TEMPERATURE DEPENDENCE OF THE ELECTRICAL RESISTANCE OF COBALT BETWEEN 1.3 *AND* 4.2°K

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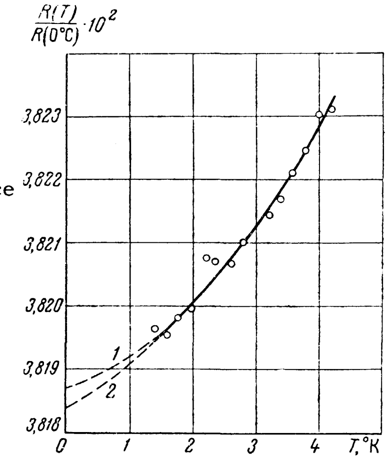
The temperature dependence of the electrical resistance of the ferromagnetic metal cobalt has been measured over the temperature range from 1.3 to 4.2°K. It has been found that for cobalt, as for iron and nickel, investigated previously, the resistance-temperature diagram has a characteristic form which is due to the scattering of electrons by spin waves (which contributes a linear term). Over the range from 1.3 to 4.2°K, the temperature dependence of the additional resistance can be described by a binomial containing a linear term and a term in T^2. The coefficient of the linear term is at least as large as that for iron, and larger than that for nickel.

THE temperature dependence of the electrical resistance of the ferromagnetic metals has a characteristic form in the helium temperature region, due to additional scattering of the conduction electrons by spin waves. The spin component of the electrical resistance at helium temperatures may be represented in the form[1,2] $\rho = AT + bT^2$. At the same time, in the true, but non-ferromagnetic, transition metals (e.g. platinum)[3,4] the electrical resistance at low temperatures is chiefly determined by the scattering of electrons upon impurities, and is described by the relation $\rho = \rho_0 + CT^2$. Thus for the ferromagnetic metals the electrical resistance in this temperature region is described by the expression $\rho = \rho_0 + AT + BT^2$, where the quadratic term incorporates both scattering mechanisms.

The existence of an electrical resistance relation of this form at helium temperatures has already been observed for iron and nickel[3,5-7]. It is naturally of interest, therefore, to measure the temperature dependence of the electrical resistance for other ferromagnetic metals as well. The present communication reports the data obtained from measurements made on cobalt.

The cobalt samples investigated had a purity of 99.9984%, and a residual resistance $r = R(0°K)/R(0°C) = (3.8185 \pm 0.0002) \times 10^{-2}$. The specimens were prepared by electric-spark cutting from a Co rod 5 mm in diameter, and had a cross-section of $\sim 0.30 \times 0.25$ mm^2 and a length of ~ 35 mm. The electrical resistance measurements were conducted over the temperature range from 1.3 to 4.2°K. The terrestrial magnetic field was compensated by means of a set of Helmholtz coils.

The results of the measurements on one of the cobalt specimens are presented in the figure.



Temperature dependence of the relative electrical resistance of cobalt.

Over this temperature range, the curve R(T) is described, as for iron and nickel, by an expression of the form

$$R(T)/R(0°C) = r + AT + BT^2,$$
$$A = (3.3 - 5.5)\cdot 10^{-6}, \qquad B = (1.5 - 1.7)\cdot 10^{-6}.$$

Owing to the comparatively large residual resistance r, it was impossible to achieve great accuracy in determining the temperature-dependent component of the electrical resistance; curves 1 and 2 in the figure correspond to the following values for the coefficients:

$$1 - A = 3.3\cdot 10^{-6}, \quad B = 1.7\cdot 10^{-6}, \quad r = 3.8187\cdot 10^{-2},$$
$$2 - A = 5.5\cdot 10^{-6}, \quad B = 1.5\cdot 10^{-6}, \quad r = 3.8184\cdot 10^{-2}.$$

From these data it may be concluded that within the temperature range under study cobalt shows a singularity in the temperature dependence of its electrical resistance which is due to the scattering of conduction electrons by spin waves. This is manifest by the appearance of the linear term in R(T). The coefficient of the linear term is no smaller than that for iron, and larger than that for nickel.

As regards the quadratic term, it is of interest to note that it is of the same order of magnitude for iron, nickel[3], cobalt and platinum[3] (respectively, $\sim 1.1 \times 10^{-6}$, $\sim 2.7 \times 10^{-6}$, $\sim 1.6 \times 10^{-6}$, and $\sim 1.8 \times 10^{-6}$). This indicates that the quadratic component associated with the spin scattering mechanism is, in all probability, either small, or of the same order as that for the electron-electron interaction.

Clearly, going in the future to higher purity cobalt and lower temperatures (as was the case for iron[7]) will permit a more accurate determination of the coefficients in the resistance-temperature relation for cobalt.

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