contact is produced by applying a destructive pressure on the metal and by breaking down the oxide with an electric discharge. As is well known, T_c may greatly exceed T_{cb}, for example, in the case of films condensed at low temperatures [6] or superconductors subjected to plastic deformation at low temperatures.

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GALVANOMAGNETIC PROPERTIES OF NIOBIUM SINGLE CRYSTALS

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The Fermi surfaces of a number of transition metals, including niobium, have not been thoroughly investigated as yet. The main reason is the difficulty is obtaining pure and sufficiently perfect single crystals of these metals. We measured the galvanomagnetic properties of niobium samples with resistance ratios $\alpha = \rho_{300^\circ K}/\rho_{4.2^\circ K}$ from 400 to 1000. The initial material were niobium single crystals obtained by zone melting in an electron-beam furnace. The single crystals were roasted after melting at 2200°C in an oxygen atmosphere and a pressure 10^{-4} mm Hg. They were then annealed for eight hours at 2200°C in a vacuum of 10^{-9} - 10^{-10} mm Hg. A mass-spectral analysis of the single crystals prepared in this manner revealed the presence of the impurities listed in the table. The samples were prepared by

Mass-spectral analysis of niobium

	Ta	Zr	W	Mo	Hf	Ti	Fe	Ni	Cu
C(10^{-4} at.%)	330	80	3	9	3	1	0.1	0.1	0.2

electric-spark cutting from the x-ray oriented single crystals. The samples usually measured 0.3 x 0.3 x 5 mm. They were etched in a mixture of hydrofluoric and nitric acid, after which current and potential leads, terminating in small drops of nickel, were attached to them. To prevent possible contamination during the welding of the potential leads, the samples were cut in such a way that small potential projections were provided at a distance of 1 mm from each end of the sample. The potential leads were then welded to these projections. The samples prepared in this manner were mounted either on a rotating holder located between the poles of permendur concentrators placed in a superconducting solenoid [1], or in the holder of a pulse

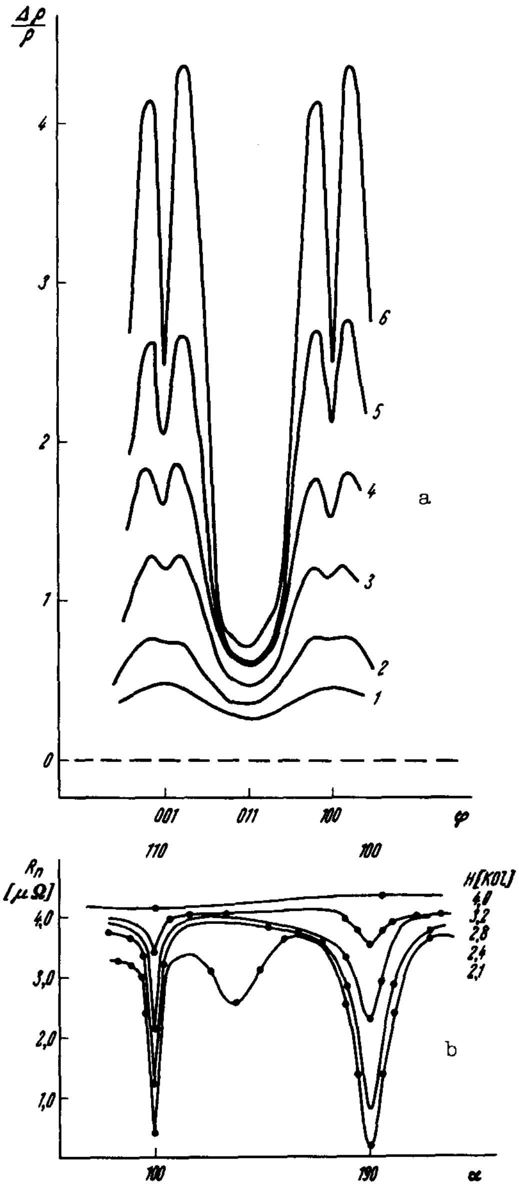

Fig. 1. a - $\rho_H(\phi)$ plots; curve 6 - sample No. 1, $\theta = 45^o$, $\phi = 0^o$, $\alpha = \rho_{300}/\rho_{4.2} = 1000$, H = 78 kOe; curves 1-5 - sample No. 11, $\theta = 45^o$, $\phi = 0^o$, $\alpha = 450$, fields: 1 - 22.3 kOe, 2 - 32 kOe, 3 - 46 kOe, 4 - 60 kOe, 5 - 73 kOe; b - $\rho_H(\phi)$ plot in weak fields for sample No.1.

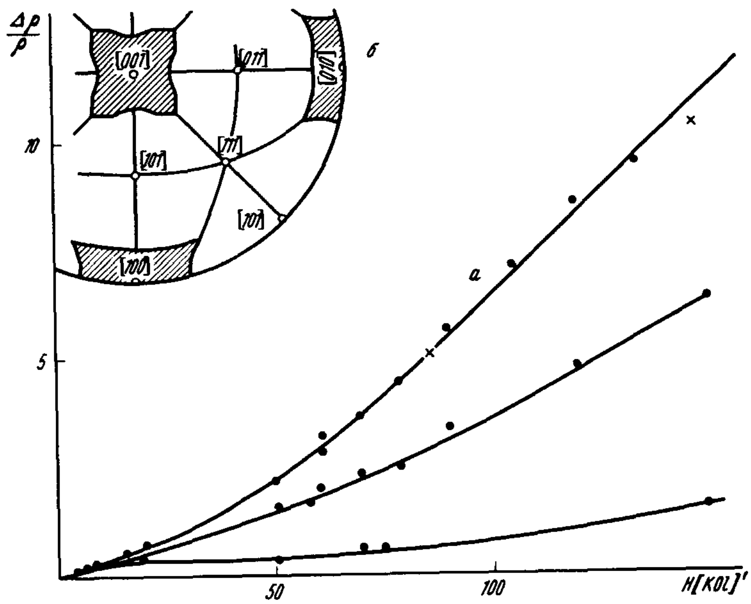

Fig. 2. a - $\rho_\phi(H)$ plot for sample No. 11 from data obtained in stationary and pulsed fields; b - stereographic projection of Nb

solenoid with copper winding [2].

In the former case, the measurements were made in stationary magnetic fields up to 80 kOe, and the $\rho_H(\phi)$ and $\rho_\phi(H)$ were obtained with automatic-plotting potentiometers (EPP-09 and PDS-021), while in the latter case the measurements were made in pulsed magnetic fields up to 250 kOe and the plots obtained with oscilloscopes. To measure the Hall emf, the samples were provided with two pairs of mutually-perpendicular potential leads.

The measurements were made on 16 samples with different relative orientations of the crystallographic and sample axes. Figure 1a shows $\rho_H(\phi)$ for samples 1 and 11, and Fig. 2a $\rho_\phi(H)$ plots for different ϕ. The obtained $\rho_\phi(H)$ plots, as can be seen from the curves, deviate from the theoretical ones; for example, complete saturation is not observed at the minimum, and in the maximum the exponent is smaller than 2, possibly owing to the relatively small excess (by a factor 2 - 3) of the employed fields over H_0.

It should be noted that in measurements in weak fields in the range 2 - 4 kOe (performed in the electrmagnet), we observed an appreciable anisotropy of the resistance as it went into the superconducting state (see Fig. 1b). The conductivity measurements were made here with samples having both quadratic and round sections. Such an anisotropy may be due, for example, to the anisotropy of the impurity or defect distribution in the sample, or else may be the result of anisotropy of the energy gap.

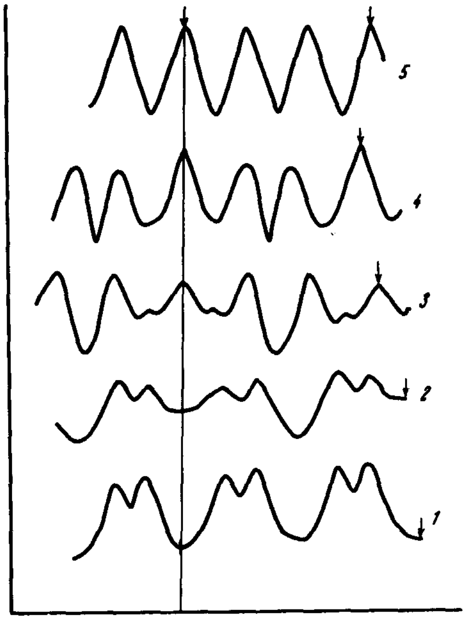

Fig. 3. $\rho_H(\phi)$ plot obtained with orientation varied from [001] and [111]: 1 - $\theta = 0°$, $\phi = 0°$; 2 - $\theta = 10°$, $\phi = 35°$; 3 - $\theta = 20°$, $\phi = 35°$; 4 - $\theta = 30°$, $\phi = 35°$; 5 - $\theta = 55°$, $\phi = 35°$

Starting from the obtained data and the $\rho_H(\phi)$ plots obtained while varying the orientation of the samples relative to the crystallographic axes (Fig. 3), we constructed a stereographic projection of the singular directions. In this projection, the two-dimensional regions of the singular directions lie only in the vicinities of fourfold axes (Fig. 2b). It can be concluded on the basis of the stereographic projection that Nb has an open Fermi surface in the form of a net of corrugated cylinders, whose axes lie parallel to the fourfold axes. The average diameter of the cylinders can be estimated from the size of the two-dimensional region at 0.27 V. The minimum cylinder diameter d_{min} can be estimated from measurements of the Hall emf in rational directions. Since Nb is an uncompensated metal, the determination of d_{min} calls for knowledge of $V_e - V_h$, which in turn can be determined from Hall-emf measurements in the direction of the minimum of the $\rho_H(\phi)$ dependence. Using the values of the Hall constant for the [001] and [110] directions, we get $d_{min} = 0.15$ V. If we take account of the fact that the corrugated cylinders of the open part of the niobium Fermi surface are not round, then we can assume that the agreement between the average d and d_{min} is satisfactory.

As is well known, the Fermi surface of metals of group V was calculated in a paper by Mattheiss [3]. Our data agree quite well with this surface, if it is assumed that it has open directions only along fourfold axes.

Upon completion of this paper we received a communication from Fawcett, Reed, and Soden, who investigated the galvanomagnetic properties of four samples of tantalum and one sample of niobium. Our data agree quite satisfactorily with their data on niobium.

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