4.0 K from text; reported error 0.3%.
44	172	Jha, D., et al.	1970		0.32–4.2		Similar to the above specimen and conditions except 0.016 In (0.015 at.%).
45	10	Coltman, R.R., Klabunde, C.E., and Redman, J.K.	1967		3.2, 290		99.999 pure (reported as 5N nominal purity), polycrystalline; fcc crystal structures; wire specimen 0.025 cm x 10 cm (0.010 in x 4 in); annealed at 1023 K for 32 h in 15 mTorr air, furnace cooled; residual resistance ratio $R(290\ K)/R(3.2\ K) = 1715$; data of $\rho(3.2\ K)$ extracted from table; $\rho(290\ K)$ obtained by using $\rho(3.2\ K)$ and residual resistance ratio.
46	22	Grüneisen, E. and Reddemann, H.	1934		22–273	Ag I	Pure; from Degussa; drawn; annealed at 623 K for 2 h in vacuum; data extracted from tables.
47	22	Grüneisen, E. and Reddemann, H.	1934		83, 273	Ag θ_4	Pure; single crystal; deformed; data extracted from table.
48	22	Grüneisen, E. and Reddemann, H.	1934		22–273	Ag θ_4	The above specimen and conditions except annealed at 623 K for 2 h in vacuum.
49*	22	Grüneisen, E. and Reddemann, H.	1934		83	Ag θ_5	Pure; single crystal; data extracted from table.
50	182	Sedström, E.	1919		273, 373		Wire specimen 1 mm in diam; rolled and drawn; annealed at near melting point for at least 0.5 h; data extracted from table.
51	182	Sedström, E.	1919		273, 373		Wire specimen 1 mm in diam; rolled and drawn; annealed at near melting point for at least 0.5 h; data extracted from table.
52	77	Smith, A.W.	1925	B	298		100 Cu; measured on a Kelvin double bridge of the Wolff type; data extracted from table.
53	123	Schulze, F.A.	1911		298		100 Ag; data extracted from table.
54*	95	Brown, H.M.	1927		273		99.9 pure; bar specimen 0.318 cm (0.125 in) in diam and 10 cm long; obtained from Baker and Co; data extracted from table; reported error 0.1%.
55	164	Anderson, A.C., Peterson, R.E., and Robichaux, J.	1968		300		99.999 pure; rectangular cross section with minimum dimension 1.27×10^{-2} cm, $A/\ell = 1.36 \times 10^{-4}$ cm; obtained from Cominco American; unannealed; residual resistivity ratio $\rho(300\ K)/\rho(0\ K)$ when mounted in cryostat, 740; data of 4 K from text; $\rho(300\ K)$ determined from $\rho(4\ K)$ and residual resistivity ratio; resistivity constant below 4 K to within 1%.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
56	87	Van Witzenburg, W. and Laubitz, M.J.	1968		4.2, 273		99.9999 pure; wire specimen 1.6 mm in diam; supplied by Cominco; oxidized in pure oxygen at 950 K for 39 h, then annealed in 10^{-5} mmHg vacuum at 770 K for 17 h; residual resistivity ratio $\rho(273\ K)/\rho(4.2\ K) = 1650$; residual resistivity $9 \times 10^{-4}\ 10^{-8}\ \Omega$ m extracted from table and assigned as $\rho(4.2)$; $\rho(273)$ calculated from residual resistivity ratio and $\rho(4.2)$.
57	19	Fletcher, R., Friedman, A.J., and Stott, M.J.	1972		4.2, 273		Specimen 0.20 mm thick; supplied by National Research Council, Ottawa; originated from Cominco "69" grade silver; rolled, etched, and annealed in vacuo at 773 K for 18 h; residual resistivity ratio $\rho(273)/\rho(4.2) = 600$; $\rho(4.2\ K)$ extracted from table; $\rho(273)$ calculated from residual resistivity ratio and $\rho(4.2\ K)$.
58	167	Crisp, R.S. and Rungis, J.	1970	→	4.2, 273		Pure; wire specimen with diam somewhere between 0.5 and 1 mm and a length somewhere between 1 and 5 cm; resistivity of this specimen previously measured by Roberts, R.B. (Queen's University, Kingston, Ontario, Canada, Ph.D. thesis, 1966); if diam was 1 mm when received, specimen drawn, etched, washed in distilled water and alcohol, dried, sealed in quartz capsule with 0.33 atm of oxygen and annealed for 72 h at 1173 K; data extracted from table; for a typical specimen absolute resistivity has error about 1%; resistivity reported to $\pm 0.0025\ 10^{-8}\ \Omega$ m; accuracy of absolute temperature measurements estimated to be better than 0.05 K for all temperatures; voltages measured using 6-figure 9144 Douphinee potentiometer with resolution of 0.01 μV; temperature at which residual resistivity measured assigned 4.2 K.
59	167	Crisp, R.S. and Rungis, J.	1970	→	4.2, 273		0.16 Au (0.09 at.%), composition estimated using Nordheim's rule and figures of Linde, J.O. (University of Stockholm, Thesis, 1939) for residual resistivity increase per solute at.%; specimens purchased from Cambridge Metals Research Ltd., England, having been made from 6N grade Ag and 5N and 6N grade Au; wire specimen with diam somewhere between 0.5 and 1 mm and a length somewhere between 1 and 5 cm; if diam was 1 mm when received, specimen drawn, etched, washed in distilled water and alcohol, dried, sealed in quartz capsule with 0.33 atm of oxygen and annealed for 72 h at 1173 K; data extracted from table; for a typical specimen absolute resistivity has error about 1%; resistivity reported to $\pm 0.0025\ 10^{-8}\ \Omega$ m, accuracy of absolute temperature measurements estimated to be better than 0.05 K for all temperatures; voltages measured using 6-figure 9144 Douphinee potentiometer with resolution of 0.01 μV; temperature at which residual resistivity measured assigned 4.2 K.
60	163	Vatolin, N.A., Esin, O.A., and Dubinin, E.L.	1967	R	1873		Presumably 99.999 pure; liquid state; data point extracted from figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
61	112	Laubitz, M.J.	1969	A	268-900		99.9999 pure (reported as silver of 6N quality); 0.00003-0.0002 Fe, <0.0001 Ca, <0.0001 Cu, <0.0001 Mg, and <0.0001 Si, range of impurities detected in three spectrographic analyses; purchased from Cominco; annealed in oxygen for 4 weeks at 900 K; density after annealing 10.512 ± 0.001 g cm^{-3} at 293 K; ice point resistivity after annealing ρ(273.15 K) = (1.468 ± 0.001) x 10^{-8} Ω m; platinum legs of the thermocouples used as potential probes; resistivity, except ρ(273.15 K) which was from table, deduced from i) ρ = -0.0754 + 5.3862 x 10^{-3} T + 0.9783 x 10^{-6} T^2, uncorrected for thermal expansion, with ρ in units of 10^{-8} Ω m and T in units of K, root mean square deviation of 0.20%, and ii) data points, extracted from figures, of percent deviation from equation given in i); estimated extraction error, for temperatures less than 300 K, ±0.42 K in temperature and ±0.0033% in percent deviation and, for temperatures above 300 K, ±2.1 K in temperature and ±0.016% in percent deviation; max error estimate varies from ±0.12% at 300 K to ±0.5% at 900 K; equation in i) could reasonably be extrapolated to about 1100 K with an error somewhat less than 1%.
62	112	Laubitz, M.J.	1969	A	268-900		The above specimen and conditions except special silver wires used as potential probes and these results agree with the results for the above data set to within 0.11% at room temperature but at higher temperatures a systematic difference of about 0.3% exists between them.
63	91	White, G.K. and Woods, S.B.	1959		10-295	Ag A	99.999 pure; wire specimen 0.2 mm in diam and 6-8 cm long; from Johnson Matthey Ltd., London; vacuum annealed 803 K; residual resistance ratio R(295)/R(residual) = 261; error in reading galvanometer amplifier 1 in 400; values normalized using ρ_i(273) in Gerritsen, A.N. (Handbuch der Physik, 19, 137, 1956) due to uncertainty in diam of wire; $\rho = \rho_0 + \rho_i$, smoothed values of ideal resistivity given in tabular form as 0.0002, 0.0011, 0.0038, 0.010, 0.020, 0.058, 0.11, 0.17, 0.230, 0.290, 0.355, 0.420, 0.545, 0.675, 0.795, 0.92, 1.04, 1.16, 1.34, 1.47, and 1.61 x 10^{-8} Ω m at 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 220, 250, 273, and 295 K, respectively; ρ_0 obtained from residual resistance ratio and assuming ρ(295 K) = ρ_i(295 K), ρ_0 = 0.0062 x 10^{-8} Ω m.
64	165	Ascoli, A., Germognoli, E., and Guarini, G.	1966		374-1198		99.999 pure; wire specimen 0.25 mm in diam and about 10 cm long; supplied by Johnson, Matthey and Co., Ltd., London; well annealed; resistance measured on 6-digit Tinsley 5205 E potentiometer; measurements performed in a vacuum of 10^{-5} mmHg for temperatures below 1023 K and in argon at atmospheric pressure for temperatures above 1023 K, this necessitated a subtraction of the small increase in resistance due to use of argon gas to get a normalization between the "vacuum" and "argon gas" portions of one curve; data points of a typical set of results extracted from a figure of ℓn(10^3 ρ/T) versus T with estimated extraction error ±3.3 K in temperature and ±0.0085 in ℓn(10^3 ρ/T); average temperature known to better than ±0.1 K; reported resistivity ρ = R(T) [ρ(room temperature)/R(room temperature)] [1 + $\bar{\alpha}$(T - T(room temperature))] where ρ(room temperature) = ρ(293 K) = 1.6 x 10^{-8} Ω m from p. 695 of Smithells, C.J. (Metals Reference Book, Vol. II, 3rd edition, Butterworths, London, 1962) and $\bar{\alpha}$, the average linear expansion coeff between T and T(room temperature), from Simmons, R.O. and Balluffi, R.W. (Phys. Rev., 119, 600, 1960).

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
65	108	Iyer, V.K. and Asimow, R.M.	1967		275-1096		99.999 pure; wire specimen; probably annealed; resistance measured in vacuum and between measurements, to prevent evaporation, specimen maintained in argon for temperatures above 673 K; corrected for linear expansion using the factor $[1+\bar{\alpha}(T-T_0)]$ with values of $\bar{\alpha}$ obtained from p. 102 of Wise, E.M. (Gold: Recovery, Properties, and Applications, D. Van Nostrand Co., Inc., Princeton, N.J., 1964); estimated average specimen temperature reported to accuracy of ±0.3% T(T in °C); standard deviation of points from best fitting curve of a single run less than 0.5% of mean value; data points extracted from figure with estimated extraction error ±4.9 K in temperature and $\pm 0.049 \times 10^{-8}$ Ω m in resistivity; second specimen used to obtain data between 273 and 303 K and was annealed in argon; data for 300 K probably from average of the two specimens at 300 K.
66	176	Matsumura, T. and Laubitz, M.J.	1970	A	84-358		99.9999 pure (reported as 6N purity); ~0.00003 Fe, ~0.0000 Si, <0.0000 Cu, and <0.00001 Mg detectable impurities; polycrystalline; bar specimen nominally 0.7 cm in diam and 10 cm long; obtained from Cominco; measured residual resistivity ratio, in as received condition, 1050 ± 250 and specimen not subjected to further annealing; resistivity measured using standard dc potentiometric technique; resistivity, except $\rho(273.15\ K)$ which was ice-point resistivity and taken from text, deduced from i) $\rho = -1.2144 \times 10^{-1} + 5.8579 \times 10^{-3}\ T + 9.1473 \times 10^{-8}\ T^2 - 4.6269/T$, uncorrected for thermal expansion, with ρ in units of 10^{-8} Ω m and T in K, and ii) data points, extracted from figure, of percent deviation from equation given in i); estimated extraction error ±0.85 K in temperature and ±0.041% in percent deviation; estimate of error in measurement ±0.39% at 90 K to ±0.12% at 350 K with contributions to this error as follows: error in current measurement 0.03%, error in potential difference measurement from 0.30% at 90 K to 0.03% at 360 K, error in potential lead separation determination 0.03%, and error in cross-sectional area 0.03%
67	168	Ehrlich, A.C. and Schriempf, J.T.	1974	-	5.1-20		High purity; single crystal; specimen approx 0.25 cm in diam and about 17 cm long with a voltage-measuring probe separation of about 7.5 cm; residual resistivity ratio RRR = 10,000 obtained by oxygen annealing a crystal with RRR of approx 140; voltages measured with Honeywell 2768 potentiometer with a resolution of 1×10^{-9} V and a sensitive Research Type 9460 photocell galvanometer amplifier, system precision about 2×10^{-9} V; temperature dependent electrical resistivity, total resistivity minus residual resistivity, for two separate experimental runs extracted from figure with estimated extraction error 1.4% in temperature and 1.4% in temperature dependent resistivity.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
68	66	Rumbo, E.R.	1976	→	1.3-6.9	Ag 1	Very pure; concentration of magnetic impurities less than 1 part in 10^9; single crystal; crystal orientation <111>; specimen thickness 0.549 mm, width 2.38 mm, and length 28.6 mm; Cominco material underwent distillation to improve resistance ratio using specially prepared graphite crucibles free of magnetic impurities, grown into single crystal by Bridgman method, annealed in oxygen, cut using spark erosion, and before measurement, annealed in vacuum to remove spark damage; fitted value of residual resistivity $0.00053119 \times 10^{-8}\ \Omega$ m (least-squares fit to data made with $\rho_0 + aT^3 + bT^5$, for each point below 3 K, a and b used to obtain individual values for ρ_0 which were plotted versus T and extrapolated to T = 0 K to give final value of ρ_0); residual resistance ratio 2785; mean free path 0.159 mm; resistance measured with superconducting galvanometer, the slug, in a potentiometer circuit, limiting resolution of slug circuit 1 to 3 parts in 10^4; uncertainty in absolute resistivity 0.3% due to balancing resistor and 0.5% due to form factor; form factor calculated from measured resistance at 273 K and value tabulated for resistivity at 273 K in Hall, L.A. (National Bureau of Standards Technical Note 365, 111 pp., 1968); data extracted from table.
69	66	Rumbo, E.R.	1976	→	1.2-8.5	Ag 2	Similar to the above specimen and conditions except crystal orientation <001>, thickness 0.456 mm, fitted value of residual resistivity $0.00045304 \times 10^{-8}\ \Omega$ m, residual resistance ratio 3270, and mean free path 0.186 mm.
70	66	Rumbo, E.R.	1976	→	1.2-8.5	Ag 4	Very pure; concentration of magnetic impurities less than 1 part in 10^9; polycrystalline; specimen thickness 0.371 mm, width 2.38 mm, and length 28.6 mm; Johnson-Matthey material; annealed in oxygen; residual resistivity $0.0013460 \times 10^{-8}\ \Omega$ m; residual resistance ratio 1100; mean free path 0.0627 mm; resistance measured with superconducting galvanometer, the slug, in a potentiometer circuit, limiting resolution of slug circuit 1 to 3 parts in 10^4; uncertainty in absolute resistivity 0.3% due to balancing resistor and 0.5% due to form factor; form factor calculated from measured resistance at 273 K and value tabulated for resistivity at 273 K in Hall, L.A. (National Bureau of Standards Technical Note 365, 111 pp., 1968); original data in tabular form and additional information supplied by author.
71	174	Kos, J.F.	1972	→	1.4-4.1	Ag 1	Pure; impurity content 0.00005 Si, 0.00003 Al, 0.00003 Fe, 0.00002 Ca, and 0.00001 Mg with analysis supplied by Cominco after extrusion; specimen 1.0 mm in diam and about 10 m long; obtained from Cominco; annealed at 923 K for 48 h in vacuum of 10^{-7} Torr by passing current of about 2 A through specimen, slowly cooled during next 2 d to room temperature; residual resistance ratio $R_{273.16}/R_0 = 1728.44$; resistance measured with Guildline nanovolt potentiometer and galvoamplifier; specimen wound non-inductively; at a given temperature, 6 separate readings taken (with temperature not drifting more than 3 mK), 3 different currents used, the 6 readings weighed according to measuring current, and average value used; original data of reduced resistance $R_T/R_{273.16}$ in tabular form supplied by author where R_T is the resistance at temperature T; resistivity deduced by assuming $\rho_{273} = 1.468 \times 10^{-8}\ \Omega$ m.
72	174	Kos, J.F.	1972	→	1.4-4.1	Ag 2	Similar to the above specimen (extruded from the same pure ingot) and conditions except specimen 0.50 mm in diam and $R_{273.16}/R_0 = 1952.95$.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
73	174	Kos, J. F.	1972	→	1.4-4.1	Ag 3	Similar to the above specimen (extruded from the same pure ingot) and conditions except impurity content 0.0001 Al, 0.00007 Si, 0.00005 Ca, 0.00003 Fe and 0.00002 Mg; specimen 0.25 mm in diam; and $R_{273.16}/R_0$ = 2101.28.
74	174	Kos, J. F.	1972	→	1.4-4.1	Ag 4	Pure; impurity content 0.0005 Au, 0.0005 Pd, 0.0002 Cu, 0.0002 Fe, <0.0001 Bi, <0.0001 Cd, and <0.0001 Mg with analysis supplied by Johnson Matthey after extrusion; specimen 0.50 mm in diam and about 10 m long; purchased from Johnson Matthey; annealed at 923 K for 48 h in vacuum of 10^{-7} Torr by passing current of about 2 A through specimen, slowly cooled during next 2 d to room temperature; residual resistance ratio $R_{273.16}/R_0$ = 648.1726; resistance measured with Guildline nanovolt potentiometer and galvoamplifier; specimen wound non-inductively; at a given temperature 6 separate readings taken (with temperature not drifting more than 3 mK), 3 different currents used, the 6 readings weighted according to measuring current, and average value used; original data of reduced resistance $R_T/R_{273.16}$ in tabular form supplied by author; where R_T is the resistance at temperature T; resistivity deduced by assuming ρ_{273} = 1.468 x 10^{-8} Ω m.
75	175	Kos, J. F.	1973	→	2.0-287	U 1	Very pure; impurity content after extrusion supplied by Cominco 0.00005 Si, 0.00003 Al, 0.00003 Fe, 0.00002 Ca, and 0.00001 Mg; specimen supplied by Cominco; specimen 0.5223 mm in radius and (12.170 ± 0.001) m long; unannealed, as obtained after extrusion; residual resistivity ρ_0 = 0.004714 x 10^{-8} Ω m (determined by curve fitting data between 1.38 and 4.15 K to $(\rho_T - \rho_0)/T^3 = A + BT^2$ and varying ρ_0 to obtain lowest standard deviation); resistance measured with Guildline nanovolt potentiometer and galvoamplifier corrected for thermal expansion; resistance converted to resistivity by weighing specimen; to within ± 0.0005%, to determine diameter and then measuring length, to within ± 0.01%; absolute accuracy of resistivity measurement about 0.1%; data points of total resistivity minus residual resistivity, $\rho_T - \rho_0$, extracted from figures with estimated extraction error 2.5% in temperature and 5.6% in $\rho_T - \rho_0$; data of ρ(273.16) from table; original data in tabular form of $(\rho_T - \rho_0)$ versus ρ_0 at 4.49, 6.81, 9.01, 15.94, and 23.66 K supplied by author; total resistivity ρ_T arrived at from $(\rho_T - \rho_0) + \rho_0$.
76	175	Kos, J. F.	1973	→	2.0-44	A1	The above specimen and conditions after annealed at 923 K for 48 h in vacuum of 10^{-6} Torr, specimen 0.5218 mm in radius and (7.523 ± 0.001) m long, and residual resistivity 0.0009155 x 10^{-8} Ω m.
77	175	Kos, J. F.	1973	→	4.5-273	U2	Very pure; impurity content after extrusion supplied by Cominco 0.00005 Si, 0.00003 Al, 0.00003 Fe, 0.00002 Ca, and 0.00001 Mg; specimen supplied by Cominco; specimen 0.2539 mm in radius and (30.615 ± 0.002) m long; unannealed, as obtained after extrusion; residual resistivity ρ_0 = 0.005219 x 10^{-8} Ω m (determined by curve fitting data between 1.38 and 4.15 K to $(\rho_T - \rho_0)/T^3 = A + BT^2$ and varying ρ_0 to obtain lowest standard deviation); resistance measured with Guildline nanovolt potentiometer and galvoamplifier; corrected for thermal expansion; resistance converted to resistivity by weighing specimen, to within ± 0.0005%, to determine diameter and then measuring length, to within ± 0.01%; absolute accuracy of resistivity measurement about 0.1%; original data of total resistivity minus residual resistivity $(\rho_T - \rho_0)$ from author except ρ(273.16 K) from table; total resistivity ρ_T arrived at from $(\rho_T - \rho_0) + \rho_0$.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (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	175	Kos, J. F.	1973	→	4.5-273	A2	The above specimen and conditions after annealed at 923 K for 48 h in vacuum of 10^{-6} Torr, specimen 0.2515 mm in radius and (5.634 ± 0.001) m long, and residual resistivity 0.0007612 x 10^{-8} Ω m.
79	175	Kos, J. F.	1973	→	4.5-273	U3	Very pure; impurity content after extrusion supplied by Cominco 0.0001 Al, 0.00007 Si, 0.00005 Ca, 0.00003 Fe, and 0.00002 Mg; specimen supplied by Cominco; specimen 0.1298 mm in radius and (31.707 ± 0.001) m long; unannealed, as obtained after extrusion; residual resistivity ρ_0 = 0.01003 x 10^{-8} Ω m (determined by curve fitting data between 1.38 and 4.15 K to $(\rho_T - \rho_0)/T^3 = A + BT^2$ and varying ρ_0 to obtain lowest standard deviation); resistance measured with Guildline nanovolt potentiometer and galvoamplifier; corrected for thermal expansion; resistance converted to resistivity by weighing specimen, to within ± 0.0005%, to determine diameter and then measuring length, absolute accuracy of resistivity measurement about 0.1%; data points of total resistivity minus residual resistivity $(\rho_T - \rho_0)$ extracted from figure, except ρ(273.16 K) from table; estimated extraction error results in ± 0.00006 x 10^{-8} Ω m for ρ_T; total resistivity ρ_T arrived at from $(\rho_T - \rho_0) + \rho_0$; $\rho = \rho_T$.
80	175	Kos, J. F.	1973	→	4.5-273	A3	The above specimen and conditions after annealed at 923 K for 48 h in vacuum of 10^{-6} Torr, specimen 0.1288 mm in radius and (4.160 ± 0.001) m long, residual resistivity 0.0007046 x 10^{-8} Ω m, and original data in tabular form of $\rho_T - \rho_0$ supplied by author with ρ(273.16 K) from table.
81*	175	Kos, J. F.	1973	→	4.5-273	U4	Very pure; impurity content after extrusion supplied by Johnson Matthey 0.0005 Au, 0.0005 Pd, 0.0002 Cu, 0.0002 Fe, < 0.0001 Bi, < 0.0001 Cd, and < 0.0001 Mg; specimen supplied by Johnson Matthey; specimen 0.2509 mm in radius and (12.271 ± 0.001) m long; unannealed, as obtained after extrusion; residual resistivity ρ_0 = 0.01027 x 10^{-8} Ω m (determined by curve fitting data between 1.38 and 4.15 K to $(\rho_T - \rho_0)/T^3 = A + BT^2$ and varying ρ_0 to obtain lowest standard deviation); resistance measured with Guildline nanovolt potentiometer and galvoamplifier; corrected for thermal expansion; resistance converted to resistivity by weighing specimen, to within ± 0.0005%, to determine diameter and then measuring length, to within ± 0.01%; absolute accuracy of resistivity measurement about 0.1%; data points of total resistivity minus residual resistivity $(\rho_T - \rho_0)$ extracted from figure, except ρ(273.16 K) from table; estimated extraction error result in ± 0.00006 x 10^{-8} Ω m for ρ_T; total resistivity ρ_T arrived at from $(\rho_T - \rho_0) + \rho_0$; $\rho = \rho_T$.
82	175	Kos, J. F.	1973	→	4.5-273	A4	The above specimen and conditions after annealed at 923 K for 48 h in vacuum of 10^{-6} Torr, specimen 0.2506 mm in radius and (6.646 ± 0.001) m long, residual resistivity 0.002273 x 10^{-8} Ω m, and original data in tabular form of $\rho_T - \rho_0$ supplied by author with ρ(273.16 K) from table.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
83	64	Roll, A. and Motz, H.	1957		1181-1464		99.995 pure; in solid and liquid states; mp 1233 K; rotating field method used in liquid state with thermal expansion correction carried out; accuracy of temperature measurements ± 1 K; maximum measurement uncertainty in resistivity in liquid state ± 0.7% for errors in frequency, current density, torsional deviation, and sample temperature; accuracy of rotating field method in liquid state, about 1% on the basis of reproduced experiments on same metals under most diverse conditions; data points extracted from figure with estimated extraction error ± 1.6 K in temperature and ± 0.16 x 10^{-8} Ω m in resistivity.
84	102, 170	Fenton, E.W., Rogers, J.S., and Woods, S.B.	1962, 1963	→	2.3-11	1	Pure; wire specimen; bar obtained from Engelhard Industries (Toronto); bar 3 mm in diam and 8 cm long rolled to square cross section 1 mm on a side, immersed in nitric acid, drawn through diamond dies to round wire, cut from wire, etched in nitric acid, annealed; residual resistivity ratio in original condition ρ(room temperature)/ρ(4.2 K) = 40; residual resistivity 7.99 x 10^{-10} Ω cm; voltage difference across specimen measured by a galvanometer amplifier; ℓ/A = 2020, calculated using known resistivity of pure metal at room temperature and measured resistance; data extracted from table; reported error 1%; ρ_i also reported as 8.9 x 10^{-14} $T^{3.3}$ Ω cm.
85	102	Fenton, E.W.	1962	→	2.1-17	2	The above conditions and specimen cut from the same wire as the above specimen except ℓ/A = 1440, residual resistivity 6.70 x 10^{-10} Ω cm.
86	102	Fenton, E.W.	1962	→	2.2-11	5	The above conditions and specimen cut from the same wire as the above specimen; ℓ/A = 1470 and residual resistivity 1.075 x 10^{-9} Ω cm.
87	107	Howe, R.A. and Enderby, J.E.	1967		1408		99.999 pure (reported as grade 5N); supplied by Koch-Light; in liquid state; fused quartz sample holder used to contain the liquid; data point extracted from figure.
88	52	Niccolai, G.	1908	B	84-674		Pure; material from C.A.F. Kahlbaum, Berlin; wire specimen 0.046 cm in diam and 850.1 cm long; resistance measured using a Wheatstone Bridge; data, corrected for thermal expansion, extracted from table; thermal expansion correction made using the expansion coefficient of Ayres, H.D. (Phys. Rev., p. 38, 1908) for temperatures between 86 and 313 K and data of Fizeau and LeChatelier (Landolt Tables) for higher temperatures; resistivity, uncorrected for thermal expansion, reported as 0.419, 0.497, 0.641, 0.768, 0.915, 1.075, 1.221, 1.351, 1.507, 1.569, 1.575, 1.653, 1.797, 1.943, 2.100, 2.242, 2.389, 2.530, 2.677, 2.821, 2.962, 3.098, 3.240, 3.381, 3.508, 3.642, and 3.771 x 10^{-8} Ω m at 84.2, 98.4, 122.0, 148.4, 173.0, 197.5, 223.2, 248.0, 273.4, 284.2, 285.2, 298.2, 323.0, 347.8, 374.2, 398.2, 423.6, 448.0, 473.2, 498.4, 524.1, 547.6, 573.4, 599.0, 624.6, 648.7, and 673.8 K, respectively; temperature reported is average of two thermocouples.
89	177	Matuyama, Y.	1927		1253-1530		Chemically pure; in liquid state; radius of specimen 2.38 mm and length 36.12 mm; from Merck; mp 1233 K; electrical resistivity of the molten metal at the mp 17.3 x 10^{-8} Ω m; ratio of electrical resistivity of molten metal at mp to electrical resistivity of solid phase at mp found to be 2.08; data extracted from table; temperature difference along the length of 10 cm in the apparatus did not exceed 1 K (reported as 1 °C).
90	186	Uemura, O. and Ikeda, S.	1973	→	1277, 1319		In liquid state; electrical resistivity measured by the dc four-probe technique; data points extracted from figure with estimated extraction error ± 3 K in temperature and ± 0.06 x 10^{-8} Ω m in resistivity.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
91	55	Ozelton, M.W., Wilson, J.R., and Pratt, J.N.	1967	R	1273		In liquid state; data point at zero at.% Ge extracted from figure with estimated extraction error ± 0.3 at.% Ge in concentration and ± 0.6 x 10^{-8} Ω m in resistivity.
92	97	Busch, G. and Güntherodt, H.J.	1967	→	1233, 1257		99.999 pure; in liquid state; from Johnson, Matthey and Co., London; resistivity measured by an ac current- ac magnetic field method; data points extracted from figure with estimate of extraction error ± 1.7 K in temperature and ± 0.09 x 10^{-8} Ω m in resistivity; the absolute accuracy of measurement of electrical resistivity was about 3%.
93	188	Yatsenko, S.P. and Kononenko, V.I.	1969	→	1300		High purity and total impurity concentration below 0.001; in liquid state; resistance measured by an electrodeless method; reported error in electrical resistance ± 3%; reproducibility of results on heating and cooling approx 0.5%; data point at 100% Ag extracted from figure with estimate of extraction error ± 0.7 at.% in concentration and ± 0.7 x 10^{-8} Ω m in resistivity.
94	184	Takeuchi, S. and Endo, H.	1962	R	1253-1331		99.99 pure; in liquid state; mp 1233 K; resistivity at mp 17.3 x 10^{-8} Ω m; $d\rho/dT$ = 6 x 10^{-11} Ω m K^{-1}; residual resistivity 4.0 x 10^{-8} Ω m obtained by extrapolating the temperature dependence of resistivity back to 0 K; resistivity determined by comparison with known value of resistivity for Hg of 95.6 x 10^{-8} Ω m at 293 K; data points extracted from figure with estimate of extraction error ± 1.7 K in temperature and ± 0.03 x 10^{-8} Ω m in resistivity.
95	8	Bornemann, K. and Wagenmann, K.	1914		1273-1673		Chemically pure precipitation silver; Cu, Pb, nor Zr detected analytically; in liquid state; data extracted from table.
96*	11	Dawson, H.I.	1965		78		99.999 pure; polycrystalline; approx grain size 0.05-0.1 mm; wire specimen 0.20 or 0.25 mm in diam; from Johnson Matthey; annealed for 1 h at 723 K in vacuum of 10^{-5} mmHg; data point extracted from table.
97	185	Tanner, D.B. and Larson, D.C.	1968	→	4.2-282		99.999 pure; bulk crystal; residual resistance ratio = 250; specimen mounted in cryostat; voltage measured with Honeywell Model 2768 potentiometer; data extracted from figure with estimated extraction error of ± 1.92% in T and ± 1.89% in ρ; temperature accurate to about 0.1 K; resistivity accurate to about 8%.
98	185	Tanner, D.B. and Larson, D.C.	1968	→	4.2-285		99.9999 pure; single-crystalline; crystal orientation {100} planes parallel to substrate; 1700 Å film thickness; grown by epitaxial deposition onto rocksalt substrate heated to 573 K; mounted in cryostat; voltage measured with Honeywell Model 2768 potentiometer; data extracted from figure with estimated extraction error of ± 1.92% in T and ± 1.89% in ρ; temperature accurate to about 0.1 K; resistivity accurate to about 8%.
99	185	Tanner, D.B. and Larson, D.C.	1968		4.2-282		Similar to the above specimen and conditions except 28000 Å film thickness.
100*	185	Tanner, D.B. and Larson, D.C.	1968		4.2-282		Similar to the above specimen and conditions except crystal orientation {111}, 7400 Å film thickness, and deposited onto mica substrate.
101	83	Tsutsumi, H.	1918		291-1541		In solid and liquid states; obtained from Kahlbaum; mp 1230 K, 1235 K; resistivity at mp in solid state ρ_S = 9.32 x 10^{-8} Ω m and in liquid state ρ_L = 16.2 x 10^{-8} Ω m with a ratio ρ_L/ρ_S = 1.74; to prevent oxidation, hydrogen gas continually passed through furnace; data extracted from table; measurements taken with increasing temperature.
102	83	Tsutsumi, H.	1918		834-1508		Same as the above specimen and conditions except measurements taken with decreasing temperature.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
103	82	Teixeira, J.	1974	→	1.3-292		99.999 pure (reported as 5N); 0.2786 mm in diam, calculated from specimen mass taking the density of Ag as 10.5, and 102.25 cm between voltage probes; material from Johnson and Matthey; starting material melted, rolled and passed through dies of tungsten carbide and diamond to obtain nominal diam of 0.282 mm; annealed in vacuum at 823 K for 4 h and slowly cooled; residual resistivity ρ_0 = 2.517 nΩ cm, residual resistance ratio $\rho(273\ K)/\rho_0$ = 579.7; resistance measured using four-probe dc method; resistivity ρ derived from resistance R by, $\rho = RM/d\ell^2$ where M is the specimen mass, ℓ is specimen length, and d is density of Ag as stated above; data extracted from table and text; uncertainty in voltage measurements is 10^{-4} in worst case but usually 10^{-6}; imprecision of ℓ and M are reported as $\Delta\ell/\ell \simeq 2 \times 10^{-3}$ and $\Delta M/M \simeq 10^{-4}$; uncertainty in temperature of 0.1 K but relative uncertainty of 0.001 K; author fits data to $\rho = A + DT^5J_5(\theta/T)(1 + 2\alpha\gamma T)$ with an absolute average quadratic error of 0.552 nΩ cm where $J_5(\theta/T)$ is the integral of Grüneisen evaluated at temperature T, A = 2.51770 nΩ cm, D = 8.14898 x 10^{-9} nΩ cm K^{-5}, $2\alpha\gamma$ = 1.1646, θ = 226.50 K, and T is in kelvins.
104*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.4-21	Sample 19	99.999 (reported as 5N), high purity; wire specimen 0.62 mm in diam and between 20 cm and 1 m long; geometrical factor determined from specimen length and from its mass by using lattice spacing data to deduce diam; high pressure low temperature annealed: either sealed in capsule containing up to 10 Torr O_2, or in continuous flow of O_2 at about 0.1 Torr, and at about 873 K for 6-10 h; residual resistivity ρ_0 = (2.2738 ± 0.0002) x 10^{-11} Ω m; resistance measurements made using conventional four terminal potentiometric techniques: sample currents stabilized to a few ppm, potentiometer was of thermal free design, and null detector was galvanometer amplifier of nanovolt sensitivity; temperature reproducibility to within 100 mK between 4.2 and 10 K, possibly to 200 mK at 20 K; temperature uncertainty often dominant error; uncertainty in geometrical factor less than 1%; original data in tabular form and additional information supplied by authors.
105*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.5-20	Sample 19	The above specimen and conditions except a separate run; and ρ_0 = (2.2805 ± 0.0005) x 10^{-11} Ω m.
106*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.0-20	Sample 19	The above specimen and conditions except a separate run; ρ_0 = (2.1410 ± 0.0005) x 10^{-11} Ω m, and the four measurements at 4.22 K made on warming up to 4.22 K after a pump down.
107*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.0-20	Sample 19	The above specimen and conditions except a separate run; ρ_0 = (2.1613 ± 0.0005) x 10^{-11} Ω m, and the two measurements at 4.22 K made on warming up to 4.22 K after a pump down.
108*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.4-21	Sample 19	The above specimen and conditions except a separate run; ρ_0 = (2.230 ± 0.001) x 10^{-11} Ω m, and the last two values at 4.22 K measured on warming up to 4.22 K after a pump down.
109*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.0-11	Sample 19	The above specimen and conditions except a separate run; ρ_0 = (2.2300 ± 0.0005) x 10^{-11} Ω m, and the first value at 4.22 K measured on warming up to 4.22 K after a pump down.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
110*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.0–20	Sample 34	99.9999 (reported as 6N), high purity; wire specimen 0.62 mm in diam and between 20 cm and 1 m long; geometrical factor determined from specimen length and from its mass by using lattice spacing data to deduce diam; high pressure low temperature annealed: either sealed in capsule containing up to 10 Torr O_2, or in continuous flow of O_2 at about 0.1 Torr, and at about 873 K for 6-10 h; residual resistivity $\rho_0 = (2.71 \pm 0.01) \times 10^{-11}\ \Omega$ m; resistance measurements made using conventional four terminal potentiometric techniques: sample currents stabilized to a few ppm, potentiometer was of thermal free design, and null detector was galvanometer amplifier of nanovolt; temperature reproducibility to within 100 mK between 4.2 and 10 K, possibly to 200 mK at 20 K; temperature uncertainty often dominant error; uncertainty in geometrical factor less than 1%; original data in tabular form and additional information supplied by authors.
111*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.6–10	Sample 34	The above specimen and conditions except a separate run and $\rho_0 = (2.6588 \pm 0.0002) \times 10^{-11}\ \Omega$ m.
112*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.3–21	Sample 65	99.9999 (reported as 6N), high purity; wire specimen 0.54 mm in diam and between 20 cm and 1 m long; geometrical factor determined from specimen length and from its mass by using lattice spacing data to deduce diam; high pressure low temperature annealed: either sealed in capsule containing up to 10 Torr O_2, or in continuous flow of O_2 at about 0.1 Torr, and at about 873 K for 6-10 h; residual resistivity $\rho_0 = (1.4619 \pm 0.0001) \times 10^{-11}\ \Omega$ m; resistance measurements made using conventional four terminal potentiometric techniques: sample currents stabilized to a few ppm, potentiometer was of thermal free design, and null detector was galvanometer amplifier of nanovolt sensitivity; temperature reproducibility to within 100 mK between 4.2 and 10 K, possibly to 200 mK at 20 K; temperature uncertainty often dominant error; uncertainty in geometrical factor less than 1%; original data in tabular form and additional information supplied by authors; the last two values at 4.22 K measured on warming up to 4.22 K after a pump down.
113*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.5–18	Sample 61	99.999 (reported as 5N), high purity; wire specimen 0.54 mm in diam and between 20 cm and 1 m long; geometrical factor determined from specimen length and from its mass by using lattice spacing data to deduce diam; high pressure low temperature annealed: either sealed in capsule containing up to 10 Torr O_2, or in continuous flow of O_2 at about 0.1 Torr, and at about 873 K for 6-10 h; residual resistivity $\rho_0 = (4.61640 \pm 0.00005) \times 10^{-11}\ \Omega$ m; resistance measurements made using conventional four terminal potentiometric techniques: sample currents stabilized to a few ppm; potentiometer was of thermal free design, and null detector was galvanometer amplifier of nanovolt sensitivity; temperature reproducibility to within 100 mK between 4.2 and 10 K, possibly to 200 mK at 20 K; temperature uncertainty often dominant error; uncertainty in geometrical factor less than 1%; original data in tabular form and additional information supplied by authors; the last two values at 4.22 K measured on warming up to 4.22 K after a pump down.
114*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.5–20	Sample 62	Similar to the above specimen and conditions except $\rho_0 = (1.7127 \pm 0.0001) \times 10^{-11}\ \Omega$ m.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (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*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.6–20	Sample 76	99.999 (reported as 5N), high purity; wire specimen 0.51 mm in diam and between 20 cm and 1 m long; geometrical factor determined from specimen length and from its mass by using lattice spacing data to deduce diam; high pressure low temperature annealed: either sealed in capsule containing up to 10 Torr O_2, or in continuous flow of O_2 at about 0.1 Torr, and at about 873 K for 6–10 h; residual resistivity $\rho_0 = (1.5462 \pm 0.0005) \times 10^{-11}\ \Omega$ m; resistance measurements made using conventional four terminal potentiometric techniques: sample currents stabilized to a few ppm, potentiometer was of thermal free design, and null detector was galvanometer amplifier of nanovolt sensitivity; temperature reproducibility to within 100 mK between 4.2 and 10 K, possibly to 200 mK at 20 K; temperature uncertainty often dominant error; uncertainty in geometrical factor less than 1%; original data in tabular form and additional information supplied by authors; the first two measurements at 4.22 K made on warming up to 4.22 K after a pump down.
116*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.6–20	Sample 77	Specimen cut from same length of wire as above specimen and same conditions except $\rho_0 = (1.537 \pm 0.001) \times 10^{-11}\ \Omega$ m and value at 4.20 K and the fourth value at 4.22 K measured on warming up to 4.22 K after a pump down.
117*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.6–20	Sample 78	Specimen cut from same length of wire as above specimen and same conditions except $\rho_0 = (1.537 \pm 0.001) \times 10^{-11}\ \Omega$ m and the third and fourth values at 4.22 K measured on warming up to 4.22 K after a pump down.
118*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.7–20	Sample 89	99.999 (reported as 5N), high purity; wire specimen 0.45 mm in diam and between 20 cm and 1 m long; geometrical factor determined from specimen length and from its mass by using lattice spacing data to deduce diam; low pressure (approx 10^{-4} Torr) high temperature (approx 1173 K) annealed; residual resistivity $\rho_0 = (1.2195 \pm 0.0005) \times 10^{-11}\ \Omega$ m resistance measurements made using conventional four terminal potentiometric techniques: sample currents stabilized to a few ppm, potentiometer was of thermal free design, and null detector was galvanometer amplifier of nanovolt sensitivity; temperature reproducibility to within 100 mK between 4.2 and 10 K, possibly to 200 mK at 20 K; temperature uncertainty often dominant error; uncertainty in geometrical factor less than 1%; original data in tabular form and additional information supplied by authors.
119*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.6–20	Sample 87	Similar to the above specimen and conditions except diam 0.46 mm; $\rho_0 = (1.1060 \pm 0.0001) \times 10^{-11}\ \Omega$ m, and second value at 4.21 K measured on warming up to 4.22 K after a pump down.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
120*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.5-20	Sample 35	0.064 Au (0.035 at.%) nominal concentration; specimen 0.38 mm in diam and between 20 cm and 1 m long; geometrical factor determined from specimen length and from its mass by using lattice spacing data to deduce diam; specimen prepared by standard small scale metallurgical techniques: commercially available high purity constituents melted together in quartz ampoule, homogenized rolled, and drawn; high pressure low temperature annealed: either sealed in capsule containing up to 10 Torr O_2 or in continuous flow of O_2 at about 10^{-1} Torr and about 873 K for 6-10 h; residual resistivity $\rho_0 = (15.6415 \pm 0.0005) \times 10^{-11}\ \Omega$ m; nominal residual resistivity $12.6 \times 10^{-11}\ \Omega$ m calculated from nominal concentration and values given by Linde, J.O. (Ann. Phys. Lpz., 15, 219-48, 1932) of $0.36 \times 10^{-11}\ \Omega$ m/at.%; resistance measurements made using conventional four terminal potentiometric techniques: sample currents stabilized to a few ppm, potentiometer was of thermal free design, and null detector was galvanometer amplifier of nanovolt sensitivity; temperature reproducibility to within 100 mK between 4.2 and 10 K, possibly to 200 mK at 20 K; temperature uncertainty often dominant error; uncertainty in geometrical factor less than 1%; original data in tabular form and additional information supplied by authors.
121*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.0-20	Sample 36	Similar to the above specimen and conditions except 0.13 Au (0.07 at.%) nominal concentration, specimen 0.40 mm in diam, residual resistivity $\rho_0 = (31.3791 \pm 0.0001) \times 10^{-11}\ \Omega$m and nominal residual resistivity $25.2 \times 10^{-11}\ \Omega$m.
122*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.7-20	Sample 90	Similar to the above specimen and conditions except 0.0077 Pd (0.0078 at.%) nominal concentration, specimen 0.25 mm in diam, residual resistivity $\rho_0 = (6.069020 \pm 0.000005) \times 10^{-11}\ \Omega$m on a T^4 extrapolation, and nominal residual resistivity $3.4 \times 10^{-11}\ \Omega$m.
123*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.4-20	Sample 51	Similar to the above specimen and conditions except 0.033 Au (0.018 at.%) nominal concentration, specimen 0.15 mm in diam, residual resistivity $\rho_0 = 8.575 \times 10^{-11}\ \Omega$m, nominal residual resistivity $6.5 \times 10^{-11}\ \Omega$m, and the last two values at 4.22 K measured on warming up to 4.22 K after a pump down.
124*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.4-21	Sample 57	Similar to the above specimen and conditions except 0.090 Pd (0.091 at.%) nominal concentration, specimen 0.36 mm in diam, residual resistivity $\rho_0 = (42.255 \pm 0.001) \times 10^{-11}\ \Omega$m, nominal residual resistivity $39.6 \times 10^{-11}\ \Omega$m calculated using value of $0.436 \times 10^{-8}\ \Omega$m/at.%, and the two values at 4.22 K measured before pump down.
125*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.4-21	Sample 58	Similar to the above specimen and conditions except 0.090 Pd (0.091 at.%) nominal concentration, specimen 0.36 mm in diam, residual resistivity $\rho_0 = (41.5365 \pm 0.0005) \times 10^{-11}\ \Omega$m, nominal residual resistivity $39.6 \times 10^{-11}\ \Omega$m, and the two values at 4.22 K measured before pump down.

* Not shown on either figure.

TABLE 12. MEASUREMENT INFORMATION ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

Data Set No.	Ref. No.	Author(s)	Year	Method Used	Temp. Range, K	Name and Specimen Designation	Composition (weight percent), Specifications, and Remarks
126*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.4-20	Sample 46	0.0508 Pt (0.0281 at.%) nominal concentration; specimen 0.40 mm in diam and between 20 cm and 1 m long; geometrical factor determined from specimen length and from its mass by using lattice spacing data to deduce diam; specimen prepared by standard small scale metallurgical techniques: commercially available high purity constituents melted together in quartz ampoule, homogenized, rolled, and drawn; high pressure low temperature annealed: either sealed in capsule containing up to 10 Torr O_2 or in continuous flow of O_2 at about 10^{-1} Torr and about 873 K for 6-10 h; residual resistivity $\rho_0 = (42.3190 \pm 0.0005) \times 10^{-11}\ \Omega m$; nominal residual resistivity $41.3 \times 10^{-11}\ \Omega m$ calculated from nominal concentration and values given by Linde, J.O. (Ann. Phys. Lpz., 15, 219-48, 1932) of $1.59 \times 10^{-8}\ \Omega m$/at.%; resistance measurements made using conventional four terminal potentiometric techniques; sample currents stabilized to a few ppm, potentiometer was of thermal free design, and null detector was galvanometer amplifier of nanovolt sensitivity; temperature reproducibility to within 100 mK between 4.2 and 10 K, possibly to 200 mK at 20 K; temperature uncertainty often dominant error; uncertainty in geometrical factor less than 1%; original data in tabular form and additional information supplied by authors.
127*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.4-20	Sample 47	Similar to the above specimen and conditions except 0.094 Pt (0.0052 at.%) nominal concentration, specimen 0.40 mm in diam, residual resistivity $\rho_0 = 82.1654 \times 10^{-11}\ \Omega m$, and nominal residual resistivity $83.0 \times 10^{-11}\ \Omega m$.
128*	166	Barber, A.J. and Caplin, A.D.	1975	A	1.4-21	Sample 45	Similar to the above specimen and conditions except 0.012 Pt (0.0067 at.%) nominal concentration, specimen 0.40 mm in diam, residual resistivity $\rho_0 = (14.3845 \pm 0.0003) \times 10^{-11}\ \Omega m$, nominal residual resistivity $10.3 \times 10^{-11}\ \Omega m$, and last value at 4.22 K measured on warming up to 4.22 K after a pump down.
129*	166	Barber, A.J. and Caplin, A.D.	1975	A	2.4-20	Sample 91	Similar to the above specimen and conditions except 0.0043 Pt (0.0024 at.%) nominal concentration, specimen 0.28 mm in diam, residual resistivity $\rho_0 = 7.3968 \times 10^{-11}\ \Omega m$, nominal residual resistivity $3.8 \times 10^{-11}\ \Omega m$, and last two values at 4.22 K measured on warming up to 4.22 K after a pump down.
130	169	Ekern, R. and Czanderna, A.W.	1977	A	293-908		99.9995 pure; silver wire analyzed for surface contamination but only expected oxygen impurity detected; wire specimen 2.54×10^{-2} cm in diam; specimen from Materials Research, MARZ grade; resistivity measured using a high-temperature vacuum furnace backfilled with He to 13.3 Pa; silver wires used as potential probes; data extracted from table; reported error of data ±2%; data fitted to $\rho = 3.88 \times 10^{-2} + (5.35 \times 10^{-3})T + (9.10 \times 10^{-7})T^2$ with T in units of K and ρ in units of $10^{-8}\ \Omega m$, calculated resistivity differs from experimental data with a root mean square deviation of $5.27 \times 10^{-11}\ \Omega m$.

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag

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

T	ρ
DATA SET 1	
4.2	0.00556
20.4	0.0105
77	0.284
195	0.994
273	1.47
DATA SET 2	
4.2	0.0110
20.4	0.0161
77	0.294
195	1.04
273	1.49
DATA SET 3	
4.2	0.00129
20.4	0.00510
77	0.279
195	0.992*
273	1.50
DATA SET 4	
4.2	0.000734
20.4	0.00433
77	0.276*
195	0.991*
273	1.50*
DATA SET 5*	
273	1.51
DATA SET 6*	
273	1.52
DATA SET 7	
90.15	0.377
194.7	1.036*
273	1.509*
373	2.121*

T	ρ
DATA SET 8	
90.15	0.341
194.7	1.035
273	1.510*
373	2.123*
491.11	2.863
DATA SET 9	
22.7	0.00555
31.6	0.0216
38.1	0.0433
44.0	0.0726
50.2	0.104
60.9	0.154
71.6	0.244
80.2	0.295
99.2	0.419
111	0.491
122	0.575
135	0.656
153	0.789
177	0.933
196	1.02
259	1.38
287	1.55
307	1.69
DATA SET 10	
10	0.00095
20	0.00404
30	0.01933
40	0.05405
50	0.1041*
60	0.1634
70	0.2265
80	0.2910*
90	0.3558
100	0.4199*
120	0.5460
140	0.6701
160	0.7924
180	0.9136
200	1.0337
220	1.1536
240	1.2732

T	ρ
DATA SET 10 (cont.)	
260	1.3931
273.2	1.4720*
295	1.6029
DATA SET 11	
10	0.00095*
20	0.00403*
30	0.01931*
40	0.05398*
50	0.1039
60	0.1631*
70	0.2261*
80	0.2906
90	0.3553*
100	0.4193*
120	0.5452*
140	0.6692*
160	0.7913*
180	0.9123*
200	1.0323*
220	1.151*
240	1.271*
260	1.391*
273.2	1.468*
295	1.6001*
DATA SET 12	
273.2	1.707
DATA SET 13	
273.2	1.533
DATA SET 14*	
273.2	1.487
DATA SET 15	
16	0.02
30	0.04
46	0.08
64	0.18
75	0.26

T	ρ
DATA SET 15 (cont.)	
89	0.36
103	0.45
120	0.53
135	0.63
149	0.72
164	0.82
179	0.91
199	1.03*
211	1.10
228	1.18
237	1.24
250	1.35
DATA SET 16	
94.7	0.453
94.9	0.472
95.1	0.455*
95.3	0.471*
95.6	0.470*
95.7	0.470
97.1	0.456
103.2	0.505
122.0	0.609
128.3	0.660
134.0	0.693
164.2	0.880
170.7	0.923
174.6	0.942
218.3	1.236
220.4	1.239*
	1.245
260.2	1.468
261.2	1.471*
273.2	1.550
294.2	1.675
294.2	1.676*
294.[illegible]	1.684*
DATA SET 17	
199	.05*
268	.52
470	[illegible].72
569	3.36
667	4.03

T	ρ
DATA SET 18*	
273	1.55
DATA SET 19	
273	1.63
DATA SET 20	
77	0.21
161	0.86
196	0.99*
247	1.23
306	1.68
462	2.68
575	3.44
672	4.11
736	4.47
DATA SET 21	
88	0.284
DATA SET 22	
91	0.520
DATA SET 23	
338.2	1.89
352.2	2.00
385.2	2.21
412.2	2.41
455.2	2.67
503.2	2.97
587.2	3.51
667.2	4.01
753.2	4.62
786.2	4.87
863.2	5.48
917.2	5.91
DATA SET 24	
407	1.95
455	2.19
530	2.67

T	ρ
DATA SET 24 (cont.)	
651	3.28
739	3.94
810	4.34
871	4.75
DATA SET 25	
76.1	0.3897
191.3	1.0213
230.9	1.2408
273	1.468*
273.80	1.4886*
290.40	1.5857*
291.35	1.5727*
291.45	1.5881*
333.2	1.8362
371.30	2.0622
410.4	2.2737
465.3	2.6084
DATA SET 26	
91	0.472
173	0.962
193	1.138
273.7	1.561*
292	1.643*
373	2.139*
DATA SET 27	
100	0.43*
200	0.99
300	1.84
400	2.43
500	3.14
600	3.88
700	4.64
800	5.43
DATA SET 28	
291	1.63
373	2.13

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

T	ρ
DATA SET 29	
293.9	1.664*
296.3	1.677*
308.1	1.751
310.2	1.760*
311.2	1.766*
313.1	1.780
323.2	1.848
331.0	1.890
333.2	1.900
DATA SET 30	
295	1.76
307	1.85
338	2.05
757	4.81
1053	7.00
1096	7.35
1155	7.80
1181	8.00
1202	8.21
1221	11.00
1225	10.00
1225.8	14.00
1228.2	16.50
1229.6	15.00
1232.2	16.60
1235	8.50
1243.2	16.71
1247.8	15.00
1251.8	16.81
1262.6	16.83
1269.8	17.00
1277.5	17.01
1311.4	17.50
1319.6	17.51
1352.2	18.00
1361.2	18.01
1396.2	18.50
1398.8	18.50
1436.6	19.01
1445.2	19.00
1482.5	19.49
1527.8	20.00
1616.6	21.00

T	ρ
DATA SET 31	
4.2	0.003
77.3	0.27
273	1.47*
295	1.60*
DATA SET 32	
4.2	0.02
77.3	0.29*
273	1.48*
295	1.61*
DATA SET 33	
4.2	0.22
77.3	0.51
273	1.69
295	1.83
DATA SET 34	
4.2	0.72
77.3	1.01
273	2.18
295	2.32
DATA SET 35	
4.2	1.28
77.3	1.57
273	2.73
295	2.86
DATA SET 36	
1.5	0.169
293	19.44
DATA SET 37	
298	1.63*
323	1.77*
373	2.03
473	2.61
573	3.25
673	3.86

T	ρ
DATA SET 38	
298	1.63*
323	1.82
373	2.11
473	2.71
573	3.34
673	3.98
DATA SET 39	
14	0.00447
16	0.00519
18	0.00619
20	0.00743
70	0.238*
80	0.297*
90	0.359*
273	1.47*
DATA SET 40	
14	0.00694
16	0.00758
18	0.00852
20	0.00983*
70	0.235*
80	0.299*
90	0.363*
273	1.48*
DATA SET 41	
14	0.233
16	0.234
18	0.236
20	0.237
70	0.473
80	0.534
90	0.595
273	1.69
DATA SET 42	
14	0.523
16	0.521
18	0.523
20	0.526
70	0.772
80	0.830

T	ρ
DATA SET 42 (cont.)	
90	0.881
273	1.98
DATA SET 43	
0.667	0.01835*
0.834	0.01830*
0.949	0.01820*
1.09	0.01813
1.20	0.01801
1.36	0.01795
1.58	0.01784
1.75	0.01777
1.94	0.01769
2.17	0.01761
2.34	0.01757
2.54	0.01746
2.86	0.01748
3.18	0.01735
3.44	0.01726
3.66	0.01729
4.00	0.01715*
4.0	0.01721
DATA SET 44	
0.323	0.02658*
0.400	0.02656*
0.451	0.02658*
0.511	0.02660*
0.542	0.02660*
0.615	0.02657*
0.802	0.02648*
0.910	0.02652*
1.03	0.02647
1.41	0.02653
1.78	0.02653
2.20	0.02653
2.69	0.02649
3.16	0.02647
3.53	0.02642
4.0	0.02655*
4.19	0.02656
DATA SET 45	
3.2	0.00100
290	1.715*

T	ρ
DATA SET 46	
22	0.0397
83	0.345
273	1.50*
DATA SET 47	
83	0.361
273	1.50*
DATA SET 48	
22	0.0271
83	0.332
273	1.49*
DATA SET 49*	
83	0.361
DATA SET 50	
273	1.88
373	2.57
DATA SET 51	
273	1.75
373	2.42
DATA SET 52	
298	1.70
DATA SET 53	
298	1.744
DATA SET 54*	
273	1.491
DATA SET 55	
44	0.00203
300	1.50

T	ρ
DATA SET 56	
4.2	0.0009
273	1.485*
DATA SET 57	
4.2	0.00246
273	1.476*
DATA SET 58	
4.2	0.002
273	1.490*
DATA SET 59	
4.2	0.033
273	1.532*
DATA SET 60	
1873	22.3
DATA SET 61	
268	1.438
268	1.439*
269	1.444
272	1.463*
273.15	1.468
276	1.486
279	1.504
284	1.535
286	1.545*
292	1.580
299	1.622
319	1.743
320	1.751
321	1.753*
346	1.906
358	1.981
374	2.076
445	2.517
455	2.580
521	3.004
598	3.515
601	3.513*
604	3.555
604	3.545*

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

T	ρ
DATA SET 61 (cont.)	
604	3.544*
604	3.539*
604	3.533
698	4.187
798	4.861
798	4.858
900	5.582
DATA SET 62	
268	1.437*
269	1.443*
270	1.449*
272	1.462*
273.15	1.468*
278	1.496*
284	1.533
286	1.547
291	1.576*
299	1.624
321	1.754*
322	1.762
326	1.784
346	1.904*
358	1.979
375	2.082*
448	2.537
448	2.534*
455	2.579*
521	3.000
596	3.492
597	3.501*
597	3.487*
598	3.499*
601	3.510*
601	3.508*
602	3.511
699	4.185
796	4.839
800	4.850
900	5.555
DATA SET 63	
10	0.00637
15	0.00727
20	0.00997
25	0.0162

T	ρ
DATA SET 63 (cont.)	
30	0.0262
40	0.0642
50	0.116
60	0.176
70	0.236
80	0.296
90	0.361
100	0.426
120	0.551
140	0.681
160	0.801
180	0.926*
200	1.05
220	1.17
250	1.35*
273	1.48*
295	1.62
DATA SET 64	
374	2.08
454	2.57
574	3.33
647	3.80
713	4.26
786	4.76
836	5.12
883	5.46
923	5.76
954	5.99
1040	6.67
1070	6.92
1092	7.10
1108	7.24
1124	7.38
1139	7.51
1158	7.67
1178	7.85
1198	8.02
DATA SET 65	
275	1.53*
293	1.64*
300	1.68
330	1.89
382	2.19
425	2.48

T	ρ
DATA SET 65 (cont.)	
474	2.81
501	2.96*
531	3.20
582	3.47
623	3.76
659	4.02
690	4.21
732	4.49
782	4.81
821	5.11
853	5.34
889	5.63
931	5.91
976	6.26
999	6.39
1031	6.70
1096	7.14
DATA SET 66	
84	0.317
88	0.341
98	0.406
103	0.438
117	0.526
129	0.600
167	0.832*
167	0.833
219	1.144*
263	1.407
273.15	1.469*
316	1.724
348	1.917*
358	1.978*

T	ρ_i
DATA SET 67	
5.08	0.00000308*
5.46	0.00000542*
5.68	0.00000553*
6.22	0.00000986*
6.53	0.0000126*
6.84	0.0000171*
7.38	0.0000219*
7.38	0.0000245*
7.89	0.0000305*

T	ρ_i
DATA SET 67 (cont.)	
8.41	0.0000363*
8.61	0.0000440*
9.04	0.0000556*
9.48	0.0000692*
10.3	0.000105
10.5	0.000110
11.1	0.000154
11.4	0.000161
11.7	0.000200
12.2	0.000246
12.6	0.000286
13.1	0.000337
14.1	0.000508
14.2	0.000537
15.1	0.000716
15.8	0.000891
16.2	0.00101
17.2	0.00138
18.3	0.00173
18.3	0.00189
19.0	0.00213
19.4	0.00243
19.9	0.00273
20.2	0.00303

T	ρ
DATA SET 68	
1.279	0.0005313
1.653	0.0005313*
1.750	0.0005317*
1.979	0.0005327
2.159	0.0005321*
2.460	0.0005327*
2.566	0.0005329*
2.726	0.0005332
2.953	0.0005332*
3.269	0.0005342
3.545	0.0005349*
3.867	0.0005360
4.106	0.0005371
4.519	0.0005394*
4.801	0.0005418
5.007	0.0005425*
5.283	0.0005458
5.642	0.0005494*
5.985	0.0005532

T	ρ
DATA SET 68 (cont.)	
6.100	0.0005565*
6.346	0.0005597*
6.583	0.0005641
6.801	0.0005668*
6.927	0.0005687
DATA SET 69	
1.158	0.0004525
1.158	0.0004532*
1.158	0.0004532*
1.273	0.0004531*
1.284	0.0004530*
1.627	0.0004533*
1.914	0.0004532*
2.098	0.0004535*
2.249	0.0004537*
2.428	0.0004538*
2.703	0.0004540
2.971	0.0004544*
3.115	0.0004548*
3.426	0.0004555
3.697	0.0004564*
3.917	0.0004573
4.178	0.0004585*
4.423	0.0004597
4.629	0.0004611*
4.874	0.0004621
5.138	0.0004652*
5.376	0.0004672
5.633	0.0004700*
5.876	0.0004729
6.142	0.0004763*
6.349	0.0004793
6.609	0.0004832*
6.796	0.0004863
7.015	0.0004905*
7.018	0.0004904
7.272	0.0004955*
7.506	0.0005008
7.797	0.0005075*
8.061	0.0005144
8.307	0.0005215*
8.468	0.0005262
DATA SET 70	
1.1792	0.001346

T	ρ
DATA SET 70 (cont.)	
1.3579	0.001346*
1.7905	0.001348*
2.2176	0.001348*
2.8254	0.001349*
3.0683	0.001349*
3.4343	0.001351
3.6965	0.001353*
3.9605	0.001355*
4.3382	0.001358*
4.6171	0.001361
4.9010	0.001365*
5.2833	0.001370
5.6878	0.001378*
6.0375	0.001385
6.2532	0.001391*
6.5516	0.001400
6.9467	0.001412*
7.3480	0.001426
7.6139	0.001436*
7.8901	0.001447
8.4437	0.001473*
8.5304	0.001478
DATA SET 71	
1.390	0.0008494
1.601	0.0008494*
1.952	0.0008495*
2.198	0.0008496*
2.555	0.0008498*
3.060	0.0008502
3.426	0.0008507*
3.774	0.0008513
4.154	0.0008523
DATA SET 72	
1.390	0.0007517
1.601	0.0007518*
1.952	0.0007519*
2.198	0.0007519*
2.555	0.0007522
3.060	0.0007527*
3.426	0.0007533
3.774	0.0007541
4.154	0.0007554

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

DATA SET 73

T	ρ
1.390	0.0006987
1.601	0.0006987*
1.952	0.0006988*
2.198	0.0006989*
2.555	0.0006991
3.060	0.0006997*
3.426	0.0007003
3.774	0.0007013
4.154	0.0007023

DATA SET 74

T	ρ
1.390	0.002265
1.601	0.002265*
1.952	0.002265*
2.198	0.002265*
2.555	0.002265*
3.060	0.002266*
3.426	0.002266*
3.774	0.002267*
4.154	0.002268

DATA SET 75

T	ρ
1.95	0.004714
2.17	0.004714*
2.45	0.004715*
2.55	0.004715*
2.72	0.004715*
3.03	0.004716*
3.11	0.004716*
3.35	0.004716*
3.43	0.004717*
3.78	0.004718*
4.06	0.004719*
4.39	0.004721
4.49	0.004721*
5.51	0.004732
6.03	0.004740*
6.30	0.004746*
6.76	0.004755
6.81	0.004755*
7.10	0.004769
7.80	0.004790*
8.81	0.004833*
8.81	0.004853*
9.01	0.004850
10.7	0.005010

DATA SET 75 (cont.)

T	ρ
11.9	0.005180
12.9	0.005406
13.9	0.005678
15.6	0.006200*
15.94	0.006268
17.2	0.007080
19.1	0.008279
21.2	0.0102
22.8	0.0130*
23.66	0.01276*
29.2	0.0244
33.9	0.0395
38.0	0.0582
43.2	0.0785
47.8	0.106
52.2	0.127
59.2	0.165*
62.1	0.186
66.5	0.217
74.3	0.271
80.5	0.308
84.7	0.341*
89.9	0.366*
95.9	0.403*
104	0.472
115	0.552
127	0.607*
138	0.709
153	0.767
163	0.829*
171	0.888
181	0.951
191	1.00
202	1.06*
208	1.12*
220	1.13
226	1.17*
239	1.19
253	1.29
265	1.47
275	1.50*
287	1.56*

DATA SET 76

T	ρ
1.95	0.0009157
2.17	0.0009158*
2.44	0.0009159*

DATA SET 76 (cont.)

T	ρ
2.52	0.0009160
2.67	0.0009161*
2.99	0.0009164*
3.16	0.0009166*
3.35	0.0009169*
3.44	0.0009170
3.79	0.0009175*
3.92	0.0009182
4.06	0.0009186*
4.42	0.0009196
4.49	0.0009196*
5.60	0.0009264
6.05	0.0009311*
6.46	0.0009365*
6.73	0.0009420
6.81	0.0009420*
7.21	0.0009507*
7.93	0.0009717
8.95	0.0009979
8.95	0.00101*
9.01	0.001001*
10.8	0.00110
12.0	0.00121
12.8	0.00133
14.2	0.00158
15.7	0.00198
15.94	0.001995*
17.4	0.00267
19.1	0.00377
21.3	0.00544
22.9	0.00752
23.66	0.007620*
29.4	0.0180
34.3	0.0314
38.5	0.0486
43.9	0.0670

DATA SET 77

T	ρ
4.49	0.005229
6.81	0.005271
9.01	0.005378
15.94	0.006880
23.66	0.01358
273.16	1.475*

DATA SET 78

T	ρ
4.49	0.0007659
6.81	0.0007909
9.01	0.0008459
15.94	0.001803
23.66	0.007427
273.16	1.466*

DATA SET 79

T	ρ
4.49	0.01004
6.81	0.01009
9.01	0.01002
15.94	0.01193
23.66	0.01909
273.16	1.478*

DATA SET 80

T	ρ
4.49	0.0007095
6.81	0.0007320
9.01	0.0007867
15.94	0.001742
23.66	0.007359*
273.16	1.468*

DATA SET 81*

T	ρ
4.49	0.01028
6.81	0.01034
9.01	0.01224
15.94	0.01214
23.66	0.01925
273.16	1.483

DATA SET 82

T	ρ
4.49	0.002278
6.81	0.002310
9.01	0.002381
15.94	0.003514

DATA SET 82 (cont.)

T	ρ
23.66	0.009392
273.16	1.468*

DATA SET 83

T	ρ
1181	7.94
1202	8.24
1223	8.44
1231	8.52
1243	17.36
1263	17.61
1283	17.68
1303	17.87
1323	18.11
1343	18.20
1363	18.33
1384	18.46
1404	18.61
1423	18.86
1443	19.13
1464	19.33

DATA SET 84

T	ρ
2.25	0.000800
2.85	0.000802
3.30	0.000802*
3.77	0.000805
4.12	0.000815
6.35	0.000828
7.79	0.000857
9.20	0.000918
10.96	0.001026

DATA SET 85

T	ρ
2.12	0.000671
2.40	0.000671
2.82	0.000673
3.49	0.000678
4.13	0.000682
5.79	0.000691
6.09	0.000689
11.35	0.000956
14.92	0.001604
16.56	0.002202

DATA SET 86

T	ρ
2.23	0.001077
2.74	0.001084
3.22	0.001084
3.79	0.001084
4.14	0.001094
5.53	0.001084
6.85	0.001094
8.96	0.001178
10.76	0.001296

DATA SET 87

T	ρ
1408	18.7

DATA SET 88

T	ρ
84.2	0.417
98.4	0.495
122.0	0.639
148.4	0.766
173.0	0.913
197.5	1.073
223.2	1.220
248.0	1.350*
273.4	1.507*
284.2	1.569
285.2	1.576*
298.2	1.654
323.0	1.798*
347.8	1.945
374.2	2.104*
398.2	2.247
423.6	2.395
448.0	2.538*
473.2	2.687
498.4	2.833
524.1	2.976
547.6	3.114
573.4	3.259*
599.0	3.402
624.6	3.531
648.7	3.668
673.8	3.800

DATA SET 89

T	ρ
1253	17.8
1283	17.9

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

T	ρ
DATA SET 89 (cont.)	
1301	18.3
1381	19.2
1425	20.6
1493	21.4
1530	21.7
DATA SET 90	
1277	17.11
1319	17.59
DATA SET 91	
1273	18.0
DATA SET 92	
1233	17.2
1257	17.5
DATA SET 93	
1300	21.5
DATA SET 94	
1253	17.62
1262	17.71
1271	17.78
1281	17.85*
1290	17.92
1299	18.00
1309	18.08
1319	18.17
1331	18.25
DATA SET 95	
1273	19.22
1323	19.86
1373	20.48
1423	21.19
1473	21.67
1523	22.24
1573	22.79
1623	23.30
1673	23.80
DATA SET 96*	
78	0.27
DATA SET 97	
4.16	0.00637
17.4	0.0102
20.5	0.0147
21.8	0.0175
23.0	0.0193
25.6	0.0305
27.8	0.0352
29.2	0.0430
30.1	0.0541
32.4	0.0638
37.6	0.0843
41.0	0.107
45.0	0.125
49.2	0.148
61.1	0.193
69.7	0.251
74.6	0.272*
109	0.445
113	0.472
120	0.533*
130	0.577
138	0.621
147	0.676
163	0.776
175	0.842
188	0.914
205	1.02
225	1.11
282	1.61
DATA SET 98	
4.20	0.136
16.7	0.139
17.7	0.141
19.1	0.146
20.8	0.152
22.2	0.157
24.4	0.163
26.4	0.173
28.1	0.177
29.9	0.183
33.0	0.197
37.8	0.222
DATA SET 98 (cont.)	
42.3	0.248
50.2	0.279
55.6	0.307
59.2	0.324
62.2	0.348
75.5	0.431
109	0.608
117	0.655
127	0.714
141	0.784
156	0.887
180	1.00
208	1.15
285	1.76
DATA SET 99	
4.22	0.00927
16.9	0.0125
18.4	0.0150
19.2	0.0164
20.0	0.0184
21.3	0.0213
22.8	0.0257
25.0	0.0330
27.1	0.0416
28.0	0.0444
30.3	0.0535*
33.6	0.0714
37.8	0.0955
51.2	0.154
56.5	0.179
58.0	0.190
60.5	0.200
62.1	0.208
76.0	0.284*
111	0.467
123	0.561
145	0.665
182	0.883
209	1.05
282	1.61*
DATA SET 100*	
4.17	0.0246
17.7	0.0307
19.9	0.0353
DATA SET 100 (cont.)*	
21.9	0.0405
24.8	0.0475
27.0	0.0550
27.9	0.0589
29.2	0.0650
32.2	0.0804
36.1	0.100
40.7	0.126
150	0.724
282	1.61
DATA SET 101	
291	1.63*
545	3.25
703	4.33
966	6.44
1153	8.21
1226	9.19
1244	10.0
1244	12.3
1244	14.2
1244	16.2
1251	16.6
1303	17.2
1541	20.0
DATA SET 102	
834	4.88
1068	7.41
1147	8.28
1211	9.22
1216	9.41
1216	10.9
1216	12.5
1216	14.0
1216	15.6
1269	16.7
1356	17.8
1508	19.7
DATA SET 103	
1.281	0.002518
1.531	0.002517*
1.755	0.002516*
1.950	0.002518*
DATA SET 103 (cont.)	
2.117	0.002518*
2.290	0.002517*
2.504	0.002518*
2.724	0.002517*
2.871	0.002519*
3.012	0.002517*
3.185	0.002524
3.289	0.002523*
3.465	0.002521*
3.652	0.002522*
3.891	0.002524*
4.063	0.002522*
4.182	0.002522*
4.283	0.002528*
4.369	0.002521*
4.450	0.002521*
4.471	0.002527*
4.553	0.002525*
4.645	0.002525*
4.761	0.002527*
4.861	0.002525*
4.968	0.002527*
5.100	0.002527*
5.230	0.002530
5.349	0.002532*
5.473	0.002533*
5.601	0.002539*
5.743	0.002539*
5.997	0.002542
6.388	0.002546*
6.821	0.002553*
7.365	0.002569
8.112	0.002589
9.389	0.002640
10.175	0.002687
10.929	0.002749*
11.785	0.002828*
12.222	0.002897
13.197	0.003028*
14.235	0.003236
14.886	0.003403*
15.697	0.003645*
16.526	0.003952
17.505	0.004377*
18.605	0.004962
19.970	0.005868*
21.643	0.007314
22.807	0.008547*
DATA SET 103 (cont.)	
23.744	0.009701*
25.222	0.011809
26.387	0.013738*
28.363	0.017606*
29.989	0.021340*
31.758	0.026027
33.813	0.032219*
35.031	0.036286*
37.581	0.045682
39.822	0.054832*
44.288	0.075373
48.683	0.098040*
54.105	0.128455
60.877	0.169032
69.740	0.224469*
75.308	0.259733*
88.475	0.344395*
94.201	0.380799
97.838	0.403919*
103.593	0.440216*
109.623	0.477938*
113.006	0.498930*
115.591	0.514986
118.745	0.534607*
121.257	0.550144*
124.823	0.571982*
130.376	0.605841*
136.333	0.642227*
147.733	0.711583*
154.509	0.752524*
160.520	0.788755*
166.809	0.826733*
172.854	0.863029
178.979	0.899523*
185.019	0.935414*
191.138	0.991955
197.391	1.009259*
203.572	1.045985*
209.769	1.082783*
215.936	1.119264
222.148	1.156157*
228.727	1.195053*
234.783	1.230712*
240.969	1.267241*
247.348	1.305052
253.598	1.342136*
260.168	1.381145*
266.329	1.417585

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

T	ρ	T	ρ	T	ρ	T	ρ	T	ρ	T	ρ
DATA SET 103 (cont.)		DATA SET 105 (cont.)*		DATA SET 106 (cont.)*		DATA SET 107 (cont.)*		DATA SET 109 (cont.)*		DATA SET 111 (cont.)*	
272.793	1.456165*	2.77	0.0022817	5.20	0.0021648	19.30	0.0059090	4.22	0.0022347	4.22	0.0026658
273.15	1.458*	2.77	0.0022820	6.40	0.0021782	19.30	0.0058980	4.49	0.0022385	4.22	0.0026651
279.034	1.493147*	2.96	0.0022808	6.60	0.0021856	20.35	0.0067140	4.65	0.0022385	4.22	0.0026658
285.433	1.531083*	2.96	0.0022807	6.95	0.0021954	20.35	0.0067100	4.81	0.0022443	4.93	0.0026809
291.910	1.569884*	3.17	0.0022820	7.30	0.0022082			5.80	0.0022544	5.25	0.0026836
		3.17	0.0022823	8.60	0.0022576	DATA SET 108*		6.35	0.0022639	5.50	0.0026904
DATA SET 104*		3.38	0.0022820	9.20	0.0022999			6.80	0.0022746	6.40	0.0027073
		3.38	0.0022827	10.05	0.0023689	1.44	0.0022303	7.35	0.0022931	6.70	0.0027124
1.44	0.0022735	3.60	0.0022839	11.70	0.0025687	1.44	0.0022297	8.55	0.0023467	7.05	0.0027242
1.44	0.0022740	3.60	0.0022840	13.30	0.0028639	4.22	0.0022330	9.15	0.0023800	7.35	0.0027371
2.98	0.0022757	3.76	0.0022815	13.30	0.0028630	4.22	0.0022338	9.85	0.0024348	8.70	0.0027882
2.98	0.0022762	3.76	0.0022813	14.30	0.0031545	4.22	0.0022372	10.15	0.0024769	9.30	0.0028265
4.22	0.0022809	3.99	0.0022842	14.30	0.0031562	4.22	0.0022382	11.10	0.0025730	10.20	0.0028939
4.22	0.0022807	3.99	0.0022832	15.30	0.0035446	4.50	0.0022367				
4.65	0.0022831	4.22	0.0022842	15.40	0.0035428	4.82	0.0022424	DATA SET 110*		DATA SET 112*	
5.12	0.0022885	4.22	0.0022847	16.30	0.0039068	5.55	0.0022504				
5.61	0.0022942	4.22	0.0022860	16.30	0.0039051	6.50	0.0022678	1.00	0.0027100	1.33	0.00146208
6.00	0.0023018	4.22	0.0022859	17.10	0.0043839	6.90	0.0022790	4.22	0.0027110	1.33	0.00146212
6.50	0.0022999	4.59	0.0022865	17.10	0.0043797	7.45	0.0022982	4.22	0.0027112	1.60	0.00146189
7.28	0.0023337	4.96	0.0022882	19.30	0.0059162	7.95	0.0023214	4.75	0.0027142	1.60	0.00146200
7.71	0.0023486	5.38	0.0022942	19.30	0.0059018	8.60	0.0023472	5.30	0.0027192	1.92	0.00146231
8.27	0.0023772	5.77	0.0023010	20.35	0.0067088	9.35	0.0023927	5.70	0.0027284	1.92	0.00146223
8.71	0.0024001	6.37	0.0023116	20.35	0.0067021	10.60	0.0025082	6.70	0.0027467	2.39	0.00146229
8.98	0.0024159	6.96	0.0023290			11.50	0.0026070	7.25	0.0027652	2.39	0.00146239
9.62	0.0024617	7.60	0.0023533	DATA SET 107*		12.30	0.0027411	8.90	0.0028329	2.69	0.00146304
10.28	0.0025171	8.23	0.0023775			13.50	0.0029773	10.10	0.0029167	2.98	0.00146321
11.20	0.0026229	8.65	0.0024009	1.00	0.0021613	13.50	0.0029815	10.10	0.0029185	2.98	0.00146310
12.33	0.0027863	9.30	0.0024452	4.22	0.0021694	14.30	0.0032359	11.60	0.0030722	3.26	0.00146399
13.32	0.0029999	9.75	0.0024786	4.22	0.0021691	14.30	0.0032476	11.60	0.0030675	3.26	0.00146401
13.94	0.0031608	10.15	0.0025271	4.70	0.0021723	15.10	0.0035397	13.00	0.0033034	3.57	0.00146476
15.15	0.0035558	11.35	0.0026514	5.20	0.0021802	15.10	0.0035276	13.00	0.0032923	3.57	0.00146490
16.25	0.0040199	12.25	0.0028222	5.70	0.0021847	16.40	0.0040920	14.30	0.0036039	3.90	0.00146619
17.03	0.0043992	13.15	0.0030076	6.60	0.0022027	16.40	0.0040775	14.30	0.0035849	3.90	0.00146609
18.35	0.0052000	14.10	0.0032597	7.20	0.0022192	17.50	0.0046544	15.10	0.0038310	4.22	0.00146747
19.35	0.0059365	15.23	0.0036279	8.80	0.0022904	17.50	0.0046516	15.10	0.0037928	4.22	0.00146750
20.55	0.0068842	16.40	0.0041462	9.95	0.0023848	18.40	0.0052922	16.30	0.0042039	4.22	0.00146757
		17.45	0.0047645	9.95	0.0023866	18.40	0.0052491	16.30	0.0041827	4.22	0.00146778
DATA SET 105*		18.40	0.0053191	11.80	0.0026056	19.55	0.0061070	17.20	0.0046320	4.39	0.00146881
		19.60	0.0062738	11.80	0.0025856	19.55	0.0060540	17.20	0.0045932	5.63	0.00148084
1.50	0.0022795			13.20	0.0028847	20.75	0.0071600	19.20	0.0057967	6.50	0.00149422
1.50	0.0022803	DATA SET 106*		13.20	0.0028716	20.75	0.0071350	19.20	0.0057071	6.97	0.00150572
1.72	0.0022816			14.40	0.0032208			20.35	0.0065243	7.35	0.00151860
1.72	0.0022806	1.00	0.0021410	14.40	0.0032236	DATA SET 109*		20.35	0.0064742	7.85	0.00153440
2.00	0.0022798	4.22	0.0021519	15.40	0.0035772					8.40	0.00155199
2.00	0.0022804	4.22	0.0021511	15.40	0.0035253	1.00	0.0022300	DATA SET 111*		8.85	0.00157290
2.36	0.0022811	4.22	0.0021507	16.40	0.0039728	1.44	0.0022300			9.30	0.00160295
2.36	0.0022811	4.22	0.0021509	16.40	0.0039710	2.23	0.0022300	1.55	0.0026586	10.05	0.00164834
2.58	0.0022806	4.91	0.0021568	17.30	0.0045000	4.22	0.0022349	1.55	0.0026590	10.95	0.00172582
2.58	0.0022808	5.20	0.0021616	17.30	0.0044790	4.22	0.0022341	4.22	0.0026654	11.75	0.00180623

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

DATA SET 112 (cont.)*

T	ρ
13.25	0.00203038
14.80	0.00237522
15.80	0.00267784
20.20	0.00489820
20.85	0.00543660

DATA SET 113*

T	ρ
1.50	0.00461628
1.50	0.00461627
1.72	0.00461650
1.72	0.00461646
2.00	0.00461678
2.00	0.00461658
2.36	0.00461694
2.36	0.00461682
2.58	0.00461716
2.58	0.00461714
2.77	0.00461771
2.77	0.00461767
2.96	0.00461797
2.96	0.00461789
3.17	0.00461835
3.17	0.00461833
3.38	0.00461904
3.38	0.00461892
3.60	0.00461971
3.60	0.00461969
3.76	0.00462011
3.76	0.00462017
3.99	0.00462059
3.99	0.00462063
4.22	0.00462259
4.22	0.00462255
4.22	0.00462270
4.22	0.00462274
4.52	0.00462478
4.92	0.00462869
5.35	0.00463349
5.78	0.00464134
6.38	0.00465218
7.05	0.00467163
7.65	0.00469595
8.25	0.00472201
8.75	0.00474679
9.30	0.00478352
9.80	0.00482194
10.15	0.00485893
11.18	0.00496789

DATA SET 113 (cont.)*

T	ρ
12.25	0.00512836
13.20	0.00530233
14.10	0.00551190
15.23	0.00585090
16.30	0.00625557
17.45	0.00680571
18.40	0.00725381

DATA SET 114*

T	ρ
1.50	0.00171300
1.50	0.00171307
1.68	0.00171340
1.68	0.00171335
2.01	0.00171321
2.01	0.00171323
2.36	0.00171378
2.36	0.00171368
2.58	0.00171381
2.77	0.00171417
2.77	0.00171412
2.96	0.00171433
2.96	0.00171436
3.17	0.00171482
3.17	0.00171484
3.38	0.00171525
3.60	0.00171573
3.60	0.001715596
3.76	0.00171580
3.76	0.00171596
3.99	0.00171678
3.99	0.00171693
4.22	0.00171789
4.22	0.00171803
4.22	0.00171811
4.22	0.00171813
4.68	0.00172104
5.04	0.00172388
5.48	0.00172827
5.80	0.00173340
6.35	0.00173999
6.91	0.00175203
7.55	0.00177195
8.05	0.00179045
8.57	0.00180635
9.43	0.00184879
9.67	0.00186105
10.15	0.00190009
11.40	0.00200660

DATA SET 114 (cont.)*

T	ρ
12.20	0.00211519
13.15	0.00224611
14.25	0.00244536
15.23	0.00269225
16.45	0.00312724
17.50	0.00357046
18.45	0.00402074
19.60	0.00473084

DATA SET 115*

T	ρ
1.65	0.0015470
1.65	0.0015464
1.90	0.0015469
1.90	0.0015459
2.34	0.0015485
2.34	0.0015473
2.69	0.0015479
2.69	0.0015475
2.96	0.0015497
2.96	0.0015487
3.20	0.0015497
3.20	0.0015490
3.58	0.0015489
3.58	0.0015488
3.92	0.0015522
3.92	0.0015515
1.55	0.0015543
4.22	0.0015536
4.22	0.0015542
4.22	0.0015551
4.23	0.0015535
5.05	0.0015604
6.00	0.0015677
6.80	0.0015931
8.10	0.0016384
9.25	0.0016939
10.08	0.0017595
11.20	0.0018683
12.40	0.0020262
13.63	0.0022359
14.43	0.0024280
15.75	0.0027956
16.44	0.0030391
17.40	0.0034658
18.36	0.0039675
19.35	0.0046075
20.38	0.0053143

DATA SET 116*

T	ρ
1.65	0.001537
1.65	0.001537
1.90	0.001537
1.90	0.001537
2.34	0.001540
2.34	0.001539
2.70	0.001538
2.70	0.001537
2.96	0.001539
2.96	0.001538
3.21	0.001538
3.21	0.001537
3.58	0.001540
3.58	0.001541
3.92	0.001541
3.92	0.001540
4.20	0.001543
4.21	0.001542
4.22	0.001544
4.22	0.001544
4.22	0.001542
4.22	0.001542
4.22	0.001542
5.08	0.001550
6.00	0.001553
6.78	0.001579
8.13	0.001620
9.30	0.001678
10.10	0.001735
11.20	0.001839
12.35	0.001980
13.63	0.002193
14.43	0.002366
15.74	0.002726
16.50	0.002994
17.40	0.003384
18.36	0.003878
19.35	0.004506
20.46	0.005236

DATA SET 117*

T	ρ
1.65	0.001536
1.65	0.001535
1.94	0.001538
1.94	0.001537
2.34	0.001536
2.34	0.001535
2.70	0.001538

DATA SET 117 (cont.)*

T	ρ
2.70	0.001538
2.96	0.001538
2.96	0.001536
3.21	0.001538
3.21	0.001538
3.58	0.001537
3.58	0.001536
3.92	0.001544
3.92	0.001542
4.22	0.001541
4.22	0.001541
4.22	0.001544
4.22	0.001544
4.21	0.001542
4.22	0.001542
4.22	0.001542
5.08	0.001551
6.01	0.001555
6.80	0.001580
8.10	0.001626
9.25	0.001682
10.01	0.001739
11.22	0.001849
12.36	0.001996
13.63	0.002212
14.41	0.002393
15.71	0.002754
16.47	0.003039
17.40	0.003431
18.40	0.003946
19.35	0.004572
20.46	0.005355

DATA SET 118*

T	ρ
1.68	0.0012188
1.68	0.0012199
1.82	0.0012170
1.82	0.0012175
2.18	0.0012194
2.18	0.0012207
2.60	0.0012203
2.60	0.0012201
2.82	0.0012173
2.82	0.0012184
3.26	0.0012214
3.26	0.0012218
3.51	0.0012203
3.51	0.0012198

DATA SET 118 (cont.)*

T	ρ
3.90	0.0012230
3.90	0.0012237
4.22	0.0012220
4.22	0.0012222
4.22	0.0012239
4.22	0.0012239
4.32	0.0012248
5.16	0.0012305
5.68	0.0012362
5.68	0.0012362
6.03	0.0012402
6.40	0.0012475
6.98	0.0012573
7.53	0.0012707
8.00	0.0012830
8.90	0.0013176
9.60	0.0013523
10.30	0.0013962
10.43	0.0014056
11.37	0.0014881
11.90	0.0015462
12.68	0.0016429
13.30	0.0017368
13.80	0.0018300
13.82	0.0018396
14.13	0.0018961
14.90	0.0020631
15.65	0.0022645
16.20	0.0024541
17.02	0.0027652
18.00	0.0032073
19.00	0.0037446
19.65	0.0041892
20.25	0.0046473

DATA SET 119*

T	ρ
1.55	0.0011060
1.99	0.0011063
2.48	0.0011068
2.77	0.0011069
3.08	0.0011079
3.36	0.0011081
3.71	0.0011093
4.00	0.0011108
4.21	0.0011119
4.21	0.0011117
5.23	0.0011207
6.07	0.0011308

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

DATA SET 119 (cont.)*

T	ρ
8.20	0.0011881
10.30	0.0012921
11.23	0.0013775
12.35	0.0015014
12.93	0.0015839
14.28	0.0018268
15.78	0.0022174
17.28	0.0027670
18.74	0.0035214
20.12	0.0044357

DATA SET 120*

T	ρ
1.50	0.0156415
4.22	0.0156548
4.22	0.0156551
4.80	0.0156645
5.40	0.0156769
5.80	0.0156905
6.70	0.0157283
7.30	0.0157623
9.00	0.0159060
10.10	0.0160438
10.10	0.0160489
11.50	0.0162954
11.50	0.0162875
12.80	0.0166253
12.80	0.0166102
14.20	0.0170900
15.00	0.0173930
15.00	0.0173620
16.00	0.0178950
16.00	0.0178550
16.90	0.0184320
16.90	0.0183560
18.90	0.0198030
18.90	0.0196770
20.15	0.0207980
20.15	0.0207280

DATA SET 121*

T	ρ
1.00	0.0313791
4.22	0.0313947
4.22	0.0313951
4.42	0.0313987
4.84	0.0314072
5.40	0.0314243
5.80	0.0314899

DATA SET 121 (cont.)*

T	ρ
6.80	0.0314894
7.40	0.0315340
9.20	0.0317280
10.15	0.0318886
10.15	0.0318964
11.40	0.0321669
11.40	0.0321607
12.80	0.0325681
12.80	0.0325656
14.10	0.0331426
14.10	0.0331044
14.80	0.0334750
15.90	0.0340734
15.90	0.0340491
16.80	0.0346534
16.80	0.0346175
18.70	0.0362230
18.70	0.0361910
19.95	0.0374540
19.95	0.0374230

DATA SET 122*

T	ρ
1.67	0.006069192
1.67	0.006069197
1.92	0.006069331
1.92	0.006069346
2.11	0.006069474
2.11	0.006069479
2.36	0.006069694
2.36	0.006069740
2.58	0.006070040
2.58	0.006070040
2.77	0.006070325
2.96	0.006070803
2.96	0.006070798
3.18	0.006071320
3.18	0.006071310
3.38	0.006072064
3.38	0.006072054
3.58	0.006072797
3.58	0.006072807
3.77	0.006073672
3.98	0.006074944
3.98	0.006074939
4.22	0.006076454
4.22	0.006076439
4.22	0.006076437
4.22	0.006076417

DATA SET 122 (cont.)*

T	ρ
4.27	0.006076520
5.08	0.006085778
6.07	0.006103807
6.53	0.006117218
7.10	0.006134527
7.80	0.006162426
7.95	0.006170174
8.78	0.006224667
9.50	0.006273647
10.20	0.006349989
10.63	0.006394437
10.80	0.006420672
12.10	0.006616240
12.95	0.006792100
13.59	0.006922990
14.63	0.007219880
15.11	0.007401560
15.71	0.007594090
16.14	0.007834640
16.38	0.007931660
16.89	0.008187870
17.86	0.008749310
18.83	0.009384540
19.38	0.009771990
20.07	0.010350800

DATA SET 123*

T	ρ
1.44	0.008575696
1.65	0.008575828
1.84	0.008575962
2.35	0.008576555
2.63	0.008577116
2.96	0.008577996
3.12	0.008578552
3.38	0.008579664
3.75	0.008581767
3.99	0.008583585
4.22	0.008585340
4.22	0.008585353
4.22	0.008585364
4.22	0.008585359
4.28	0.008586487
4.45	0.008588240
4.61	0.008590290
4.79	0.008593340
4.95	0.008596970
5.20	0.008600850
5.50	0.008607200

DATA SET 123 (cont.)*

T	ρ
6.00	0.008624110
6.95	0.008655580
7.85	0.008709310
8.50	0.008748030
9.10	0.008798900
9.70	0.008860970
10.20	0.008931170
11.10	0.009050470
12.10	0.009220500
13.10	0.009458390
14.20	0.009761360
15.30	0.010137770
16.30	0.010584400
17.20	0.011105400
18.60	0.011835900
19.45	0.012510100
20.45	0.013266400

DATA SET 124*

T	ρ
1.44	0.0422540
1.68	0.0422547
1.68	0.0422550
2.51	0.0422563
2.51	0.0422562
2.68	0.0422561
2.68	0.0422564
2.86	0.0422568
2.86	0.0422567
3.11	0.0422579
3.11	0.0422577
3.26	0.0422582
3.26	0.0422586
3.58	0.0422600
3.58	0.0422599
3.88	0.0422618
4.22	0.0422637
4.22	0.0422635
4.32	0.0422658
4.64	0.0422707
4.80	0.0422734
5.23	0.0422820
5.45	0.0422880
5.85	0.0422995
6.15	0.0423076
6.15	0.0423076
6.50	0.0423239
6.90	0.0423399
7.30	0.0423649

DATA SET 124 (cont.)*

T	ρ
7.53	0.0423854
8.50	0.0424470
9.05	0.0425090
10.25	0.0426970
11.10	0.0428480
12.05	0.0430920
13.25	0.0434140
14.20	0.0438280
15.37	0.0443870
16.30	0.0449920
17.45	0.0458340
18.50	0.0467220
19.65	0.0477720
20.75	0.0490430

DATA SET 125*

T	ρ
1.44	0.0415363
1.67	0.0415371
2.51	0.0415370
2.68	0.0415373
2.86	0.0415372
3.11	0.0415381
3.26	0.0415391
3.58	0.0415405
3.88	0.0415424
4.22	0.0415447
4.22	0.0415449
4.40	0.0415457
4.66	0.0415514
4.86	0.0415546
5.25	0.0415636
5.48	0.0415677
5.90	0.0415810
6.20	0.0415880
6.58	0.0416051
6.95	0.0416208
7.35	0.0416465
7.65	0.0416674
8.54	0.0417309
9.16	0.0417910
10.20	0.0419630
11.10	0.0421200
12.10	0.0423360
13.25	0.0426640
14.25	0.0430810
15.37	0.0436170
16.30	0.0442130
17.45	0.0450250

DATA SET 125 (cont.)*

T	ρ
18.50	0.0459040
19.65	0.0469320
20.75	0.0481460

DATA SET 126*

T	ρ
1.44	0.0423191
1.44	0.0423186
1.76	0.0423194
1.76	0.0423186
2.32	0.0423210
2.32	0.0423208
2.62	0.0423216
2.62	0.0423214
2.96	0.0423227
2.96	0.0423223
2.96	0.0423243
2.96	0.0423233
3.30	0.0423252
3.30	0.0423257
3.57	0.0423278
3.57	0.0423280
3.57	0.0423266
3.87	0.0423307
3.87	0.0423308
4.22	0.0423356
4.22	0.0423358
4.22	0.0423344
4.22	0.0423340
4.58	0.0423431
4.73	0.0423468
5.13	0.0423603
5.60	0.0423783
5.90	0.0423940
6.55	0.0424226
6.95	0.0424535
7.45	0.0425024
8.85	0.0426511
9.25	0.0427266
10.05	0.0428598
10.10	0.0428949
11.10	0.0430950
12.40	0.0434920
13.55	0.0439300
14.60	0.0444530
15.60	0.0449900
15.60	0.0449920
16.40	0.0456560
16.40	0.0456180

* Not shown on either figure.

TABLE 13. EXPERIMENTAL DATA ON THE ELECTRICAL RESISTIVITY OF SILVER Ag (continued)

DATA SET 126 (cont.)*

T	ρ
17.45	0.0464860
17.45	0.0464410
18.25	0.0470890
18.25	0.0471060
19.55	0.0483740
19.55	0.0484030

DATA SET 127*

T	ρ
1.44	0.0821656
1.44	0.0821657
1.76	0.0821661
2.32	0.0821670
2.32	0.0821672
2.62	0.0821682
2.62	0.0821687
2.62	0.0821678
2.96	0.0821699
2.96	0.0821698
3.30	0.0821723
3.30	0.0821714
3.57	0.0821758
3.57	0.0821752
3.87	0.0821791
3.87	0.0821794
4.22	0.0821850
4.22	0.0821851
4.22	0.0821846
4.22	0.0821853
4.60	0.0821944
4.75	0.0822000
5.16	0.0822154
5.65	0.0822237
6.20	0.0822604
6.60	0.0822905
7.15	0.0823352
7.55	0.0823857
8.95	0.0825640
9.45	0.0826569
10.10	0.0828250
10.10	0.0828340
11.10	0.0830944
12.50	0.0835500
13.45	0.0840190
14.60	0.0846760
15.45	0.0852700
15.45	0.0852560
16.35	0.0860310

DATA SET 127 (cont.)*

T	ρ
16.35	0.0860200
17.45	0.0870130
17.45	0.0870070
18.25	0.0878070
18.25	0.0878220
19.50	0.0893200
19.50	0.0892920

DATA SET 128*

T	ρ
1.44	0.0143849
1.44	0.0143840
1.92	0.0143848
1.92	0.0143846
2.32	0.0143847
2.32	0.0143842
2.62	0.0143854
2.62	0.0143862
2.96	0.0143872
2.96	0.0143870
3.30	0.0143877
3.30	0.0143872
3.30	0.0143884
3.57	0.0143902
3.57	0.0143896
3.86	0.0143931
3.86	0.0143934
4.22	0.0143964
4.22	0.0143969
4.22	0.0143984
4.55	0.0144024
4.68	0.0144066
5.07	0.0144137
5.52	0.0144276
5.85	0.0144380
6.45	0.0144584
6.85	0.0144803
7.40	0.0145150
8.75	0.0146210
9.25	0.0146710
9.95	0.0147670
10.10	0.0148070
11.05	0.0149380
12.50	0.0154230
13.60	0.0155390
14.60	0.0159520
15.60	0.0163050
15.60	0.0163450

DATA SET 128 (cont.)*

T	ρ
16.45	0.0168790
16.45	0.0168080
17.60	0.0174580
17.60	0.0174660
18.35	0.0179960
18.35	0.0179690
19.39	0.0188840
20.75	0.0198780
20.75	0.0198880

DATA SET 129*

T	ρ
2.36	0.007397555
2.36	0.007397548
2.59	0.007397912
2.59	0.007397924
2.77	0.007398432
2.77	0.007398444
2.96	0.007398701
2.96	0.007398688
3.18	0.007399494
3.18	0.007399513
3.39	0.007400232
3.39	0.007400238
3.58	0.007401142
3.58	0.007401173
3.77	0.007402142
3.77	0.007402142
3.98	0.007403482
3.98	0.007403425
4.21	0.007405424
4.22	0.007405237
4.22	0.007405251
4.22	0.007405204
4.22	0.00740520
4.22	0.00740522
5.06	0.007415604
6.11	0.007437424
6.50	0.007450213
7.14	0.007470896
7.80	0.007499093
7.93	0.007507764
8.75	0.007563319
8.75	0.007561734
9.50	0.007620930
10.60	0.007747739
10.83	0.007732220
12.15	0.007998970

DATA SET 129 (cont.)*

T	ρ
12.90	0.008166300
13.85	0.008369750
14.73	0.008657510
15.07	0.008798210
16.78	0.009062510
16.06	0.009223500
16.34	0.009342020
16.82	0.009590460
17.70	0.010119100
18.70	0.010759200
19.33	0.011193400
19.98	0.011762500

DATA SET 130

T	ρ
292.6	1.68*
354.9	2.07*
411.6	2.39
438.6	2.56
492.2	2.89
540.9	3.20
584.9	3.48*
638.5	3.82
680.8	4.11
687.8	4.15
696.9	4.21
725.7	4.40
768.4	4.69
821.4	5.05
868.3	5.37
908.3	5.65

* Not shown on either figure.

5. Summary

In this work, recommended values for electrical resistivity as a function of temperature from the cryogenic region to well beyond the melting point have been given for bulk pure copper, gold, palladium, and silver, with an uncertainty generally less than 5%. In addition to the total electrical resistivity values for the solid state, intrinsic electrical resistivity values have also been presented from cryogenic temperatures to the melting point. The values for the electrical resistivity have been corrected for the change in geometry due to thermal expansion. The recommendations are based on theoretical and empirical knowledge and on numerical data for the pure materials found in an extended search of the open literature. That numerical data, together with the associated information pertaining to specimen characterization and measurement conditions, have been extracted from the literature and appear as part of this work. Methods of evaluation and other considerations used in arriving at the recommendations have been described. For the solid state, an interpolation scheme has been given to aid in the determination of values between those supplied in the tables; for the liquid state, equations have been given.

The synthesis of data from different sources to produce recommended values begins with a study of all available data, selection of the data sets on which the recommended values are to be based, and the assignment to these of appropriate relative weights. In synthesizing these sometimes discordant data to get a smooth recommended curve over the whole temperature range, it has been found useful to carry out weighted-least-squares fitting of appropriate fitting functions to the selected data. To obtain fitting functions capable of approximating the rather complicated behavior of the electrical resistivity over an extremely broad range of temperatures, and thus to achieve maximum coordination of information from different temperature ranges, two modifications of the familiar Bloch-Grüneisen function were made. These involve new parameters, adjustment of which makes it possible to simulate the effects of lattice anharmonicity and thermal expansion at high temperatures and the effects of various scattering processes at low temperatures. However, the forms used are primarily determined by empirical facts and considerations of convenience, and the new parameters do not have direct physical interpretations. Neither is it necessary that a high accuracy of fit be attained (though this has been attained in a number of cases), since the fitting is intended merely to allow one to fix attention on the relatively small deviations of the data from the fitting functions. These deviations arise in part from experimental errors and other discrepancies and in part from the inadequacies of the fitting function. Values for the fractional deviation of the data from the fitting function, produced by a computer, were plotted on an expanded scale and used to construct graphically a smoothed deviation curve. Values read from this smooth curve at the temperatures of interest were added to the much larger values of the fitting function to obtain final smoothed values for the nominal intrinsic resistivity.

In the low-temperature region it was satisfactory to employ plots of $\rho_i(\text{nominal})/T^n$ against temperature, for suitable values of n, in checking, smoothing, and extrapolating data.

Once the intrinsic nominal resistivity was determined, the thermal expansion correction was applied in order to arrive at the intrinsic resistivity. Finally, after adding in the residual resistivity, the total resistivity was found.

In the section giving some theoretical background, Mott's formula for the ratio of the resistivity ρ_L of the liquid to the resistivity ρ_S of the solid, both at the melting point, was mentioned. A comparison between that formula and the ratio arrived at from the results of this work is given in table 14; in using the formula, the melting points used were those stated in table 1 and the latent heats of fusion were those stated in the first paragraph of the discussion pertaining to each element. Because Mott's theory is crude, disagreements of the experimental data with his formula are not surprising and do not suggest an inaccuracy in the recommended values.

TABLE 14. Comparison of ρ_L/ρ_S at the melting point between present results and Mott's theory

Element	$(\rho_L/\rho_S)_{T_m}$	
	Present results	Mott's formula
Copper	2.07	2.16
Gold	2.32	2.09
Palladium	1.79	2.08
Silver	2.06	2.08

6. Acknowledgments

This work was jointly supported by the Office of Standard Reference Data (OSRD) of the National Bureau of Standards (NBS), U.S. Department of Commerce, and by the Defense Logistics Agency (DLA) of the U.S. Department of Defense (DOD). This support is gratefully acknowledged.

The author wishes to thank the many researchers who responded so graciously to requests for original data and additional information. Thanks are also due to Dr. H. J. White, Jr., of the NBS Office of Standard Reference Data for his sympathetic understanding and help during the course of this work. In addition, the author wishes to recognize the valuable suggestions and guidance to this work from Dr. H. M. James, CINDAS' Resident Consultant and Senior Researcher, and from Dr. P. G. Klemens, Visiting Research Professor at CINDAS and Professor of Physics at the University of Connecticut.

7. References

The references listed under an element are the ones from which data were extracted. The number to the left of a reference is the reference number. The number within parentheses after the reference is a data set number; it refers to the data set in the tables of experimental data and measurement information under that element. This way of grouping the references allows one to quickly determine who worked on the electrical resistivity of a given element and to go from the reference to the data set of interest.

7.1. Copper

[1] Aoyama, S., and Ito, T., "Thermal and Electrical Conductivities of Copper-Zinc Alloys at Low Temperatures," Nippon Kinzoku Gakkaishi **4**, 37–40 (1940). (160)

[2] Ascoli, A., Guarini, G., and Queirolo, G. T., "Equilibrium Vacancy Resistivity in Pure Noble Metals," Cryst. Lattice Defects **1**, 159–63 (1970). (140)

[3] Baird, D. C., and Boyle, W. S., "A Method of Determining Electrical Resistivities at Low Temperatures," J. Appl. Phys. **24**, 958 (1953). (56)

[4] Banchila, S. N., and Filippov, L. P., "Study of the Electrical Conductivity of Liquid Metals," Teplofiz. Vys. Temp. **11**(6), 1301–5, 1973; English translation: High Temp. **11**(6), 1166–9 (1973). (190)

[5] Bauer, W., and Sosin, A., "The Effect of Irradiation Temperature on the Resistivity Recovery of Copper," Phys. Lett. A **24A**(4), 193–4 (1967). (84–5)

[6] Berman, R., and MacDonald, D. K. C., "The Thermal and Electrical Conductivity of Copper at Low Temperatures," Proc. R. Soc. London **A211**, 122–8 (1952). (33–4)

[7] Bornemann, K., and Von Rauschenplat, G., "The Electrical Conductivity of Metal Alloys in the Liquid State," Metallurgie (Halle, Ger.) **9**(15), 473–86 (1912); also **9**(16), 505–15 (1912). (192)

[8] Bornemann, K., and Wagenmann, K., "The Electrical Conductivity of Alloys in the Liquid State," Ferrum **11**, 276–82, 289–314, and 330–43 (1914). (191)

[9] Broom, T., "The Effect of Temperature of Deformation on the Electrical Resistivity of Cold-Worked Metals and Alloys," Proc. Phys. Soc., London, Sect. B **65**, 871–81 (1952). (143)

[10] Coltman, R. R., Klabunde, C. E., and Redman, J. K., "Survey of Thermal-Neutron Damage in Pure Metals," Phys. Rev. **156**(3), 715–34 (1967). (153)

[11] Dawson, H. I., "Recovery of Point Defects in Cold Worked Au, Ag, and Cu," Acta Metall. **13**, 453–64 (1965). (193)

[12] Dewar, J., and Fleming, J. A., "On the Electrical Resistance of Pure Metals, Alloys and Non-Metals at the Boiling-Point of Oxygen," Philos. Mag. **34**, 326–37 (1892). (182)

[13] Dewar, J., and Fleming, J. A., "XXVI. The Electrical Resistance of Metals and Alloys at Temperatures Approaching the Absolute Zero," Philos. Mag. **36**(5), 271–99 (1893). (180–1)

[14] Domenicali, C. A., and Christenson, E. L., "Effects of Transition Metal Solutes on the Electrical Resistivity of Copper and Gold Between 4° and 1200 °K," J. Appl. Phys. **32**(11), 2450–6 (1961). (73–5)

[15] Ellis, W. C., Morgan, F. L., and Sager, G. F., "The Thermal Conductivities of Copper and Nickel, and Some Alloys of Nickel," Rensselaer Polytech. Inst. Bull., No. 21, 23 pp. (1928). (159)

[16] Fevrier, A., and Morize, D., "The Effect of Magnetic Field on the Thermal Conductivity and Electrical Resistivity of Different Materials," Cryogenics **13**(10), 603–6 (1973). (21–2)

[17] Fickett, F. R., "A Preliminary Investigation of the Behavior of High Purity Copper in High Magnetic Fields," INCRA Project No. 186B, NTIS: PB 272 211 (1974). (226–38)

[18] Fickett, F. R., "A Preliminary Investigation of the Behavior of High Purity Copper in High Magnetic Fields and a Final Summary of Project 186," Annual Report, INCRA Project No. 186C (March 1976). (239–64)

[19] Fletcher, R., Friedman, A. J., and Stott, M. J., "Righi-Leduc and Hall Coefficients of the Noble Metals," J. Phys. F **2**(4), 729–41 (1972) (170)

[20] Gerritsen, A. N., and Linde, J. O., "The Electrical Resistances of Alloys of a Noble Metal and a Transition Metal," Physica (Utrecht) **18**(11), 877–90 (1952). (45)

[21] Grüneisen, E., and Goens, E., "Investigations of Metal Crystals. V. Electrical and Thermal Conductivity of Single and Polycrystalline Metals of Regular Systems," Z. Phys. **44**, 615–42 (1927). (6–20)

[22] Grüneisen, E., and Reddemann, H., "Electron and Lattice Conductivity with Heat Flow in Metals," Ann. Phys. (Leipzig) 5, **20**, 843–77 (1934). (183)

[23] Haen, P., Souletie, J., and Teixeira, J., "The Resistivity of Cu and CuMn and CuCr Alloys: Kondo Effect and Deviations from Matthiessen's Rule," J. Low Temp. Phys. **23**(1/2), 191–224 (1976). (268)

[24] Holgersson, S., and Sedström, E., "2. Experimental Measurement of the Lattice Structure of Several Metal Alloys," Ann. Phys. (Leipzig) 4, **75**(18), 143–62 (1924). (175)

[25] Hudson, W. R., "Copper Magnetoresistance Devices as Magnetometers," NASA Rept. NASA-TN-D-3536, 11 pp. (1966). (87–93)

[26] Hust, J. G., and Giarratano, P. J., "Thermal Conductivity," in "Semi-Annual Report on Materials Research in Support of Superconducting Machinery" (Reed, R. P., Durcholz, R. L., Fickett, F. R., Giarratano, P. J., Hust, J. G., Kasen, M. B., Ledbetter, H. M., Mikesell, R. P., Naimon, E. R., Schramm, R. E., Sparks, L. L., Tobler, R. L., and Weston, W. F.), NBS Rept. NBSIR-74-393, 1–35 (1974). (276)

[27] Jaeger, W., and Diesselhorst, H., "Thermal Conductivity, Electrical Conductivity, Heat Capacity, and Thermoelectric Power of Several Metals," Wiss. Abh. Phys.-Tech. Reichsanst. **3**, 269–425 (1900). (134–7)

[28] Jäger, H., Seydel, U., and Wadle, H., "Deviations from Ohm's Law for a Metal at High Current Densities," Phys. Lett. A **55A**(8), 481–2 (1976). (196–225)

[29] Kapitza, P., "The Change of Electrical Conductivity in Strong Magnetic Fields. Part I—Experimental Results and Part II—The Analysis and the Interpretation of the Experimental Results," Proc. R. Soc. London **A123**, 292–372 (1929). (120–3)

[30] Kierspe, W., "Influence of Transition Elements on Thermal Conductivity of Copper," Z. Metallkd. **58**(12), 895–902 (1967). (147–52)

[31] Kjekshus, A., and Pearson, W. B., "Thermoelectricity and Electrical Resistivity of Dilute Copper Alloys of Chromium, Manganese, Iron, and Cobalt at Low Temperatures," Can. J. Phys. **40**, 98–112 (1962). (94–111)

[32] Kos, J. F., and Moussouras, P. K., "Discovery of a Linear Temperature Dependence of the Impurity-Electron Scattering in Highly Dilute CuFe Systems," Solid State Commun. **18**, 1501–4 (1976). (277–9, 281, and 285)

[33] Laborde, O., and Radhakrishna, P., "Interaction Effects in Copper-Manganese Alloys at Low Temperatures." J. Phys. F **3**, 1731–7 (1973). (23–32)

[34] Laubitz, M. J., "Transport Properties of Pure Metals at High Temperatures," in Proceedings of the Sixth Conference on Thermal Conductivity (Minges, M. L. and Denman, G. L., Co-chairmen), Air Force Materials Laboratory, 779–93 (1966). (36–8)

[35] Laubitz, M. J., "Transport Properties of Pure Metals at High Temperatures. I. Copper," Can. J. Phys. **45**(11), 3677–96 (1967). (36–8)

[36] Lees, C. H., "XI. Bakerian Lecture. The Effects of Temperature and Pressure on the Thermal Conductivities of Solids. Part II. The Effects of Low Temperatures on the Thermal and Electrical Conductivities of Certain Approximately Pure Metals and Alloys," Philos. Trans. R. Soc. London **A208**, 381–443 (1908). (114)

[37] Lengeler, B., Schilling, W., and Wenzl, H., "Deviations from Matthiessen's Rule in Longitudinal Magnetoresistance in Copper," J. Low Temp. Phys. **2**(1), 59–86 (1970). (266)

[38] Loram, J. W., Whall, T. E., and Ford, P. J., "Resistivity of Some CuAuFe Alloys," Phys. Rev. B **2**(4), 857–74 (1970). (289–90)

[39] Lorenz, L., "III. Concerning the Conductivity of Metals for Heat and Electricity," Ann. Phys. (Leipzig) 3, **13**, 582–606 (1881). (162)

[40] Matyushenko, L. A., Shmatov, V. T., and Rodionov, K. P., "Effect of Hydrostatic Extrusion and Rolling on the Electrical Resistance of Copper," Fiz. Met. Metalloved. **30**(5), 936–41 (1970). (142)

[41] Meechan, C. J., and Eggleston, R. R., "Formation Energies of Vacancies in Copper and Gold," Acta Metall. **2**, 680–3 (1954). (179)

[42] Meissner, W., "Thermal and Electrical Conductivity of Several Metals Between 20 and 373 K," Ann. Phys. (Leipzig) 4, **47**, 1001–58 (1915). (138–9)

[43] Mikryukov, V. E., "Thermal and Electrical Properties of Copper Alloys," Vestn. Mosk. Univ., Ser. Mat., Mekh., Astron., Fiz., Khim. **11**(2), 53–70 (1956). (125)

[44] Mikryukov, V. E., "Thermal and Electrical Properties of Copper, Silver, Gold, Aluminum, and Copper-Beryllium Alloys," Vestn. Mosk. Univ., Ser. Mat., Mekh., Astron., Fiz., Khim. **12**(6), 57–67 (1957). (126–31)

[45] Mikryukov, V. E., "Thermal and Electrical Properties of Copper, Silver, Gold, Aluminum, and Alloys With a Copper Base," Issled. Zharoprochn. Splavam **3**, 420–8 (1958). (132)

[46] Mikryukov, V. E., and Rabotnov, S. M., "Thermal and Electric Conductivities of Mono- and Polycrystalline Substances from 100° to the Melting Point," Uch. Zap. Mosk. Gos. Univ. **74**, 167–79 (1944). (133)

[47] Mokrovskii, H. P., and Regel, A. R., "Electrical Conductivity of Copper, Nickel, Cobalt, Iron, and Manganese in the Solid and Liquid States," Zh. Tekh. Fiz. **23**(12), 2121–5 (1953). (274–5)

[48] Moore, J. P., McElroy, D. L., and Graves, R. S., "Thermal Conductivity and Electrical Resistivity of High-Purity Copper from 78 to 400 °K," Can. J. Phys. **45**(12), 3849–65 (1967). (35)

[49] Moussouros, P. K., and Kos, J. F., "Temperature Dependence of the Electrical Resistivity of Copper at Low Temperatures," Can. J. Phys. **55**, 2071–9 (1977). (279–87)

[50] Natarajan, N. S., and Chari, M. S. R., "Thermal Conductivity of Dilute Copper-Manganese Alloys at Helium Temperatures and in Magnetic Fields," in Ninth Conference on Thermal Conductivity (Shanks, H. R., Editor), U.S. Atomic Energy Commission, 169–77 (1970). (164–5)

[51] Nelson, W. E., and Hoffman, A. R., "Measurements of the Temperatures and Magnetic Field Dependence of Electrical Resistivity and Thermal Conductivity in OFHC Copper," in Thermal Conductivity 14 (Klemens, P. G. and Chu, T. K., Editors), Plenum Press, New York, 73–80 (1976). (265)

[52] Niccolai, G., "Electrical Resistivity of Metals Between Very High and Very Low Temperatures," Phys. Z. **9**(11), 367–72 (1908). (188)

[53] Northrup, E. F., "Resistivity of Copper in Temperature Range 20 °C to 1450 °C," J. Franklin Inst. **177**(1), 1–21 (1914). (62–4)

[54] Otter, F. A., Jr., "Thermoelectric Power and Electrical Resistivity of Dilute Alloys of Mn, Pd, and Pt in Cu, Ag, and Au," J. Appl. Phys. **27**(3), 197–200 (1956). (119)

[55] Ozelton, M. W., Wilson, J. R., and Pratt, J. N., "A Note on the Electrical Resistivity of Some I-IV and III-V Liquid Alloy Systems," Rev. Int. Hautes Temp. Refract. **4**, 109–11 (1967). (189)

[56] Pawlek, F., and Rogalla, D., "The Electrical Resistivity of Silver, Copper, Aluminum and Zinc as a Function of Purity in the Range 4–298 °K." Cryogenics **6**(1), 14–20 (1966). (1–4)

[57] Powell, R. L., Roder, H. M., and Hall, W. J., "Low-Temperature Transport Properties of Copper and Its Dilute Alloys: Pure Copper, Annealed and Cold-Drawn," Phys. Rev. **115**(2), 314–23 (1959). (65–71)

[58] Powell, R. W., and Tye, R. P., "New Measurements on Thermal Conductivity Reference Materials," Int. J. Heat Mass Transfer **10**, 581–96 (1967). (144–6)

[59] Radenac, A., Lacoste, M., and Roux, C., "Apparatus Meant for the Measurement of the Electrical Resistivity of Metals and Alloys by the Method of the Rotating Field up to About 2000 K," Rev. Int. Hautes Temp. Refract. **7**(4), 389–96 (1970). (5)

[60] Ramanathan, K. G., and Dhillon, J. S., "A New Method for Measuring Electrical Resistivities," Nature (London) **175**(4465), 948 (1955). (86)

[61] Richter, F., and Kierspe, W., "The Influence of the Transition Metals on the Electrical Resistivity of Pure Copper," Z. Naturforsch., Teil A **20a**, 1371–3 (1965). (79)

[62] Roder, H. M., Powell, R. L., and Hall, W. J., "Thermal and Electrical Conductivity of Pure Copper," in Proceedings of the 5th International Conference on Low Temperature Physics and Chemistry, 364–7 (1958). (72)

[63] Roll, A., Felger, H., and Motz, H., "Electrodeless Measurement of the Electrical Conductivity With the Rotating Field Method," Z. Metallkd. **47**(11), 707–13 (1956). (177)

[64] Roll, A., and Motz, H., "The Electrical Resistivity of Molten Metals. I. Measuring Method and Electrical Resistivity of Pure Molten Metals," Z. Metallkd. **48**(5), 272–80 (1957). (178)

[65] Rubanenko, I. R., and Grossman, M. I., "Thermal Conductivity of Brushes for Electrical Machines," Elektrotekhnika **40**(5), 38–9 (1969). (166)

[66] Rumbo, E. R., "Transport Properties of Very Pure Cu and Ag Below 8.5 K," J. Phys. F **6**(1), 85–98 (1976). (184–7)

[67] Saeger, K. E., "Hall Effect and Magnetoresistance in Copper Single Crystals at Low Temperatures," Phys. Status Solidi **28**(2), 589–602 (1968). (115–8)

[68] Sager, G. F., "Investigation of the Thermal Conductivity of the System Copper-Nickel," Rensselaer Polytechnic Institute, Ph. D. Thesis, 48 pp. (1930). (112–3)

[69] Scala, E., and Robertson, W. D., "Electrical Resistivity of Liquid Metals and of Dilute Liquid Metallic Solutions," Trans. Am. Inst. Min., Metall. Pet. Eng. **197**, 1141–7 (1953). (176)

[70] Schmitt, R. W., and Jacobs, I. S., "Magnetization and Magnetoresistance of Some Dilute Alloys of Mn in Cu," Can. J. Phys. **34**, 1285–9 (1956). (46)

[71] Schofield, F. H., "The Thermal and Electrical Conductivities of Some Pure Metals," Proc. R. Soc. London **A107**, 206–27 (1925). (83)

[72] Schriempf, J. T., "Deviations from Matthiessen's Rule in the Low Temperature Thermal and Electrical Resistivities of Very Pure Copper," in Thermal Conductivity, Proceedings of the Seventh Conference (Flynn, D. R. and Peavy, B. A., Jr., Editors), NBS Spec. Publ. 302, 249–52 (1968). (80–2)

[73] Schroeder, P. A., Wolf, R., and Woollam, J. A., "Thermopowers and Resistivities of Silver-Palladium and Copper-Nickel Alloys," Phys. Rev. **138**(1A), A105–11 (1965). (76)

[74] Sharma, R. G., and Chari, M. S. R., "Effect of Annealing on the Anomalous Electrical Resistivity of Dilute Copper-Iron Alloys at Low Temperatures," J. Low Temp. Phys. **13**(5/6), 553–71 (1973). (39–44)

[75] Sharma, R. G., and Chari, M. S. R., "The Electrical and Thermal Conductivities of Dilute Copper-Chromium Alloys at Low Temperatures," J. Low Temp. Phys. **15**(1/2), 79–89 (1974). (50–5)

[76] Siu, M. C. I., Carroll, W. L., and Watson, T. W., "Thermal Conductivity and Electrical Resistivity of Six Copper-Base Alloys," NBS Rept. NBSIR 76-1003 (1976). (267)

[77] Smith, A. W., "The Thermal Conductivities of Alloys," Ohio State University Studies 2, No. 7, Eng. Expt. Sta. Bull. No. 31, 5–61 (1925). (161)

[78] Smith, C. S., and Palmer, E. W., "Thermal and Electrical Conductivity of Copper Alloys," Am. Inst. Min. Metall. Engrs., Tech. Publ. No. 648, 21 pp. (1935). (154–8)

[79] Svensson, B., "Ferromagnetic Resistivity Increase of Copper-Nickel Alloys," Ann. Phys. (Leipzig) 5, **25**, 263–71 (1936). (141)

[80] Swanson, M. L., Piercy, G. R., and Mackinnon, D. J., "Effect of Plastic Deformation on Neutron Irradiation Damage in Copper and Aluminum at 1.8 °K," Phys. Rev. Lett. **9**(10), 418–21 (1962). (77–8)

[81] Takeuchi, S., Suzuki, K., Misawa, M., Ito, F., and Murakami, K., "On the Anomalous Physical Properties of Liquid Copper Alloys," Nippon Kinzoku Gakkaishi **37**(9), 1011–8 (1973). (60)

[82] Teixeira, J., "Resistivity of Pure Metals and Dilute Magnetic Alloys," University of Science and Medicine and National Polytechnical Institute of Grenoble, France, Ph. D. Thesis, 155 pp. (1974). (268–70)

[83] Tsutsumi, H., "On the Variation of Electric Resistance During the Fusion of Metals," Sci. Rep. Tohoku Imp. Univ. 1, **7**, 93–105 (1918). (194–5)

[84] Tye, R. P., "The Thermal and Electrical Conductivities of Porous Copper and Stainless Steel to Elevated Temperatures," ASME-AIChE Heat Transfer Conference, ASME-73-H7-47, 8 pp. (1973). (171–4)

[85] Tye, R. P., "The Thermal Conductivity and Electrical Resistivity of Copper and Copper Alloys in the Molten State," INCRA Project No. 199, 35 pp. (1976). (271–3)

[86] Van Dael, H., and Dupré, A., "The Low Temperature Thermal Conductivity of Dilute Copper-Manganese Alloys," Phys. Lett. A **32A**(7), 497–8 (1970). (167–9)

[87] Van Witzenburg, W., and Laubitz, M. J., "Magnetoresistances and the Phonon Conductivity of Metals," Can. J. Phys. **46**(17), 1887–94 (1968). (163)

[88] White, G. K., "The Thermal and Electrical Conductivity of Copper at Low Temperatures," Aust. J. Phys. **6**, 397–404 (1953). (47–9)

[89] White, G. K., and Tainsh, R. J., "Lorenz Number for High-Purity Copper," Phys. Rev. **119**(6), 1869–71 (1960). (61)

[90] White, G. K., and Woods, S. B., "Thermal and Electrical Conductivities of Solids at Low Temperatures," Can. J. Phys. **33**, 58–73 (1955). (57–9)

[91] White, G. K., and Woods, S. B., "Electrical and Thermal Resistivity of the Transition Elements at Low Temperatures," Philos. Trans. R. Soc. London **A251** (995), 273–302 (1959). (124)

7.2. Gold

[92] Arajs, S., and Dunmyre, G. R., "A Search for Low-Temperature Anomalies in the Electrical Resistivity of Dilute Gold-Erbium Alloys," J. Less-Common Met. **10**(3), 220–4 (1966). (20–2)

[93] Barratt, T., "Thermal and Electrical Conductivities of Some of the Rarer Metals and Alloys," Proc. Phys. Soc., London **26**, 347–71 (1913–14). (73)

[94] Berman, R., Brock, J. C. F., and Huntley, D. J., "Properties of Gold+0.03 Percent (at.)—Iron Thermoelements Between 1 and 300 °K and Behavior in a Magnetic Field," Cryogenics **4**(4), 233–9 (1964). (23)

[95] Brown, H. M., "Effect of Magnetic Field Upon Thermal Conductivity of Iron, Copper, Silver, and Gold," University of California, Berkeley, Ph. D. Thesis, 21 pp. (1927). (90)

[96] Brown, H. M., "Effect of Magnetic Fields Upon Thermal Conductivity of Iron, Copper, Gold, Silver, and Zinc," Phys. Rev. **32**, 508–14 (1928). (92)

[97] Busch, G., and Güntherodt, H. J., "Hall Coefficient and Specific Electrical Resistivity of Liquid Metal Alloys," Phys. Kondens. Mater. **6**, 325–62 (1967). (105)

[98] Cook, J. G., and Van der Meer, M. P., "The Thermal Conductivity and Electrical Resistivity of Gold from 80 to 340 K," Can. J. Phys. **48**(3), 254–63 (1970). (9)

[99] Damon, D. H., and Klemens, P. G., "Electrical Resistivity of Some Gold Alloys: A Search for Effects Due to Local Modes," Phys. Rev. **138**(5A), A1390–4 (1965). (10)

[100] Damon, D. H., Mathur, M. P., and Klemens, P. G., "Phonon-Assisted Impurity Scattering in Gold Alloys," Phys. Rev. **176**(3), 876–85 (1968). (13–6)

[101] Das, K. B., and Dawson, H. I., "Recovery Spectrum of Quenched Gold," J. Phys. Soc. Jpn. **30**(2), 388–98 (1971). (46–7)

[102] Fenton, E. W., "The Lorenz Numbers of Gold and Silver," University of Alberta, Canada, M. S. Thesis, 52 pp. (1962). (53–5)

[103] Fitzer, E., "Thermophysical Properties of Solid Materials. Project Section II—Cooperative Measurements on Heat Transport Phenomena of Solid Materials at High Temperature," AGARD Rept. AGARD-R-606, 107 pp. (1973). (94)

[104] Garbarino, P. L., "The Thermal and Electrical Conductivities of Gold Iron Alloys at Low Temperatures," The University of Connecticut, Ph. D. Thesis, 187 pp. (1969). (56–70)

[105] Garbarino, P. L., and Reynolds, C. A., "Thermal and Electrical Conductivities of Dilute Solutions of Iron in Gold," Phys. Rev. B **4**(1), 167–79 (1971). (56–70)

[106] Hau, N. H., "The Transport Properties of Palladium-Gold Alloys," Ohio University, Ph. D. Thesis, 109 pp. (1966). (109)

[107] Howe, R. A., and Enderby, J. E., "The Thermoelectric Power of Liquid Ag-Au," Philos. Mag. **16**(149), 467–76 (1967). (102)

[108] Iyer, V. K., and Asimow, R. M., "The Electrical Resistivity of Gold Silver Alloys," J. Less-Common Met. **13**, 18–23 (1967). (84

[109] Kannuluik, W. G., "On the Thermal Conductivity of Some Metal Wires," Proc. R. Soc. London **A131**, 320–35 (1931). (19)

[110] Kopp, J., "Magnetic Impurities in Pure Gold," Solid State Commun. **14**(11), 1059–60 (1974). (80–3)

[111] Hust, J. G., and Sparks, L. L., "Thermal Conductivity Standard Reference Materials From 4 to 300 K: AGARD Gold," NBS Rept. 9785, 84 pp. (1971). (118–20)

[112] Laubitz, M. J., "Transport Properties of Pure Metals at High Temperatures. II. Silver and Gold," Can. J. Phys. **47**(23), 2633–44 (1969). (7–8)

[113] Lebedev, S. V., Savvatimskii, A. I., and Smirnov, Yu. B., "Exploding Wire Measurement of Heat of Fusion and Electrical Conductivity of Refractory Metals," Sov. Phys.-Tech. Phys. **17**(8), 1400–6 (1973). (107)

[114] Logie, H. J., Jackson, J., Anderson, J. C., and Nabarro, F. R. N., "Effect of Plastic Deformation on Resistivity of Gold-Palladium Alloys," Acta Metall. **9**(8), 707–13 (1961). (108)

[115] MacDonald, D. K. C., Pearson, W. B., and Templeton, I. M., "Thermoelectricity at Low Temperatures. IX. The Transition Metals as Solute and Solvent," Proc. R. Soc. London **A266**(1325), 161–83 (1962). (29–44)

[116] Masumoto, H., "On the Electrical and Thermal Conductivities of Carbon Steel and Cast Iron," Sci. Rep. Tohoku Imp. Univ., 1, **16**, 417–35 (1927). (88–9)

[117] Misek, K., and Polak, J., "Resistivity of Lattice Vacancies in Gold," J. Phys. Soc. Jpn. **18II**, 179–83 (1963). (95)

[118] Mydosh, J. A., Ford, P. J., Kawatra, M. P., and Whall, T. E., "Electrical Resistivity of AuFe Alloys in the Spin-glass, Mictomagnetic, and Ferromagnetic Regimes," Phys. Rev. B **10**(7), 2845–56 (1974). (117)

[119] Northrup, E. F., "Resistivity of Pure Gold in Temperature Range 20 °C to 1500 °C," J. Franklin Inst. **177**, 287–92 (1914). (71–2)

[120] Otter, F. A., Jr., Flanders, P. J., and Klokholm, E., "Ferromagnetism in Noble Metal Alloys Containing Manganese," Phys. Rev. **99**(2), 599–600 (1955). (77)

[121] Powell, R. W., Ho, C. Y., and Liley, P. E., "Thermal Conductivity of Selected Materials," National Standard Reference Data Series-National Bureau of Standards-8, 168 pp. (1966). (78)

[122] Rowland, T., Cusack, N. E., and Ross, R. G., "The Resistivity and Thermoelectric Power of the Palladium-Gold Alloy System," J. Phys. F **4**, 2189–202 (1974). (96)

[123] Schulze, F. A., "The Thermal Conductivity of Several Series of Precious Metal Alloys," Phys. Z. **12**, 1028–31 (1911). (100–1)

[124] Shanks, H. R., Burns, M. M., and Danielson, G. C., "The Therm. Diffusivity of Gold," in Thermal Conductivity, Proceedings of th Seventh Conference (Flynn, D. R., and Peavy, B. A., Jr., Editors NBS Spec. Publ. 302, 331–6 (1968). (24–7)

[125] Sharma, J. K. N., "Heat Conductivities Below 1 °K. I," Cryogenic **7**(3), 141–56 (1967). (87)

[126] Sirota, N. N., "The Temperature Dependence of Electric Conductivity in Solids," Sov. Phys.-Dokl., **7**(3), 217–9 (1962). (28)

[127] Stewart, R. G., "Deviations from Matthiessen's Rule in Dilute Gold and Platinum Alloys," Illinois Institute of Technology, Ph. D. Thesis, 81 pp. plus appendices (1966). (111–6)

See also:

[2] Ascoli et al. (79)
[10] Coltman et al. (86)
[11] Dawson (106)
[12] Dewar and Fleming (99)
[13] Dewar and Fleming (98)
[14] Domenicali and Christensen (17–8)
[19] Fletcher et al. (93)
[20] Gerritsen and Linde (11–2)
[21] Grüneisen and Goens (1–6)

[27] Jaeger and Diesselhorst (74–5)
[29] Kapitza (48–9)
[38] Loram et al. (121–5)
[41] Meechan and Eggleston (97)
[42] Meissner (76)
[44] Mikryukov (51)
[45] Mikryukov (52)
[52] Niccolai (103)
[54] Otter (45)
[55] Ozelton et al. (104)
[64] Roll and Motz (85)
[82] Teixeira (110)
[87] Van Witzenburg and Laubitz (91)
[91] White and Woods (50)

7.3. Palladium

[128] Abramova, L. I., Fedorov, G. V., and Volkenshteyn, N. V., "Kinetic and Magnetic Properties of Palladium-Iron Alloys. I. Temperature Dependence of the Electrical Resistance," Phys. Met. Metallogr. (USSR) **33**(3), 70–6 (1972). (54)

[129] Arajs, S., Dunmyre, G. R., and Dechter, S. J., "Electrical Resistivity and Longitudinal Electrical Magnetoresistivity of Palladium-Rich Palladium-Erbium Alloys at Low Temperatures," Phys. Status Solidi **18**(2), 505–9 (1966). (37)

[130] Conybeare, J. G. G., "The Resistance of Palladium and Palladium-Gold Alloys," Proc. Phys. Soc., London **49**, 29–37 (1937). (40–1)

[131] Dubinin, E. L., Esin, O. A., and Vatolin, N. A., "Electrical Resistivity of Liquid Pd-Ni, Pd-Co, Pd-Cu, Pd-Fe, Pd-Mn, and Pd-Al Alloys", Russ. J. Phys. Chem. **43**(10), 1463–5 (1969). (45–6)

[132] Dupree, B. C., Van Zytveld, J. B., and Enderby, J. E., "The Resistivity and Thermoelectric Power of Solid and Liquid Palladium," J. Phys. F **5**, L200–2 (1975). (68–9)

[133] Gimpl, M. L., Fuschillo, N., and Zwilsky, K. M., "High-Temperature Conductor Materials Development for Aerospace Applications," IEEE Trans. Aerosp., Suppl. **AS-3**(2), 290–5 (1965). (15)

[134] Greig, D., and Rowlands, J. A., "The T^2 Electrical Resistivity in Nickel and Palladium Alloys," J. Phys. F **4**, 232–46 (1974). (48–50)

[135] Greig, D., and Rowlands, J. A., "Resistance Minima and Deviations from Matthiesen's Rule in Dilute Palladium Alloys," J. Phys. F **4**, 536–49 (1974). (33–6)

[136] Grube, G., Bayer, K., and Bumm, H., "Electrical Conductivity and Phase Diagram of Binary Alloys. 22. Palladium-Manganese System," Z. Electrochem. Angew. Phys. Chem. **42**(11), 805–15 (1936). (72)

[137] Grube, G., and Kästner, H., "Electrical Conductivity and Phase Diagram of Binary Alloys. 18. Palladium-Cobalt System," Z. Electrochem. Angew. Phys. Chem. **42**(3), 156–60 (1936). (71)

[138] Grube, G., and Knabe, R., "Electrical Conductivity and Phase Diagram of Binary Alloys. 21. Palladium-Chromium System," Z. Electrochem. Angew. Phys. Chem. **42**(11), 793–804 (1936). (70)

[139] Güntherodt, H. J., Hauser, E., Künzi, H. U., and Müller, R., "The Electrical Resistivity of Liquid Fe, Co, Ni, and Pd," Phys. Lett. A **54A**(4), 291–2 (1975). (53)

[140] Holborn, L., "The Dependence of the Resistance of Pure Metals on the Temperature," Ann. Phys. (Leipzig) 4, **59**, 145–69 (1919). (43–4)

[141] Jain, S. C., Sinha, V., and Reddy, B. K., "Thermal Conductivity of Metals at High Temperatures by the Jain and Krishnan Method. IV. Palladium," Br. J. Appl. Phys. **2**(9), 1283–9 (1969). (19–21)

[142] Kao, F. C. C., Colp, M. E., and Williams, G., "PdV: A System With a High Spin-Fluctuation or Kondo Temperature," Phys. Rev. B **8**(3), 1228–38 (1973). (51)

[143] Kemp, W. R. G., Klemens, P. G., Sreedhar, A. K., and White, G. K., "The Thermal and Electrical Conductivity of Palladium at Low Temperatures," Philos. Mag. **46**, 811–4 (1955). (13)

[144] Kemp, W. R. G., Klemens, P. G., Sreedhar, A. K., and White, G. K., "The Thermal and Electrical Conductivity of Silver-Palladium and Silver-Cadmium Alloys at Low Temperatures," Proc. R. Soc. London **A233**, 480–93 (1956). (13)

[145] Koon, N. C., Schindler, A. I., and Mills, D. L., "Spin-Disorder Resistivity in Dilute PdFe Alloys," Phys. Rev. B **6**(11), 4241–50 (1972). (57–63)

[146] Laubitz, M. J., and Matsumura, T., "High-Temperature Transport Properties of Palladium," Can. J. Phys. **50**(3), 196–205 (1972). (67)

[147] Meissner, W., and Voigt, B., "Measurements With the Help of Liquid Helium. XI. Resistance of Pure Metals at Low Temperature," Ann. Phys. (Leipzig), 5, 7, 761–97; 892–936 (1930). (5–7)

[148] Müller, R., "Electronic Transport Properties of Transition Metals and Metal Alloys of Transition in a Liquid and Amorphous State," Eidgenoessische Technische Hochschule, Zurich, Switzerland, Ph. D. Thesis, ETH-5040 (Avail. NTIS), 52 pp. (1976). (53)

[149] Mydosh, J. A., "From Giant Moment to Kondo and Spin Glass Behavior: The Electrical Resistivity of PdFe and (PdFe)H," Phys. Rev. Lett. **33**(26), 1562–6 (1974). (56)

[150] Nagasawa, H., "Resistance Minimum Phenomena in Exchange Enhanced Pd and Pt Alloys," J. Phys. Soc. Jpn. **28**(5), 1171–80 (1970). (55)

[151] Nellis, W. J., and Brodsky, M. B., "Sf Magnetism in Palladium-Actinide Solid Solutions," Phys. Rev. B **4**(5), 1594–1601 (1971). (73)

[152] Olsen-Bär, M., "Electronic Properties of Metals at Low Temperatures," University of Oxford, Ph. D. Thesis (1956). (22–4)

[153] Powell, R. W., Tye, R. P., and Woodman, M. J., "Thermal Conductivities and Electrical Resistivities of the Platinum Metals," Platinum Met. Rev. **6**(4), 138–43 (1962). (10)

[154] Ricker, T., and Pflüger, E., "The Temperature Dependence of Resistance and Other Electrical Properties of Palladium-Silver and Palladium-Rhodium Alloys," Z. Metallkd. **57**(1), 39–45 (1966). (30)

[155] Schindler, A. I., and Rice, M. J., "S-Electron-Paramagnon Scattering in Dilute Pd-Ni Alloys: Theory and Experiment," Phys. Rev. **164**(2), 759–64 (1967). (27–9)

[156] Schindler, A. I., Smith, R. J., and Salkovitz, E. I., "Preliminary Electrical-Resistivity Measurements of the Nickel-Palladium Alloy System," Phys. Chem. Solids **1**, 39–41 (1956). (25)

[157] Schriempf, J. T., "Lorenz Number of Pure Palladium at Low Temperatures," Phys. Rev. Lett. **19**(19), 1131–3 (1967). (11)

[158] Schriempf, J. T., "Three-Term Analysis of the Ideal Thermal and Electrical Resistivities of Transition Metals," Phys. Rev. Lett. **20**(19), 1034–6 (1968). (12)

[159] Schriempf, J. T., Schindler, A. I., and Mills, D. L., "Electron-Electron Scattering Effects in the Low-Temperature Lorenz Numbers of Dilute Pd-Ni Alloys," Naval Research Laboratory Rept. NRL-6949, 32 pp. (1969). (17)

[160] Ström-Olsen, J. O., and Williams, G., "Anomalous Low-Temperature Transport Properties of Dilute PdU and PtU Alloys," Phys. Rev. B **12**(5), 1986–90 (1975). (52)

[161] Szafranski, A. W., "Electrical Resistance of the $Pd_{1-x}Ag_xH_n$ Alloys from 4 to 300 K," Phys. Status Solidi A **19**, 459–66 (1973). (38)

[162] Vasil'eva, P. P., Cheremushkina, A. V., Ivanova, N. N., and Olefirenko, P. P., "Temperature Dependence of the Galvanomagnetic and Thermomagnetic Properties of Palladium," Izv. Vyssh. Uchebn. Zaved., Fiz. **16**(8), 95–7, 1973; English translation: Sov. Phys. J. **16**(8), 1117–9 (1973). (31)

[163] Vatolin, N. A., Esin, O. A., and Dubinin, E. L., "Concentration Dependence of Electrical Resistance of Molten Palladium-Silver, Palladium-Chromium, Palladium-Silicon, and Silver-Silicon Alloys," Zh. Fiz. Khim. **41**(7), 1813–5 (1967). (47)

See also:

[93] Barratt (8–9)
[10] Cultman et al. (14)
[13] Dewar and Fleming (26)
[22] Grüneisen and Reddemann (1–4)
[106] Hau (75–6)
[24] Holgersson and Sedström (18)
[27] Jaeger and Diesselhorst (42)
[114] Logie et al. (74)
[122] Rowland et al. (39)

[123] Schulze (32)
[125] Sharma (16)
[91] White and Woods (64–6)

7.4. Silver

[164] Anderson, A. C., Peterson, R. E., and Robichaux, J. E., "Thermal and Electrical Conductivity of Ag and Pt Below 1 °K," Phys. Rev. Lett. **20**(9), 459–61 (1968). (55)

[165] Ascoli, A., Germagnoli, E., and Guarini, G., "Equilibrium Resistivity of Lattice Vacancies in Pure Ag," Acta Metall. **14**, 1002–5 (1966). (64)

[166] Barber, A. J., and Caplin, A. D., "The Low Temperature Electrical Resistivity of High Purity Ag and Ag Based Alloys," J. Phys. F. **5**, 679–96 (1975). (104–29)

[167] Crisp, R. S., and Rungis, J., "Thermoelectric Power and Thermal Conductivity in the Silver-Gold Alloy System from 3–300 °K," Philos. Mag. **22**(176), 217–36 (1970). (58–9)

[168] Ehrlich, A. C., and Schriempf, J. T., "The Temperature Dependent Thermal and Electrical Resistivity of High Purity Silver from 2 to 20 K," Solid State Commun. **14**(6), 469–73 (1974). (67)

[169] Ekern, R., and Czanderna, A. W., "The Electrical Resistivity of Silver Between 300 and 900 °K," J. Phys. Chem. Solids **38**, 553–4 (1977). (130)

[170] Fenton, E. W., Rogers, J. S., and Woods, S. B., "Lorenz Numbers of Pure Aluminum, Silver, and Gold at Low Temperatures," Can. J. Phys. **41**(12), 2026–33 (1963). (84)

[171] Gerritsen, A. N., and Linde, J. O., "Thermal Conductivity of Some Dilute Silver Alloys," Physica (Utrecht) **22**, 821–31 (1956). (39–42)

[172] Jha, D., Jericho, M. H., and Taylor, P. L., "Lorenz Numbers of Dilute Ag Alloys," Phys. Rev. B **1**(4), 1870–1 (1970). (43–4)

[173] Kannuluik, W. G., "The Thermal and Electrical Conductivities of Several Metals Between −183 and 100 Degrees," Proc. R. Soc. London **A141**, 159–68 (1933). (7–8)

[174] Kos, J. F., "Evidence of Phonon Drag in the Electrical Resistivity of Silver," Phys. Status Solidi B **52**(2), 389–94 (1972). (71–4)

[175] Kos, J. F., "Determination of the Ideal Resistivity and of the Deviation from Matthiessen's Rule in Silver," Can. J. Phys. **51**(15), 1602–18 (1973). (75–82)

[176] Matsumura, T., and Laubitz, M. J., "Thermal Conductivity and Electrical Resistivity of Pure Silver Between 80 and 350 K," Can. J. Phys. **48**(12), 1499–503 (1970). (66)

[177] Matuyama, Y., "On the Electrical Resistance of Molten Metals and Alloys," Sci. Rep. Tohoku Imp. Univ., 1, **16**, 447–74 (1927). (89)

[178] Northrup, E. F., "Resistivity of Pure Silver: Solid and Molten," J. Franklin Inst. **178**, 85–7 (1914). (29–30)

[179] Pal, S., "Electrical Resistivity of Noble Metals," Can. J. Phys. **51**, 2225–32 (1973). (9)

[180] Powell, H., and Evans, E. J., "The Hall Effect and Some Other Physical Constants of Alloys. Part VII. The Aluminum Silver Series of Alloys," Philos. Mag. **34**(230), 145–61 (1943). (5–6)

[181] Pravoverlov, N. L., and Tribunskaya, I. A., "Properties of Silver Alloys Containing Small Amounts of Palladium and Cadmium," Izv. Akad. Nauk SSSR, Met., (1), 56–60 (1967); English translation: Russ. Metall. (1), 75–8 (1967). (37–8)

[182] Sedström, E., "Peltier Heat Together with Thermal and Electrical Conductivity of Several Groups of Metals," Ann. Phys. (Leipzig), 4, **59**, 134–44 (1919). (50–1)

[183] Seth, R. S., and Woods, S. B., "Electrical Resistivity and Deviations from Matthiesen's Rule in Dilute Alloys of Aluminum, Cadmium, Silver, and Magnesium," Phys. Rev. B **2**(8), 2961–72 (1970). (10–14)

[184] Takeuchi, S., and Endo, H., "The Electrical Resistivity of the Metals in the Molten State," Trans. Jpn. Inst. Met. **3**, 30–5 (1962). (94)

[185] Tanner, D. B., and Larson, D. C., "Electrical Resistivity of Silver Films," Phys. Rev. **166**(3), 652–5 (1968). (97–100)

[186] Uemura, O., and Ikeda, S., "Electrical Resistivity, Magnetic Susceptibility, and Heat of Mixing of Liquid Silver-Germanium Alloys," Trans. Jpn. Inst. Met. **14**(5), 351–4 (1973). (90)

[187] Weinberg, I., "Thermoelectric Power in Silver-Gold and Silver-Germanium Alloys," Phys. Rev. **157**(3), 564–9 (1967). (31–5)

[188] Yatsenko, S. P., and Kononenko, V. I., "Anomalous Viscosity and Electrical Resistance Changes in Binary Alloys," Zh. Fiz. Khim. **43**(1), 89–95 (1969); English translation: Russ. J. Phys. Chem. **43**(1), 44–7 (1969). (93)

See also:

[8] Bornemann and Wagenmann (95)
[95] Brown (54)
[97] Busch and Güntherodt (92)
[10] Coltman et al. (45)
[11] Dawson (96)
[12] Dewar and Fleming (26)
[13] Dewar and Fleming (25)
[102] Fenton (84–6)
[19] Fletcher et al. (57)
[22] Grüneisen and Reddemann (46–9)
[107] Howe and Enderby (87)
[108] Iyer and Asimow (65)
[27] Jaeger and Diesselhorst (28)
[109] Kannuluik (18–9)
[29] Kapitza (21–2)
[112] Laubitz (61–2)
[36] Lees (16)
[44] Mikryukov (23)
[45] Mikryukov (24)
[52] Niccolai (88)
[54] Otter (20)
[55] Ozelton et al. (91)
[56] Pawlek and Rogalla (1–4)
[154] Ricker and Pflüger (27)
[64] Roll and Motz (83)
[66] Rumbo (68–70)
[73] Schroeder et al. (15)
[123] Schulze (53)
[125] Sharma (36)
[126] Sirota (17)
[77] Smith (52)
[82] Teixeira (103)
[83] Tsutsumi (101–2)
[87] Van Witzenberg and Laubitz (56)
[163] Vatolin et al. (60)
[91] White and Woods (63)

7.5. Other References

[189] Albert, H. J., "Palladium," in *McGraw-Hill Encyclopedia of Science and Technology*, Vol. 9, McGraw-Hill Book Co., New York, 592–3 (1971).

[190] American Society for Testing and Materials, "Standard for Metric Practice," ASTM Designation E380-76, 37 pp. (1976).

[191] Bass, J., "Deviations from Matthiessen's Rule," Adv. Phys. **21**, 431–604 (1972).

[192] Bean, C. P., DeBlois, R. W., and Nesbitt, L. B., "Eddy-Current Methods for Measuring the Resistivity of Metals," J. Appl. Phys. **30**, 1976–80 (1959).

[193] Birss, R. R., and Dey, S. K., "The Temperature Dependence of the Resistivity of Ferromagnetic Metals," Proc. R. Soc. London **A263**(1315), 473–82 (1961).

[194] Bloch, F., "Concerning the Quantum Mechanics of Electrons in a Crystal Lattice," Z. Phys. **52**, 555–600 (1928).

[195] Bloch, F., "The Electrical Resistance Law at Low Temperatures," Z. Phys. **59**, 208–14 (1930).

[196] Cezairliyan, A., and McClure, J. L., "Thermophysical Measurements on Iron Above 1500 K Using a Transient (Subsecond) Technique," J. Res. Natl. Bur. Stand., Sect. A **78**(1), 1–4 (1974).

[197] Chambers, R. G., and Park, J. G., "Measurement of Electrical Resistivity by a Mutual Inductance Method," Br. J. Appl. Phys. **12**, 507–10 (1961).

[198] Chi, T. C., "Electrical Resistivity of Alkali Elements," CINDAS Rept. 40, 136 pp. (1976).

[199] Cimberle, M. R., Bobel, G., and Rizzuto, C., "Deviations from Matthiessen's Rule at Low Temperatures: An Experimental Comparison Between Various Metallic Alloy Systems," Adv. Phys. **23**(4), 639–71 (1974).
[200] Cohen, E. R., and Taylor, B. N., "The 1973 Least-Squares Adjustment of the Fundamental Constants," J. Phys. Chem. Ref. Data **2**(4), 663–734 (1973).
[201] Constant, F. W., *Theoretical Physics: Thermodynamics, Electromagetism, Waves, and Particles*, Addison-Wesley Publishing Co., Inc., Reading, Mass., 367 pp. (1958).
[202] Cusack, N. E., "The Electronic Properties of Liquid Metals," Rep. Prog. Phys. **26**, 361–409 (1963).
[203] Cusack, N., and Enderby, J. E., "A Note on the Resistivity of Liquid Alkali and Noble Metals," Proc. Phys. Soc., London **75**, 395–401 (1960).
[204] Dupree, B. C., Private Communication, University of Leicester, Leicester, Great Britain (July 23, 1976).
[205] Dupree, B. C. Private Communication, University of Leicester, Leicester, Great Britain (November 30, 1976).
[206] Gray, D. E. (Coordinating Editor), *American Institute of Physics Handbook*, 3rd Ed., McGraw-Hill Book Co. (1972).
[207] Grüneisen, E., "The Dependence of the Electrical Resistance of Pure Metals on the Temperature," Ann. Phys. (Leipzig), 5, **16**, 530–40 (1933).
[208] Grüneisen, E., "The Change of the Pressure Coefficient of the Metallic Resistance with Temperature," Ann. Phys. (Leipzig), 5, **40**, 543–52 (1941).
[209] Gschneidner, K. A., Jr., "Physical Properties and Interrelationships of Metallic and Semimetallic Elements," Solid State Phys. **16**, 275–426 (1964).
[210] Harris, F. K., *Electrical Measurements*, John Wiley and Sons, Inc., New York, 784 pp. (1952).
[211] Ho, C. Y., Powell, R. W., and Liley, P. E., "Thermal Conductivity of the Elements: A Comprehensive Review," J. Phys. Chem. Ref. Data **3**, Suppl. No. 1, 796 pp. (1974).
[212] International Electrotechnical Commission, *International Standard of Resistance for Copper*. Publ. 28. Revised Ed.. International Electrotechnical Commission, Geneva, Switzerland, 9 pp. (1925).
[213] International Organization for Standardization, "SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units," ISO International Standard 1000, First Ed., 20 pp. (1973).
[214] Kaye, G. W. C., and Laby, T. H. (Original compilers), *Tables of Physical and Chemical Constants and Some Mathematical Functions*, 14th Ed., Longman Group Ltd., London, 386 pp. (1973).
[215] Kelly, F. M., and MacDonald, D. K. C., "On θ Values in Metals," Can. J. Phys. **31**, 147–64 (1953).
[216] Kelly, F. M., "On θ Values in Metals. II," Can. J. Phys. **32**, 81–9 (1954).
[217] Laws, F. A., *Electrical Measurements*, 2nd Ed., McGraw-Hill Book Co., Inc., New York, 739 pp. (1938).
[218] Matthiessen, A., and Vogt, C., "The Influence of Temperature on the Electrical Conductivity of Alloys," Ann. Phys. (Leipzig), 2, **122**, 19–78 (1864).
[219] Meaden, G. T., *Electrical Resistance of Metals*, Plenum Press, New York, 218 pp. (1965).
[220] Mott, N. F., "The Resistance of Liquid Metals," Proc. R. Soc. London, **A146**, 465–72 (1934).
[221] National Bureau of Standards, "NBS Guidelines for Use of the Metric System," NBS Publ. LC1056, Revised, 4 pp. (August 1975).
[222] Page, C. H., and Vigoureux, P. (Editors), "The International System of Units (SI)," NBS Spec. Publ. 330, 43 pp. (1974).
[223] Rogers, W. M., and Powell, R. L., "Tables of Transport Integrals," NBS Circ. 595, 46 pp. (1958).
[224] Shortley, G., and Williams, D., *Elements of Physics*, Second Ed., Prentice-Hall Inc., Englewood Cliffs, N.J., 880 pp. (1955).
[225] Stanley, J. K., *Electrical and Magnetic Properties of Metals*, American Society for Metals, Metals Park, Ohio, 374 pp. (1963).
[226] Touloukian, Y. S., Powell, R. W., Ho, C. Y., and Klemens, P. G., *Thermal Conductivity—Metallic Elements and Alloys, Vol. 1 Thermophysical Properties of Matter—The TPRC Data Series*, IFI/Plenum Data Corp., New York, 1469 pp. (1970).
[227] Touloukian, Y. S., Powell, R. W., Ho, C. Y., and Klemens, P. G., *Thermal Conductivity—Nonmetallic Solids, Vol. 2 Thermophysical Properties of Matter—The TPRC Data Series*, IFI/Plenum Data Corp., New York, 1172 pp. (1970).
[228] Touloukian, Y. S., Kirby, R. K., Taylor, R. E., and Desai, P. D., *Thermal Expansion—Metallic Elements and Alloys, Vol. 12 Thermophysical Properties of Matter—The TPRC Data Series*, IFI/Plenum Data Co., New York, 1348 pp. (1975).
[229] Van der Pauw, L. J., "A Method of Measuring Specific Resistivity and Hall Effect of Discs of Arbitrary Shape," Philips Res. Rep. **13**, 1–9 (1958).
[230] Van der Pauw. L. J.. "A Method of Measuring the Resistivity and Hall Coefficient on Lamellae of Arbitrary Shape," Philips Tech. Rev. **20**(8), 220–4 (1958–9).
[231] Ward, R. P., *Introduction to Electrical Engineering*, Second Ed., Prentice-Hall Inc., New York, 412 pp. (1952).
[232] Weast, R. C. (Editor), *Handbook of Chemistry and Physics*, 50th Ed., The Chemical Rubber Co., Cleveland, Ohio (1969).
[233] Ziman, J. M., *Electrons and Phonons*, Oxford University Press, London, 554 pp. (1960).
[234] Zimmerman, J. E., "Measurement of Electrical Resistivity of Bulk Metals," Rev. Sci. Instrum. **32**(4), 402-5 (1961).

Appendix 1. Methods of Measuring Electrical Resistivity

A. Steady-State Methods
  1. Voltmeter and Ammeter Direct Reading Method (V) [217, p. 159; 210, pp. 244–5]
  2. dc Potentiometric Method (A) [219, pp. 151–8]
    a. 4-Probe Potentiometric Method
  3. dc Bridge Methods (B) [219, pp. 144–51]
    a. Kelvin Double Bridge Method
    b. Mueller Bridge Method
    c. Wheatstone Bridge Method
  4. Van der Pauw Method (P) [229, 230]

B. Non-Steady-State Methods
  1. Periodic Currents Involved
    a. Direct Connection to Sample
      (1) ac Potentiometric Method (C) [219, pp. 161–2]
      (2) ac Bridge Method (D) [219, p. 162]
    b. No Connection to Sample
      (1) Mutual Inductance Method (M) [197]
      (2) Self-inductance Method (S) [234]
      (3) Rotating Magnetic Field Method (R) [59]
  2. Non-Periodic Currents Involved
    a. Direct Connection to Sample
      (1) Transient (subsecond) Method (T) [196]
    b. No Connection to Sample
      (1) Eddy Current Decay Method (E) [192; 219, p. 103]

C. General Comments
  1. This conceptual scheme of organizing methods of measuring electrical resistivity into steady-state and non-steady-state methods, with the latter organized

into periodic and non-periodic subdivisions, was done by analogy with the scheme for thermal conductivity [226, pp. xv–xvi; or 227, pp. xv–xvi].

2. The letters within parentheses are the codes for the respective methods. The codes appear in the "Method Used" column in the Tables of Measurement Information.
3. Code "I" means Induction Method. This is a combination of Items B1b and B2b above. Subsumed under I is M, R, S, or E. This is used only if author indicates induction method used and does not report which specific one.
4. The symbol "→" is used in the "Method Used" column in the Tables of Measurement Information either if the method described by the author is not sufficient to assign a specific code or the use of a code would not convey the information reported in the document. As an example, if an author states an "ac method" was used without any further specification, the following wording can be used in the "Composition, Specifications, and Remarks" column of the Tables of Measurement Information: "experimental method described as an ac method." In the "Method Used" column the symbol "→" would appear. Note that this "ac method" corresponds to the heading B1 above.

Appendix 2. Conversion Factors for Units of Electrical Resistivity

TABLE A-1. Conversion factors for units of electrical resistivity

MULTIPLY VALUE by appropriate factor to OBTAIN →	(SI unit) Ω m	(Unit used in this work) $10^{-8}\ \Omega$ m
$10^{-8}\ \Omega$ m	1×10^{-8}	1
$\mu\Omega$ cm	1×10^{-8}	1
Ω cm	1×10^{-2}	1×10^{6}
Ω m	1	1×10^{8}
Ω cmil ft^{-1}	1.66243×10^{-9}	1.66243×10^{-1}
Ω in	2.54×10^{-2}	2.54×10^{6}
Ω ft	3.048×10^{-1}	3.048×10^{7}
abohm—centimeter	1×10^{-11}	1×10^{-3}
emu	1×10^{-11}	1×10^{-3}
statohm—centimeter	8.98755×10^{9}	8.98755×10^{17}
esu	8.98755×10^{9}	8.98755×10^{17}
10^{-6} ohm per centimeter cubed	1×10^{-8}	1
σ(in units of (Ω cm)$^{-1}$)	$(1\times10^{-2})/\sigma$	$(1\times10^{6})/\sigma$
Ω mm^2 m^{-1}	1×10^{-6}	1×10^{2}
percent IACS	$1\times10^{-4}/(58\times$percent IACS)	$1\times10^{4}/(58\times$percent IACS)

Notes for Table A-1

These notes identify the SI unit of electrical resistivity, give a reason for the choice of the unit used in this work, and give facts and more basic conversion factors used to justify the conversion factors in table A-1.

1. The SI unit of electrical resistivity is the ohm-meter, with the symbol Ω m [213, p. 14, item 5-43.1].
2. The symbol for the unit of electrical resistivity used in this work is $10^{-8}\ \Omega$ m; with this unit numerical values for metallic materials over a wide temperature range generally fall between 10^{-3} and 10^{3} [198; 214, pp. 102–4; 206, pp. 9–39 to 9–42]. Also, a great deal of data are reported in units of $\mu\Omega$ cm ($=10^{-8}\ \Omega$ m).
3. The conversion factors in Appendix 2 are based on the following conversion factors and definitions:
   a. SI prefixes used to form multiples and submultiples of SI units [221, table 5; 222, p. 12, table 7; 190, p. 3; and 213, p. 2, table 4].
   b. 1 in$=2.54\times10^{-2}$ m [221, table 7].
   c. "The circular mil is a unit of area, and is a circle mil (1/1000 of an inch) in diameter." [231, p. 131].
   d. 1 esu unit of electrical resistivity$=1$ statohm-centimeter [224, p. 878].
   e. 1 emu unit of electrical resistivity$=1$ abohm-centimeter [224, p. 878].
   f. 1 statohm$=10^{-5}\ c^2$ ohms where c is the numerical value of the speed of light in vacuum in units of m s^{-1}.
      (1) 1 statohm$=1$ statvolt/1 statamp [224, p. 858].
      (2) 1 ampere$=2.997\ 924\ 58\times10^{9}$ statamperes.
         (a) 1 ampere$=10\ c$ statamperes [224, pp. 857, 858, 784, and 785. The essence of the argument leading to this conversion factor is given on p. 858; 201, pp. 132–5].

(b) $c = 2.997\ 924\ 58 \times 10^8$ m s^{-1} [200, p. 717, Table 33.1, this value for the speed of light in vacuum is from the 1973 adjustment of the fundamental constants].

(c) 1 dyn $= 10^{-5}$ N [222, p. 16].

(3) 1 statvolt $= 299.792\ 458$ volts.

(a) 1 statvolt $= 10^{-6}$ c volts. This conversion factor builds upon the argument leading to the conversion factor between amperes and statamperes [see 224, p. 858 for the argument leading to the conversion factor between volts and statvolts].

(b) 1 erg $= 10^{-7}$ joule [222, p. 16].

g. 1 ohm $= 10^9$ abohm [224, p. 860].

(1) 1 abohm $=$ 1 abvolt/1 abamp [224, pp. 858 and 860].

(2) 1 abampere $=$ 10 ampere [224, p. 858, for the argument leading to this conclusion].

(3) 1 volt $= 10^8$ abvolts [224, p. 860].

h. 1 ohm per centimeter cubed is equivalent to 1 ohm-cm [231, p. 132].

i. Electrical conductivity σ is the inverse of electrical resistivity ρ.

j. Percent IACS $= 1.724\ 1 \times 100/\rho$(in $\mu\Omega$ cm) [225, p. 363].

k. IACS means International Annealed Copper Standard [225, p. 366].

l. "(1) At a temperature of 20 °C, the volume resistivity of standard annealed copper is $1/58 = 0.017\ 241$ ... ohm square millimeter per metre ((ohm mm^2)/m)" [212, p. 4].

4. Six significant digits were kept for the conversion factors in table A-1 and the usual rule for rounding was used [190, p. 11, item 4.4]. When less than six significant digits are shown, the conversion factor is exact.