Magneto-Resistance of Copper to 150,000 Oersted at 4·2° K.

Some aspects of the theory of magneto-resistance in metals can best be tested in very high magnetic fields at low temperatures[1]. We are therefore extending magneto-resistance measurements at helium temperatures to field-strengths of approximately 150,000 oersted. Such fields can only be produced at reasonable cost by employing Kapitza's technique[2] of short field pulses. De Haas and Westerdijk[3] have shown that much improved efficiency results from cooling the magnet coil in liquid helium or hydrogen, and this has been discussed in detail by one of us[4].

In our experiments the specimen was mounted inside a small solenoid immersed in liquid helium. The discharge of a bank of condensers through the solenoid produced magnetic fields up to 160,000 oersted for about one millisecond. The current in the solenoid, and the voltage generated across the specimen by an alternating measuring current of frequency about 10 kc./s., were presented on the screen of a double-beam oscillograph.

Fig. 1 shows the resistance change $\Delta R/R$ for commercial copper wire of diameter 0·1 mm.; residual resistance $R_{He}/R_{ice} = 0{\cdot}89$ per cent. One specimen was wound helically to be exposed to a transverse field. The other was placed mainly parallel to the field with approximately 15 per cent of its length at right angles to it. The error due to skin effect is less than a half per cent.

Grüneisen and Adenstedt[5] have made measurements on a single-crystal specimen of copper of approximately ten times lower residual resistance in fields up to 12,000 oersted. Our transverse results are consistent within about 30 per cent with their measurements in the direction of greatest change of resistance if Kohler's rule that $\Delta R/R$ is a function of (H/R) is correct. No comparable data are available for the longitudinal case. Our results thus provide a test of Kohler's rule in a region of magnetic field where there have hitherto been no measurements.

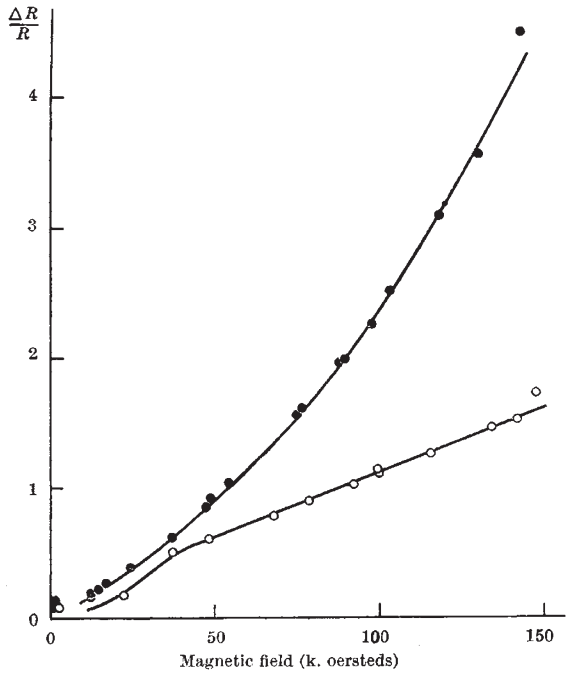

Fig. 1. Variation of electrical resistance with magnetic field in copper at 4·2° K. O —— O, longitudinal field; ● —— ●, transverse field

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Anomalous Temperature Coefficient of Permittivity in Barium Titanate

While engaged in tests on the 'ageing' of the permittivity of a sample of ceramic barium titanate, an observation was made which may be of interest in connexion with the theory of this substance. The sample was held at a temperature of 125° C., about 1° below the Curie point through which the sample had just been cooled. It was found that the temperature cycling due to the operation of the thermostat caused the capacitance of the sample to cycle in the opposite sense, that is, a negative temperature coefficient was observed, whereas the normal permittivity curve has, of course, a high positive slope just below the Curie point. A phase lag between the switching of the thermostat and the sample temperature was at first suspected; but a test made with a thermocouple clamped to the specimen and the on–off cycle very much slowed down gave the same result.

It is well known from X-ray diffraction work[1,2] that for a few degrees near the Curie temperature the cubic and tetragonal phases of barium titanate can co-exist in the same crystal. It now appears that a quite finite increment in temperature is needed to change the proportions of cubic and tetragonal material, for the effect described is easily explained by postulating that this ratio remains constant during the small temperature fluctuations (0·1° C.) due to the thermostat. The relatively high negative temperature coefficient of the cubic phase swamps the positive temperature coefficient of the tetragonal phase, so that a negative coefficient of capacitance is observed. An order-of-magnitude calculation shows the plausibility of this explanation. The measured permittivity of the sample at 125° C. was 4,100, while the permittivity of the cubic phase at this temperature and its temperature coefficient would be 6,600 and − 5 per cent per deg. C., as obtained by extrapolation of the Curie–Weiss law which holds above the Curie point. Values for the tetragonal phase are more difficult to extrapolate since no empirical law has been found for the part of the curve just below the Curie point. By continuing the slight upward curvature found between 105° and 118°, a permittivity of 2,200 and a temperature coefficient of + 3·5 per cent per deg. C. has been estimated for 125° C. Using the logarithmic mixture law, it is found that 55 per cent cubic phase and 45 per cent tetragonal phase will give the correct resultant permittivity of 4,100. The resultant temperature coefficient calculated with these proportions