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The effect of pressure on the electrical resistance of lithium, sodium and potassium at low temperatures

By J. S. DUGDALE

Division of Pure Physics, National Research Council, Ottawa

AND D. GUGAN

H. H. Wills Physics Laboratory, University of Bristol

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Measurements have been made of the electrical resistivity of lithium, sodium and potassium at temperatures between 2 and 300 °K and at pressures up to 3000 atm. From our results we have calculated the ideal electrical resistivity, ρ_i , and its volume derivative as functions of temperature for conditions of constant density. It is shown that, as predicted by simple theory, there is a linear relation between the temperature and volume coefficients of ρ_i for each metal. We conclude that the magnitude of the volume coefficient of ρ_i does not, at high temperatures at least, agree with present theoretical predictions and that this coefficient is closely connected with the high-temperature value of the thermoelectric power.

1. INTRODUCTION

In order to obtain a general understanding of how the effect of pressure on the electrical resistivity of a pure metal changes with temperature it is convenient to make use of the following simple expression for the ideal electrical resistivity of a metal:

$$\rho_i = \frac{KT}{M\theta_R^2} f(T/\theta_R). \quad (1)$$

θ_R is here a constant, having the dimensions of temperature, which characterizes the resistive properties of the metal, M is the mass of the metallic ions, and K is a parameter which measures the interaction between the conduction electrons and the lattice vibrations. f is a function which becomes constant at high temperatures and which at very low temperatures is expected to vary as $(T/\theta_R)^4$. One example of such a function occurs in the Bloch-Grüneisen expression for the temperature dependence of the ideal resistivity of a metal, but for our present purposes we do not need to make any assumption about the form of f except that it is independent of volume. We emphasize, however, that K and θ_R are assumed to be independent of temperature and to depend only on the volume.

Under these conditions, the *volume* coefficient of the ideal resistivity is related to the temperature coefficient of the ideal resistivity in the following way:

$$\left(\frac{\partial \ln \rho_i}{\partial \ln V}\right)_T = \frac{d \ln K}{d \ln V} - \frac{d \ln \theta_R}{d \ln V} \left\{ 1 + \left(\frac{\partial \ln \rho_i}{\partial \ln T}\right)_V \right\}. \quad (2)$$

At high temperatures ($T \gtrsim \theta$) $\partial \ln \rho_i / \partial \ln T$ tends to unity for most metals (at least at constant density) so that in this region we may write:

$$\partial \ln \rho_i / \partial \ln V = (d \ln K / d \ln V) + 2\gamma_R, \quad (3)$$