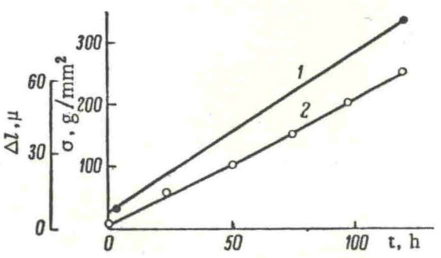

Fig. 1. Programmed loading of bismuth single crystals at room temperature and atmospheric pressure.

described earlier [5], using samples cut from the middle parts of the single-crystal rods. The pressure in the apparatus was raised up to 10 kbars at 77.3°K by means of a piston moving in a medium of solid nitrogen.

2. We can see from Fig. 1 that an increase of the applied stress at a rate of 3 g/mm² per hour up to 330 g/mm² resulted in a practically linear increase in the length without discontinuities in the "elongation-time" dependence. Discontinuous deformation has been observed [2, 3] at high loading rates of large crystals and during programmed loading of single-crystal samples of bismuth of small transverse cross section or in the presence of surface macrodefects. The discontinuities in the "elongation-time" curve, due to the appearance of twinned layers, were observed in the usual tests of bismuth single crystals at loads beginning from 160-200 g/mm². Increase of the resistance of single crystals to deformation and the absence of deformation discontinuities in our case (Fig. 1) could be explained by the diffusion hardening of weak points in the crystals, in which usual tests caused local overstresses comparable with the critical shear stresses required in twinning.

Program-hardened samples were used to investigate the change in the electrical resistivity due to uniform compression at low temperatures and the results were compared with the measurements carried out on the original (untreated) crystals.

Since the pressure in the solid nitrogen medium was not fully hydrostatic and since the structure of the untreated crystals was not uniform, irreversible shear was observed in these samples from 2-3 kbars, when a certain value of the tangential stress of the medium on the samples was reached. This increased the resistivity and destroyed the reversibility of the dependence of the electrical resistivity on pressure (Fig. 2a). When the load was increased, the electrical resistivity of a single crystal increased, but when the pressure was removed the resistivity remained about 30% higher than the initial value. Repetition of the application of pressure up to 9 kbars and the subsequent removal of the load continued to increase the residual electrical resistivity.

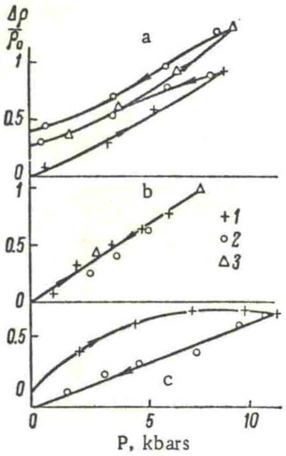

Fig. 2. Relative change in the electrical resistivity. $\Delta\rho/\rho_0$ of bismuth single crystals subjected to pressure at 77.3°K. a) Initial state; b) after programmed loading to 330 g/mm²; c) after programmed loading to 500 g/mm². 1) Pressure increasing; 2) pressure decreasing; 3) second increase in pressure.

In the case of a single crystal subjected to a preliminary programmed loading up to 330 g/cm², the electrical resistivity increased linearly with pressure up to 7.5 kbars and when the load was removed, the resistivity returned to its initial value (Fig. 2b). When pressure was applied again, the pressure dependence of the electrical resistivity coincided with the dependence obtained initially and after unloading no increase in the residual resistivity was observed.

Increase of the residual electrical resistivity after uniform compression of untreated bismuth single crystals was the consequence of the generation of a large number of defects, particularly in the first loading cycle. A preliminary programmed harding of bismuth single crystals produced a diffusion redistribution of point defects and dispersed local overstresses; this increased the structural uniformity of the whole crystal and reduced the probability of formation of new lattice defects in microvolumes.

The pressure dependence of the electrical resistivity was somewhat different for a single crystal which was slowly loaded first to 500 g/mm² until a residual deformation of 0.4% was observed. Figure 2a shows that when pressure was applied, the electrical resistivity of this crystal increased,