GALVANOMAGNETIC PROPERTIES OF INDIUM IN STRONG EFFECTIVE FIELDS

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The anisotropy of the resistance in a magnetic field and the dependence of the resistance on this field were investigated for single-crystal samples of indium. Measurements were carried out at 20.4 and 4.2°K in fields up to 35,000 Oe. The results confirm that the Fermi surface of indium is closed.

THE available literature data on the galvanomagnetic properties of indium[1-4] permit the conclusion that it is one of the metals having a closed Fermi surface. Magnetoacoustic measurements have confirmed this hypothesis.[5] Detailed measurements of the anisotropy of the galvanomagnetic properties of indium single crystals in strong effective fields have not yet been carried out.

In the present work the anisotropy of the resistance in a magnetic field and the dependence of the resistance on this field were studied in single crystals of pure indium for various orientations of the field with respect to the crystallographic axes.

The indium samples were cylindrical in shape. The sample diameter was 1.8—2 mm. Judging by the rotation diagrams and optical measurements on sample In-1, its axis was close to the four-fold symmetry axis; in sample In-2 the axis was obviously very nearly parallel to [111], while in In-3 the rotation diagram had two-fold symmetry. The deviation of the axes from these directions did not exceed 20°. The orientation of sample In-4 was similar to that of In-3.

The properties of the test samples were as follows:

	In-1	In-2	In-3	In-4
R_{273}/R_{20}:	—	50	50	50
$R_{273}/R_{4,2}$:	12400	12300	8000	3450

Measurements were carried out at temperatures of 20.4 and 4.2°K in magnetic fields up to 35,000 Oe. The current was directed along the sample axis and the magnetic field was always perpendicular to the current.

Figure 1 gives the rotation diagrams for the resistance in a magnetic field for samples In-1, In-2, and In-3. The orientation of sample In-4, as mentioned above, almost coincided with that of In-3 and, therefore, the rotation diagram of the former is not given. The diagrams for samples In-1 and In-2 were obtained in a field of 24,600 Oe, and those for samples In-3 and In-4 in a field of 35,000 Oe. It is clear from Fig. 1 that the resistance anisotropy is small in all samples. The maximum deviation from the average value is 15%.

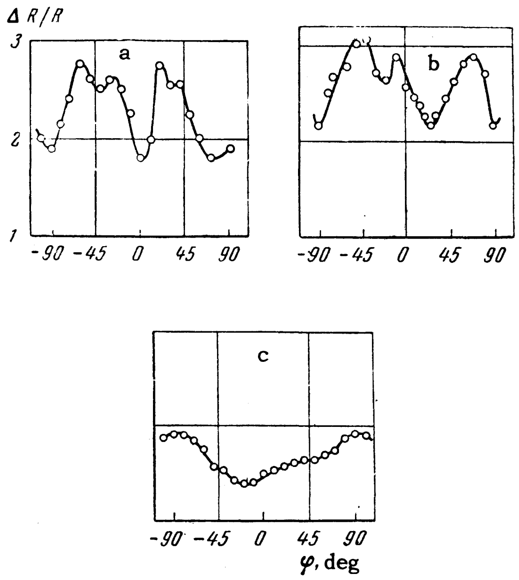

FIG. 1. Anisotropy of the resistance of indium samples at T = 2.4°K: a) In-1, H = 24 600 Oe; b) In-2, H = 24 600 Oe; c) In-3, H = 35 000 Oe (φ is the angle between the magnetic field and some fixed direction in a plane perpendicular to the current).

The dependence of the resistance on the magnetic field for various orientations of the latter with respect to the crystallographic axes is given in Figs. 2 and 3 for T = 4.2°K. It is clear that for all samples and directions the resistance in strong fields tends to saturation. The value of the relative change in resistance ΔR/R is about − 2 to − 3 at saturation.

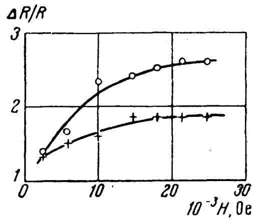

FIG. 2. Dependence of the resistance on the magnetic field for sample In-1 in the directions of the minimum and maximum in the rotation diagram.

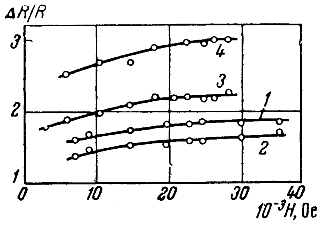

FIG. 3. Dependence of the resistance on the magnetic field for indium: 1) In-3; 2) In-4; 3) and 4) In-2 in the directions of the minimum and maximum in the rotation diagram.

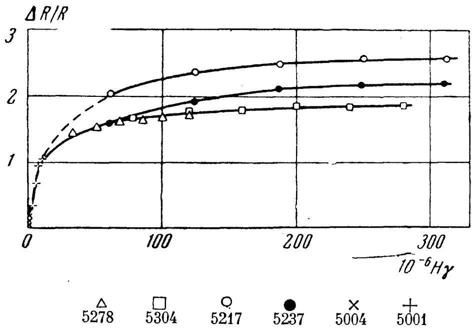

FIG. 4. Dependence of the resistance on the magnetic field in Kohler's coordinates for indium ($\gamma = R_{273}/R_T$): Δ – In-3, T = 4.2°K; □ – In-4, T = 4.2°K; ○ – In-2, T = 4.2°K; ● – In-1, T = 4.2°K; × – according to [1], T = 20.4°K; + – according to [1], T = 4.2°K.

At the temperature 20.4°K measurements were also carried out of the resistance anisotropy in the magnetic field and of the dependence of the resistance on the value of this field. Measurements showed that the resistance in the magnetic field is practically isotropic and the maximum relative increase of the resistance in a field H = 35,000 Oe is $\Delta R/R = 0.16$. The resistance of indium falls only by a factor of 50 on cooling from room temperature to 20.4°K and, therefore, we are dealing with weak effective fields.

Figure 4 shows the dependence of the resistance on the magnetic field in Kohler's coordinates (i.e., the dependence of $\Delta R/R$ on the quantity HR_{273}/R_T, which is a measure of the effective magnetic field) for indium samples of various purities. This figure gives the results for an indium sample with $R_{273}/R_{4.2} = 590$ investigated by Borovik[1] and for our samples. For single crystals the average values of $\Delta R/R$ are given. In strong effective fields the points do not lie on a single curve but the deviation from the average value does not exceed 15%. This anisotropy may be ascribed to the different crystallographic orientations of the single-crystal samples.

The isotropy of the galvanomagnetic properties of indium and the fact that the same law describes the dependence of the resistance on the magnetic field for different directions of this field with respect to the crystallographic axes confirm that the Fermi surface of this metal is closed.

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