

control of the temperature of the bomb is difficult without a vacuum jacket, we had inadvertently cooled the bomb very rapidly after changing the pressure. We thought this might have caused strain and a consequent increase in resistance both on solidification and melting of the helium; we therefore re-applied the pressure and took care to cool the bomb slowly through the solidification region of the helium. This time the resistance fell on releasing the pressure, though not quite to its original value.

This kind of behaviour recalls that found by Hatton (1955) in his experiments on residual resistance using solid hydrogen as the pressure transmitting medium. The order of magnitude of the effect in our experiments could certainly be accounted for by slight non-hydrostatic straining of the specimen (cf. Pearson 1954), and it may be that this is the cause of the 'permanent' changes of resistance in Hatton's specimens. Because small non-hydrostatic strains may have such relatively large effects it is reassuring that the results on sample I by the solid helium method agreed well with those using truly hydrostatic pressure.

Finally, it should be noted that the pressure coefficients of 'ideal' resistance derived from samples I and II are appreciably different from each other and from those of Bridgman (see figure 3). We do not at present understand the reason for this.

5. DISCUSSION; COMPARISON WITH THEORY

In comparing our experimental results with the predictions of theory it is convenient to consider separately the effect of pressure (*a*) on the thermal component of resistance—the so-called 'ideal' resistance, (*b*) on the residual resistance, and (*c*) on the resistance minimum.

(a) Pressure coefficient of the ideal resistance of copper

(i) The temperature dependence of the pressure coefficient

In considering the pressure dependence of the equilibrium properties of solids, the Grüneisen model of a solid has proved of great value. A Grüneisen solid may be defined as one in which the entropy dependence on temperature and volume has the following functional form: $S = S(\theta/T)$, where θ depends only on the volume. If the entropy is of this form then it becomes possible to relate the isothermal pressure dependence of the entropy to the temperature dependence of the entropy, i.e. the thermal expansion to the specific heat. This gives, in fact, Grüneisen's law of thermal expansion. The only quantity involved other than readily measurable thermodynamic quantities is the volume or pressure dependence of θ . (The Grüneisen relation is indeed frequently used to obtain a measure of this dependence.)

In a precisely similar manner, we find that the pressure dependence of the ideal resistivity of a metal is most easily discussed in terms of an analogous Grüneisen metal, i.e. one in which $\rho_i = (K/T)f(\theta_R/T)$.* Here K is a quantity which is independent of temperature but may change with pressure, and θ_R is a temperature which is characteristic of the resistive behaviour of the metal and assumed to depend only on volume. If this assumption is valid then it becomes possible to relate the pressure

* There are theoretical reasons for expecting this form of temperature dependence, see MacDonald (1956).

dependence of the pressure d

By making about the latt between $d\rho_i/c$ dependence of theoretical for experiment (cf pressure coeff temperature co

To obtain an expression der that $d \ln \theta_R / dp$ expansion coel volume. In wh

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If all the ass and theoretical $(1/K) dK/dp$. † specimens, but should compar 100° K the dev well be attribut deviations from temperatures (also known the trical resistance valuable as at l

Despite these the temperatur Grüneisen's the

* The function present problem.

† In that case, the change of co relatively small.