Previous theoretical proposals[9-11] to account for the general minimum phenomenon appear to be inadequate when considered in the light of these results.

I am grateful to Dr. W. B. Pearson for much help in the preparation of the copper alloys.

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Residual Resistance in Dilute Copper Alloys

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EXAMINATION of the resistance minimum occurring at ~10°K in dilute alloys of copper (reported above[1]) demanded as a check on alloy purity and concentration the detailed investigation of the resistance ratios $R_{4.2°K}/R_{273.2°K}$, and further of $R_{77.7°K}/R_{273.2°K}$ and $R_{90.2°K}/R_{273.2°K}$ for comparison with the classical results of Linde.[2] In general such data are of fundamental value when interpreted as cross sections,[3] for electron scattering and prominent deviations found from Linde's results forced us to undertake a systematic investigation. It is significant that all differences found so far are in the direction of lower cross section.

After extensive tests, alumina crucibles for high vacuum melting were chosen which caused no measurable contamination. Control spectrographic and chemical analyses were conducted during the experiments.

Linde's scattering determinations were based on measurements between liquid oxygen and room temperature, dependent on an assumed validity of Matthiessen's rule. Departures from this law, however, are now well known, particularly in the case of copper, and further confirmed by our experiments.

We find the following:

(1) In order to avoid serious errors due almost certainly to oxygen contamination, the final strain-relieving anneal after rolling or drawing must be carried out in a very high continuous vacuum, the specimen being freely suspended in a glass vessel. Following this technique in our work, pure (H.S.) Hilger copper (lab. No. 11,184) always yielded $R_{4.2°K}/R_{273.2°K}=2.9(\pm0.3)\times10^{-3}$ over a wide range of annealing temperatures and times. On the other hand, when a rolled strip received the final anneal in a fresh crucible sealed in an evacuated silica tube, a residual resistance some fortyfold greater was found, agreeing in magnitude with the range of specific resistance variation found by Linde using his annealing technique.

(2) Present results on dilute Cu—Sn alloys with oxygen contamination suggest that the absorbed atoms provide additional scattering centers approximately proportional to the number of already present (Sn) scattering centers. Apart from the general importance of such behavior, it follows that such experiments can yield an artificially high (but approximately constant) scattering cross section. We suggest that this explains the consistent but high cross sections which follow from Linde's work in certain cases.

(3) The figure illustrates some results obtained with dilute Cu—Ni (A), Cu—Sn (B), Cu—Ag (C), and Cu—C—Sn (D), alloys. The cross sections deduced for Ni and Ag call for little comment here; in particular, the scattering by Ni agrees very well with that of Linde. However, in the case of Sn (also Sb, not shown), which differs strongly in chemical valency from copper, the scattering as discussed above is much lower than found by Linde.

The major theoretical interest involved leads us to extend the work to the solute series: Zn→As and Cd→Sb.

(4) Investigation of carbon as an impurity led to curve D in Fig. 1 obtained for Sn alloys melted in spec-pure graphite cru-
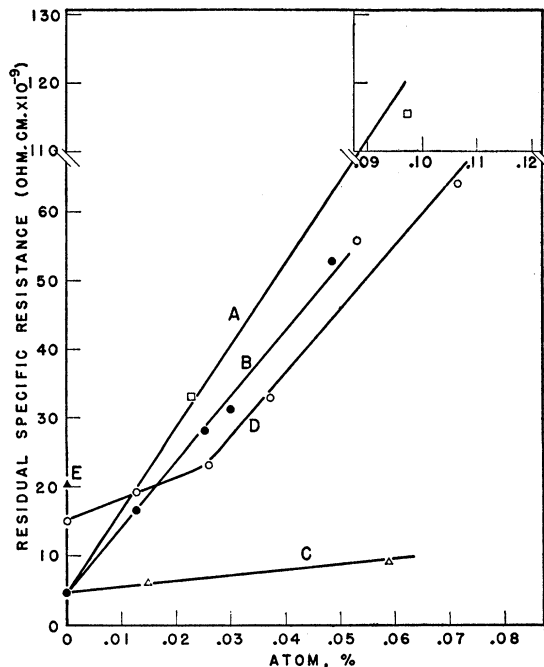

Fig. 1. Residual resistance of dilute alloys. A: Cu—Ni alloys; B: Cu—Sn alloys; C: Cu—Ag alloys; D: Cu—Sn alloys melted in spec-pure graphite crucibles; E: pure Cu melted with excess powdered graphite. (Specific resistances calculated on basis of 1.58×10^{-6} ohm cm for pure Cu at 0°C.)

cibles. That the initial additional scattering was indeed the result of carbon was confirmed by the inclusion of powdered graphite in a pure Cu melt (E). The remarkable fact emerges that, particularly for very low Sn concentrations, the scattering is far from additive. Excluding the virtually untenable hypothesis at these very low concentrations of a mutually ordered lattice structure, one is led to consider the possibility of some novel electron-ion interaction additional to the screened electrostatic potential (e^2e^{-qr}/r) normally postulated in the theory of metallic resistance.[3] In view of the associated anomaly in the resistance minimum remarked above it appears possible that some type of "resonant" interaction is involved, perhaps analogous to that proposed by Gerritsen and Korringa[4] as a special case in Ag—Mn alloys.

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The Quenching-in of Lattice Vacancies in Pure Gold*

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ALTHOUGH diffusion in close-packed lattices probably occurs as a result of the migration of vacancies, direct experimental evidence is meager. At present the main support for the theory stems from the Kirkendall effect[1] and from the agreement with