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VARIATION OF LOW-FREQUENCY COMPONENT OF THE ELECTRIC-RESISTANCE OSCILLATIONS OF ZINC IN A MAGNETIC FIELD AT PRESSURE 16,000 kg/cm^2

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In [1] there was observed a strong influence of pressure on the frequency of the lowest-frequency quantum oscillations of the electric resistance of zinc in a transverse magnetic field. At a pressure of 8100 kg/cm^2 (maximum pressure developed at helium temperatures by the bomb described in [2]) the period of the oscillations of $\Delta(1/H)$ for $\mathbf{H}\parallel[0001]$ and for current flowing through the sample in a direction lying in the (0001) plane was 2.1×10^{-5} Oe^{-1}, compared with 6.3×10^{-5} Oe^{-1} without pressure.

In fields stronger than 2500 Oe these oscillations are due, according to the latest data [3,4], to magnetic breakdown of the energy gap between the needle-like electronic part of the Fermi surface of the zinc, located along the side edge of the third Brillouin zone, and the hole surface of the second zone, called the "monster." The value of the gap includes the differences of the energies of the higher populated Landau level of each zone and the Fermi energy, which are periodic in the magnetic field. In the given particular case, owing to the fact that the effective mass for the needle-like part of the surface is approximately 100 times smaller than the mass for the "monster" [5], the periodicity is determined entirely by the value of the extremal section S_m of the needle-like surface, parallel to the (0001) plane. The periodicity of the energy gap in the magnetic field leads to periodicity of the electric resistivity.

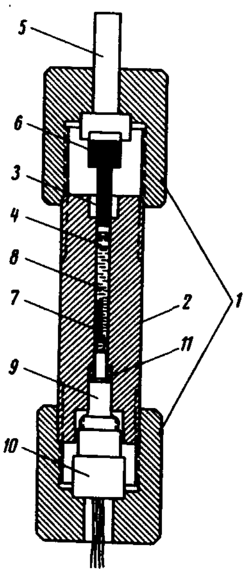

Fig. 1. Bomb

We have produced a new bomb (see Fig. 1), which makes it possible to develop hydrostatic pressure up to 18,000 kg/cm^2 at helium temperatures. Using this bomb, we traced the variation of the period of the oscillation in question to higher pressures.

We can note two important features of this bomb: a) the bomb container is self-sealing, b) the piston and the bearing are made of solid nonmagnetic microlite ceramic and nonmagnetic material. The maximum bomb diameter is 48 mm, the diameter of the working channel is 6.5 mm. The construction of the bomb is clear from Fig. 1, where 1 - locking nuts, 2 - bomb container, 3 - microlite piston with beryllium-bronze jacket, 4 - anvil and gasket, 5 - ram to transmit force from press, 6 - bearing of microlite in beryllium-bronze cup, 7 - sample, 8 - pressure-transmitting medium (oil-kerosene mixture), 9 - seal, 10 - seal bearing cylinder, 11 - seal gasket. The operating principle of the bomb is similar to that described in [2]. A detailed description of the bomb will be published in the near future.

The zinc single crystals used in the work were cut so that the sample axis was in the (0001) plane; $R_{300}/R_{4.2}$ = 15,000.

Measurements were made without pressure and at 11,100 and 15,900 kg/cm^2 in fields ranging from 2000 to 11,000 Oe. The pressure was determined either by measuring the superconducting transition temperature of a tin manometer, or by extrapolating the $P_{4.2}$ vs. P_{300} plot obtained in [2] to pressures above 11,000 kg/cm^2. Comparison of the two methods yielded an estimate of 5% for the error in pressure determination.

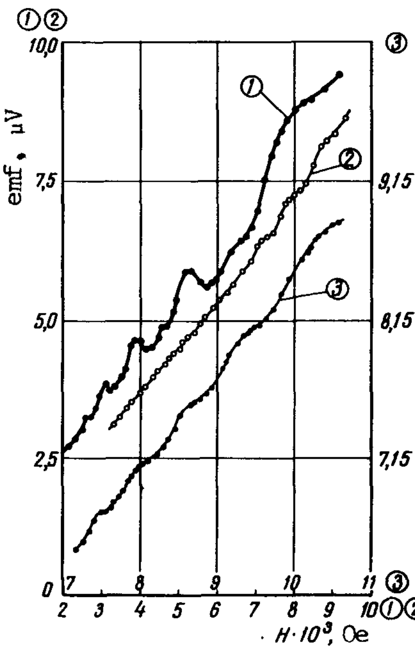

Fig. 2. Dependence of measured signal on the magnetic field: at pressures 0 (1), 11,100 (2), and 15,900 kg/cm^2 (3).

Figure 2 shows the signal from the potential pickups of the sample vs. the magnetic field at $\underset{\sim}{H} \| [0001]$, while Fig. 3 shows the same signal vs. the reciprocal magnetic field. The table lists the results at 4.2°K. The area of the extremal section was calculated from the formula

$$S_m = \frac{eh}{c\Delta(1/H)} = \frac{9.45 \times 10^{-9}}{\Delta(1/H)\ \mathrm{Oe}^{-1}}\ \text{Å}^{-2}$$

The abrupt decrease in the oscillations under pressure is apparently connected both with the deterioration of crystal quality, which very markedly affects the amplitude in the case of breakdown [3], and with the increase in the number of oscillations and hence with the increase in the effective mass. We see from Fig. 3 that in a field H = 8000 Oe the second maximum is replaced at 16,000 kg/cm^2 by the 13th maximum ("2" and "13" are the numbers of the maxima). It is interesting to compare the value of S_m obtained in the experiment with the data calculated by the Harrison model [6]. We can calculate S_m by extrapolating to 16,000 kg/cm^2 the compressibility of zinc single crystals, which Bridgman [7] measured up to 12,000 kg/cm^2, and which were confirmed in practice by data obtained for the elastic moduli [8]. The calculation results are listed in the table, and the agreement between

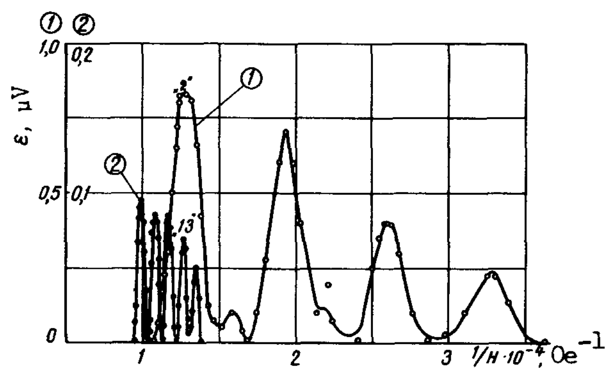

Fig. 3. Dependence of measured signal on the reciprocal magnetic field: 1 - P = 0, 2 - P = 15,900 kg/cm^2.

P kg/cm^2	$(1/H) \times 10^{-5}$ Oe^{-1}	Amplitude, in per-cent of total signal (for largest peak)	$S_{m\ exp}$ Å^{-2}	$S_{m\ calc}$ Å^{-2}
0	6.33 ± 0.06	10.8	0.00015	0.00037
11,100 ± 500	1.284 ± 0.012	3.5	0.00074	0.0011
15,900 ± 700	0.898 ± 0.007	1.5	0.00105	0.0015

the calculated and experimental data is satisfactory.

Thus, the Harrison model can explain the obtained results and can be used for an estimate of the expected pressure effect in hexagonal metals. In particular, an estimate made for cadmium, using data on the compressibility [9], shows that the critical ratio c/a at which the needle-like surface is produced is attained at a pressure close to 1000 kg/cm^2, and that at 15,000 kg/cm^2 we have c/a = 1.8200, which leads to $S_{m\ calc} = 6.3 \times 10^{-4}$ Å^{-2}. Even if we assume that these values are too high, as is also the case for zinc, observation of the needle-shaped surface of cadmium and of its growth can still be attempted in the pressure range at our disposal.

In conclusion, the authors take the opportunity of thanking Professor L. F. Vereshchagin for continuous interest in the work.

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ANISOTROPY OF ODD PHOTOMAGNETIC EFFECT IN SEMICONDUCTORS OF CUBIC SYMMETRY

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Until recently, experimental studies were devoted mainly to the anisotropy of the even photomagnetic effects in Ge crystals [1-3]. In strong magnetic fields, however, it is possible to obtain data on the behavior of purely anisotropic odd photomagnetic effects, depending on the magnitude and orientation of the magnetic field. These effects, like the purely anisotropic even ones, are determined by the carrier spectrum and by the carrier relaxation times.