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DISTRIBUTION OF CURRENT IN THE RESISTIVE STATE OF A TYPE II SUPERCONDUCTOR

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In memory of Professor H. Niewodniczański

The distribution of the magnetic field in a slot cut in the middle part of an $In_{94}Pb_6$ cylinder (a type-II superconductor) carrying a current was measured by means of a bismuth probe. The change of the magnetic induction along the radius of the specimen allowed us to infer the distribution of the current density. Fluctuations of the current distribution were observed just at the transition to the resistive state.

In order to investigate the destruction of superconductivity by an electrical current we have determined the distribution of the magnetic induction and the current density in a cylindrical superconductor placed in zero external field. Earlier measurements of this kind, also performed in our laboratory, were concerned with type I superconductors. In the present work we have extended the same method of measurements to type II superconductors.

The sample made of 94 at. % In and 6 at. % Pb was cylindrical in shape, 75 mm long and 4 mm in diameter. For homogeneity the specimen was thermally treated at 413°K for 18 days.

From the other measurements [1] it is known that the transition temperature for this alloy is 3.802°K and the Ginzburg-Landau parameter $\varkappa$ is 0.96.

In the middle part of the sample there was a narrow slit cut out along a diameter plane. The magnetic induction inside the slit was measured by a bismuth probe, 20 μm thick and 2.5 mm long. The probe was aligned parallelly to the sample axis. It was moved along the slit in the radial direction by a mechanism with a micrometer screw. The schematic diagram of the experimental arrangement is shown in Fig. 1. In order to avoid the influence of the external magnetic field the cryostat was shielded by a permalloy sheath and coaxial current leads were used. Preliminary results of measurements of the magnetic induction have been recently published [2].

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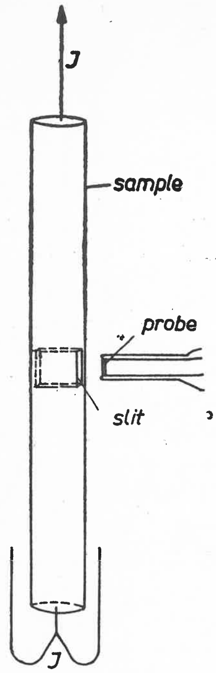

Fig. 1. Diagram of the experiment

The radial distribution of the axial component of the total current density may be determined on the basis of these measurements using the relation $\frac{1}{r}\cdot\frac{d(rB)}{dr} = j$, where r is the distance from the sample axis, B is magnetic induction, and j is the total current density. However, for determining the density of the transport current the radial distribution of the magnetic field (H) should be known. In roughly estimating the density of the transport current we have considered that, for $H > H_{c1}$, the contribution of the shielding current is rather small.

Figure 2 shows the current density in the investigated sample at different temperatures. The current flowing through the sample was constant for all temperatures and equal to 26 A. Owing to the edge effect of the slit, measurements of the magnetic induction were unadequate at distances less than 0.3 mm from the sample surface; therefore, the values of current density in the vicinity of the sample surface (the dashed parts of the curves in Fig. 2) were obtained by extrapolation.

The curve a in Fig. 2 indicates the current density distribution when the resistance just begins to appear, *i. e.* when the magnetic field of the current reaches the value of H_{c1} at the sample surface. For the inner part of the sample the current density in this case has not been calculated because of trapped flux.

With an increase in temperature to about 3.654°K the distribution of current density becomes unstable and varies with time. In this nonstationary flow of current the role played by the release of Joule heat seems to be highly important.

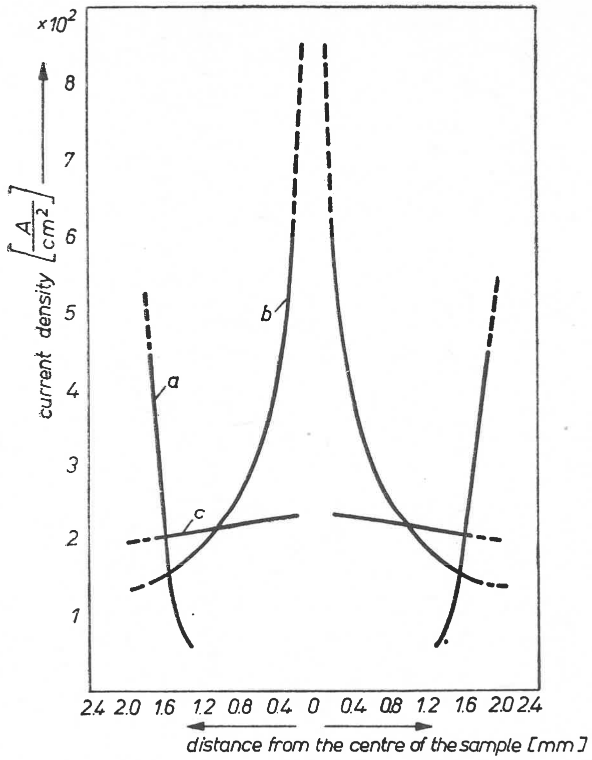

Fig. 2. Dependence of the current density on the distance from the axis of the specimen. *a* – 3.640°K, *b* – 3.654°K, *c* – 3.766°K

When the temperature attains the value 3.654°K (curve *b* in Fig. 2) the stable flow of current begins and the current density reaches maximum value in an axial portion of the sample.

With the sample approaching the normal state, the current density becomes independent on the radial distance (curve *c*).

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