TRANSPORT PROPERTIES OF CONCENTRATED Ag–Pd AND Cu–Ni ALLOYS
FROM 300–1000 K*

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For temperatures above 300 K, thermal conductivity data for concentrated binary silver–palladium and copper–nickel alloys are scarce. A recent review and analysis of thermal conductivity data for selected binary alloy systems by Ho et al.1 included extrapolations of existing data for Ag–Pd and Cu–Ni into composition and temperature regions where data were absent. Over a broad composition range, the electronic Lorenz functions that were calculated showed high temperature values significantly below the Sommerfeld value, \( L_0 = 2.443 \times 10^{-8} \) \( \text{V}^2\text{K}^{-2} \). These results strongly suggested the collection of additional experimental data to confirm the published extrapolation. Values for thermal conductivity, \( \lambda \), electrical resistivity, \( \rho \), and absolute Seebeck coefficient, \( S \), were measured for the alloys silver (50 wt %)–palladium (50 wt %) and copper (50 wt %)–nickel (50 wt %) in the temperature interval 300–1000 K. Results for the three transport properties presented in this paper show that the electronic Lorenz functions exceed the Sommerfeld value over most of the temperature range studied.

The experimental apparatus used in this work has been described in detail in papers by Moore et al.2,3 It is a guarded longitudinal heat flow apparatus designed to accept cylindrical samples approximately 1.0 cm in diameter and 7.6 cm in length. Measurements of heat flux and temperature gradient were made under steady state conditions and used to calculate thermal conductivity.

The Pt versus Pt-Rh (10%) thermocouples used to measure the temperature gradient were also used to determine \( \rho \) and \( S \). The \( \rho \) data were supplemented by a single room temperature value obtained using a high accuracy knife-edge device. The knife-edge apparatus was also used to determine distances between thermocouples. The total determinate errors for the heat flow apparatus are ±0.14 \( \mu \text{V K}^{-1} \) for \( S \), ±0.4\% for \( \rho \), ±1.3\% for \( \lambda \) at 300 K and ±2.2\% for \( \lambda \) at 1000 K. Results for \( \lambda \) and \( \rho \) measured with the heat flow apparatus are within the limits recommended by NBS for SRM 735 (\( \lambda \) ± 5\%) and SRM 798 (\( \rho \) ± 2\%).

Cylindrical rods of the two alloys were prepared by arc-casting equal weights of the elements present in each alloy. Cylindrical rods approximately 1.0 by 7.6 cm were machined and annealed prior to instrumentation and installation in the apparatus. A spectrographic analysis of the Cu-Ni alloy showed 0.03 wt \( \% \) Cr, 0.03 wt \( \% \) Si, an upper bound of 0.3\% As and small amounts of several other metals. Analytical results for both alloys showed C, O, N, and H concentrations in the low PPM range.

Smoothed results for \( \lambda \), \( \rho \), and \( S \) are given in Table 1 for the Cu-Ni alloy and in Table 2 for the Ag-Pd alloys. The smoothed values were obtained from a least squares fit of the experimental data. Table 3 contains the constants and identifies the equations used for the six data fits. For both of the alloys studied the measured thermal conductivity was 10–15\% above the values given by Ho et al.\(^1\)

Values for the electronic Lorenz function, \( L_e \), given in Tables 4 and 5 have been calculated for temperatures in the interval 400–1000 K by three methods using the following equation.

\[
L_e = (\lambda - \lambda_L) \rho / T
\]

The specific choices used for \( \lambda \), \( \lambda_L \), and \( \rho \) in each of the three calculations are indicated in Tables 4 and 5. Method C which utilizes data for \( \lambda \) and \( \rho \) and a calculated \( \lambda_L \) which includes an electron-phonon scattering term\(^5\) gives the best result for \( L_e \).

The experimental results given in this paper suggest re-examination of the reference data for the Ag-Pd and Cu-Ni alloys.\(^1\) The present results indicate a significant upward adjustment of the \( \lambda \) values for both alloys in the mid-composition range. The calculated \( L_e \), includes an estimate of lattice resistivity due to electron-phonon scattering, approach the Sommerfeld value at high temperatures and are offered as a replacement for earlier published values.\(^6\)