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# CHARACTERISTIC OF THE ELECTRIC FIELD IN THE RESISTIVE STATE OF TYPE-II SUPERCONDUCTOR*

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It has been established that in a sample of type-II superconductor in the resistive state the transversal voltage occurs when the current flows along the sample axis. The dependence of the transversal voltage on current and the position of the contacts have been estimated. It is assumed that the occurrence of the transversal voltage is caused by the motion of the magnetic flux quanta in the sample.

As we have reported earlier [1], the distribution of the magnetic induction in a cylindrical sample of type-II superconductor carrying a current greater than the critical value takes a characteristic form. It permits the distribution of the total current density to be determined in a sample in the resistive state [2]. Hence, the question arises of whether it is also possible to observe any motion of the vortices in the resistive state due to the electrical current which destroys superconductivity in the absence of the external magnetic field.

In the present paper we report the results of measurements of the electrical field intensity between two contacts (denoted $A$ and $B$ in Fig. 1). The contact $B$ was mounted on the sample axis (in the middle of the cylinder); the slipping contact $A$ was placed on the sample surface. The latter could be shifted by means of a micrometer screw.

The sample 80 mm long and 4 mm in diameter was made of In + 10% Pb alloy by casting in a cylindrical mould and keeping it at room temperature for one month.

Other contacts, $C$ and $D$, for measuring the longitudinal voltage ($U_{||}$) were fastened mechanically 46 mm apart to the sample. The current leads were concentric in shape. A permalloy screen shielded the sample from the external laboratory magnetic field. The dependence of the voltages $U$ and $U_{||}$ on current at temperatures below the Onnes temperature ($T_c = 3.80$K) were recorded with an $x-y$ recorder. A Keithley type 149 milli-

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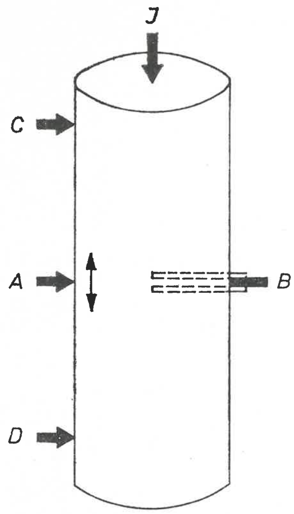


Fig. 1. Scheme of the contact positions on the sample

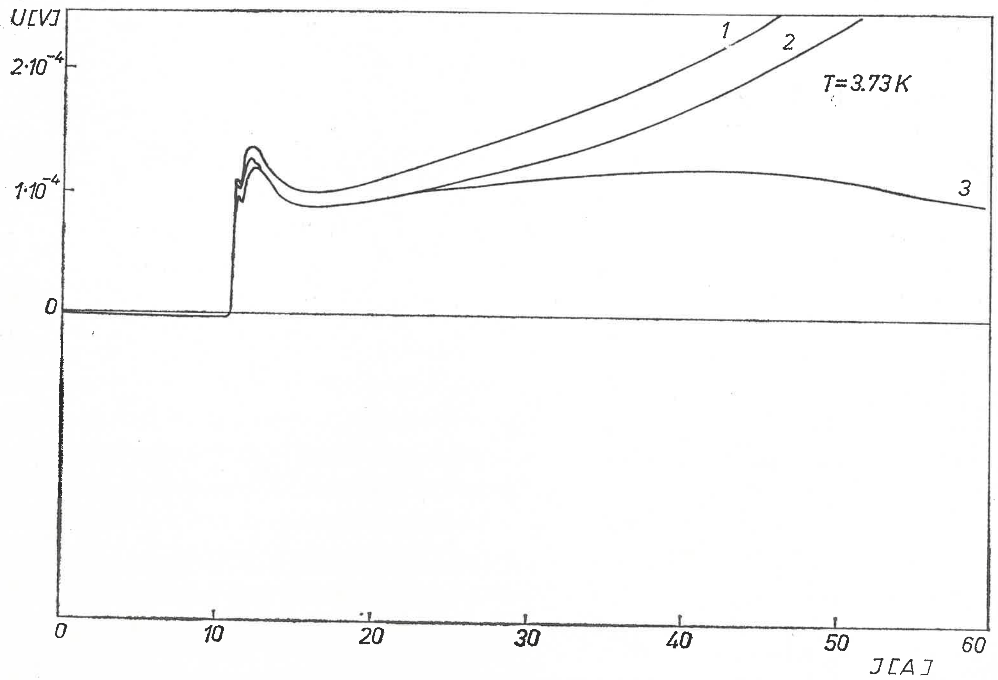


Fig. 2. The family of the curves $U(I)$ obtained by slightly shifting contact $A$ in one direction

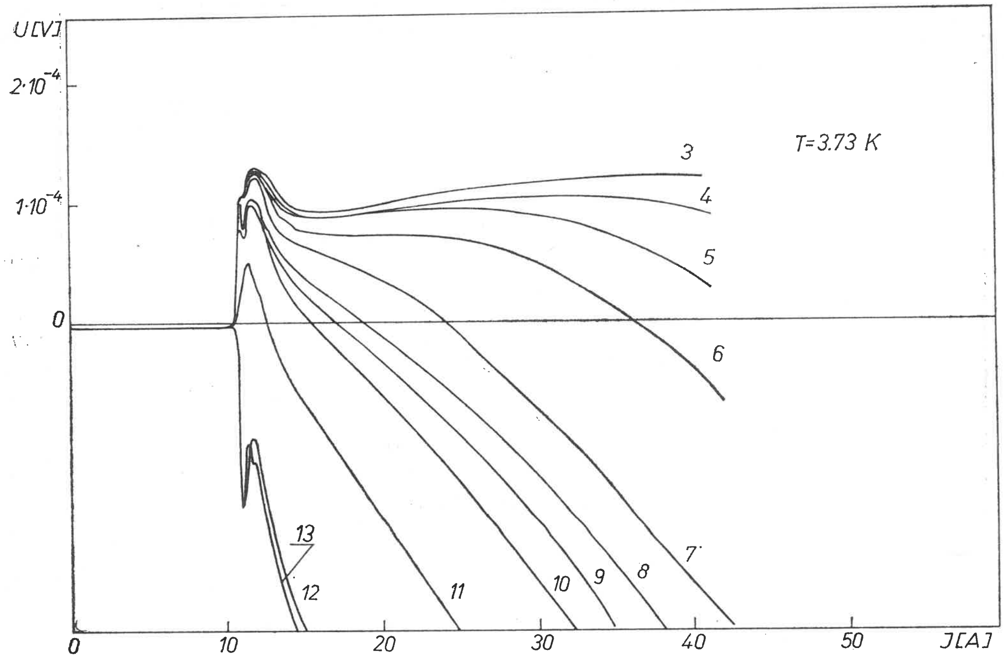


Fig. 3. The family of the curves $U(I)$ obtained by slightly shifting contact $A$ in one direction

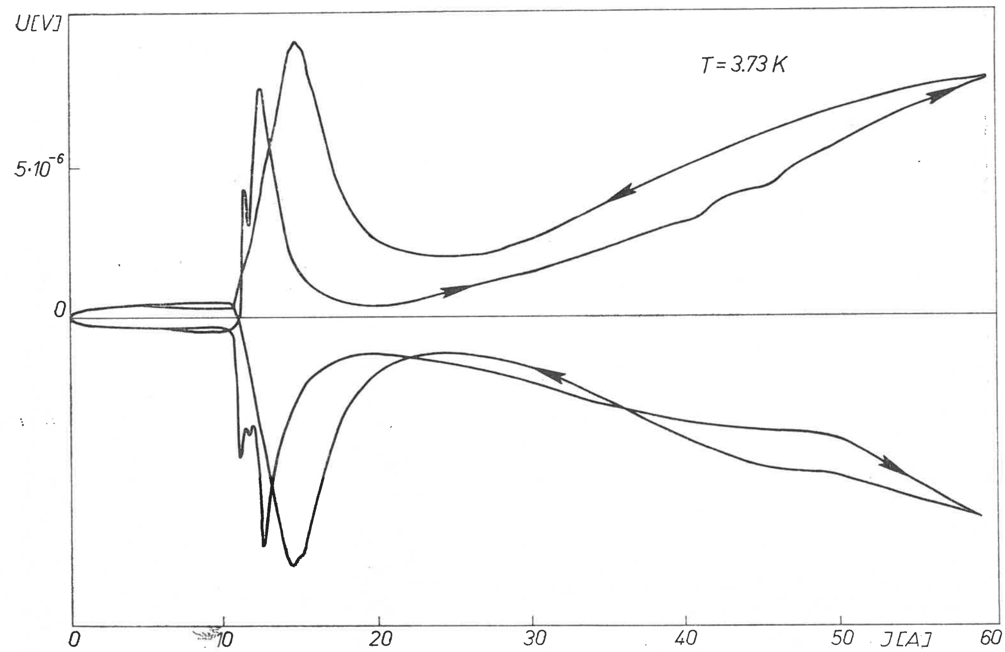


Fig. 4. Dependence $U(I)$ at 3.73 K. The position of contact $A$ is fixed at 4.2 K

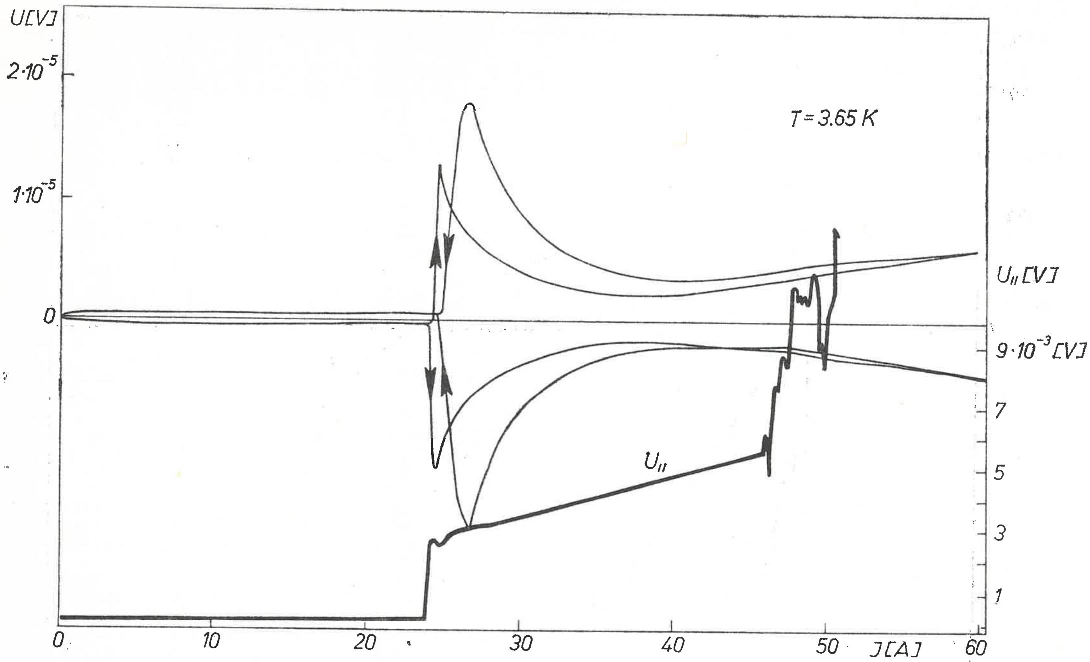


Fig. 5. Dependence $U(I)$ at 3.65 K. The position of contact $A$ is fixed at 4.2 K. The $U_{||}(I)$ curve shows the measured longitudinal voltage across the sample

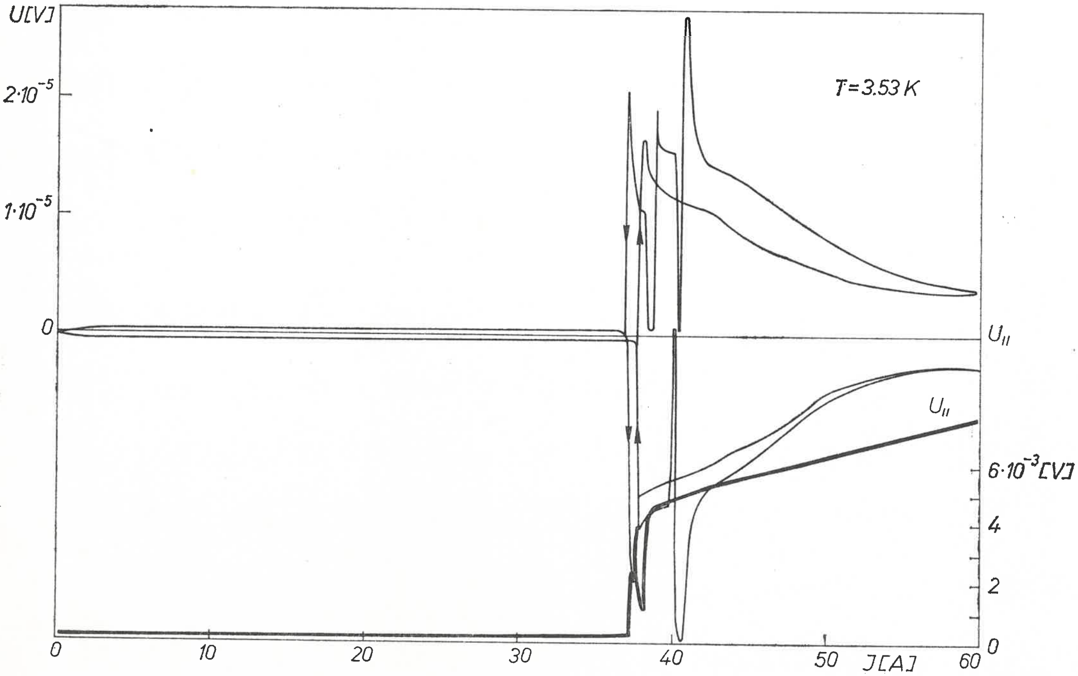


Fig. 6. Dependence $U(I)$ at 3.53 K. The position of contact $A$ is fixed at 4.2 K. The $U_{||}(I)$ curve shows the measured longitudinal voltage across the sample

-microvoltmeter and F 116/1 photo-microvoltampermeter were used as amplifiers. The current was variable from zero to 60 A.

Figures 2 and 3 show the family of curves obtained for several positions of the contact *A* on the sample surface. The change in position of this contact was performed by moving it in one direction only by small steps of about 100 μm.

At the instant of transition into the resistive state the voltage appears. For different positions of the contact *A* the voltage varies with increasing current in the following way:

a) the measured voltage decreases with increasing current to about 15 A and then rises again (curves *1* to *3* in Fig. 2), b) the measured voltage decreases monotonically (curves *6* to *11* in Fig. 3), c) the measured voltage changes its sign (curves *12* and *13* in Fig. 3).

The temperature of the helium bath during the run was kept constant. The dependence of the curve shape on the position of the slipping contact *A*, given in Figs 2 and 3, indicates that during the transition to the resistive state the transversal voltage appears. There is also a longitudinal voltage due to a small shift of the contant *A* away from the plane passing through the contact *B* perpendicularly to the sample axis. In order to eliminate this longitudinal component of voltage, the position of the contact *A* with respect to contact *B* was established so as to obtain a minimum of the voltage *U* (amounting to no more than $\pm 1$ μV) in the normal state.

Figures 4, 5 and 6 show the results of the recordings of the transversal voltage $U(I)$ for temperatures 3.73, 3.65 and 3.53 K, respectively. The upper and lower curves were obtained for opposite directions of current. In Figs 5 and 6 there are also plotted the voltages $U_{||}(I)$. The final part of the $U_{||}(I)$ curve in Fig. 5 is deformed owing to random (external) disturbances during the measurements. It should be noted that at the transition of the sample to the resistive state at 3.53 K strong voltage fluctuations appear. They are shown in Fig. 6.

The symmetry of the curves given in Figs 4, 5 and 6, indicates that within measurement accuracy there is no additional transversal voltage independent of the current direction. It is worthwhile to note that all the curves $U(I)$ given in Figs 4,5 and 6 are similar in shape. On the basis of the results given above the conclusion can be drawn that the occurrence of the transversal voltage in the resistive state results from the motion of the vortices. The occurrence of this voltage and its value is probably due to the flow of magnetic flux quanta in the sample.

These findings should be treated as preliminary ones and further examination of this phenomenon should cast more light on this problem.

## REFERENCES

[1] A. Sikora, B. Makiej, E. Trojnar, *Phys. Letters*, **27A**, 175 (1968).
[2] B. Makiej, A. Sikora, E. Trojnar, *Acta Phys. Polon.*, **A38**, 449 (1970).