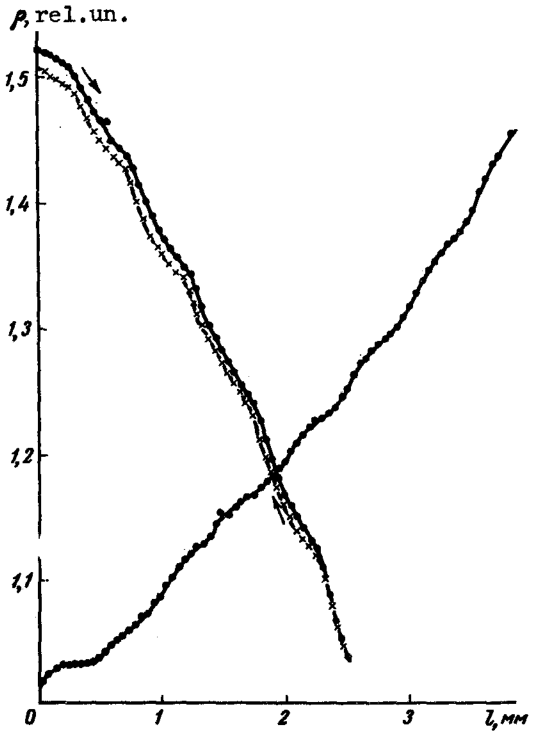

Fig. 2

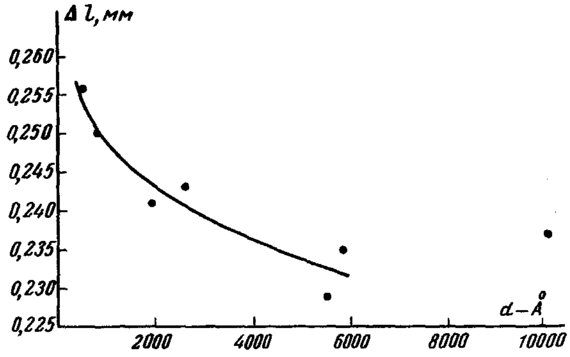

Fig. 3

No change of resistance was observed in a silver film 3000 Å thick subjected to a similar deformation.

Figure 3 shows the dependence of the period of the oscillations $\Delta\ell$ on the thickness of the bismuth film. Attention is called to the very slight decrease of the period with increasing d. When the thickness is changed from 500 to 5000 Å, the change of $\Delta\ell$ amounts to approximately 10%.

In our opinion, the foregoing results can be interpreted on the basis of the quantum size effect (it is difficult to conceive of any other cause of the nonmonotonic variation of ρ). The observed weak $\Delta\ell(d)$ dependence is connected, in all probability, with the change in the shapes of the energy bands following such a complicated deformation.

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[1] N. B. Brandt and V. A. Venttsel', Zh. Eksp. Teor. Fiz. 35, 1083 (1958) [Sov. Phys.-JETP 8, 757 (1959)].
[2] N. B. Brandt, Yu. P. Gaidukov, E. S. Itskevich, and N. D. Minina, ibid. 47, 455 (1964) [20, 301 (1965)].
[3] R. Jaggi and A. L. Jain, Phys. Lett. 7, 181 91963).
[4] I. O. Kulik, ZhETF Pis. Red. 5, 423 (1967) [JETP Lett. 5, 345 (1967)].

ABSORPTION OF SOUND IN MOLTEN SEMIMETALS

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It is shown in a number of recent theoretical papers devoted to the absorption of low-frequency sound in metals that the main contribution to sound absorption in dislocation-free metallic single crystals is made by the conduction electrons (see, e.g., [1]). It is of considerable interest, in this connection, to trace the influence of various types of structural realignments on the absorption of sound in metals. To this end, we measured the

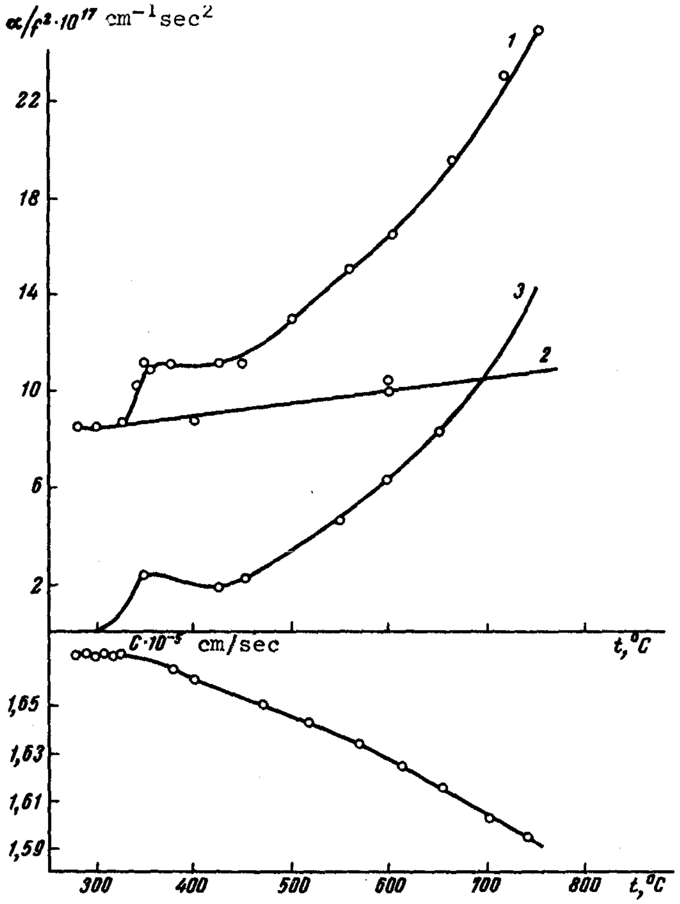

Fig. 1

absorption of sound in a wide temperature interval in a number of molten semimetals, in which the metling is accompanied by a structure realignment that extends over into the liquid state. These include liquid bismuth and antimony. The sound absorption was measured by a pulsed method at a frequency f = 100 MHz in the temperature interval from melting to 900°C, using apparatus described in [2].

Figures 1 and 2 show the results of the measurement of the sound absorption coefficient α in molten bismuth and antimony, respectively (curves 1). According to x-ray diffraction data, the realignment of the structure in bismuth continues in superheat of 30 - 40°C above the melting point [3]. This is also evidenced by results of investigations of the electric conductivity and of the speed of sound [4]. Apparently the same processes find a manifestation in the absorption of sound, since sound absorption in in bismuth remains unchanged at superheats on the order of several dozen degrees (see the graph). The absorption then increases quite rapidly and stabilizes in the region of 350°C. A monotonic increase of the sound absorption coefficient begins only starting with temperatures on the order of 500°C. The sound absorption coefficient in molten antimony behaves in similar fashion, although in this substance the processes of structure realignment extend over a wider temperature interval, as revealed by x-ray diffraction data.

We note that in liquid metals in which no realignment of structure is produced by heating, the sound absorption is a monotonically increasing function of the temperature [2].

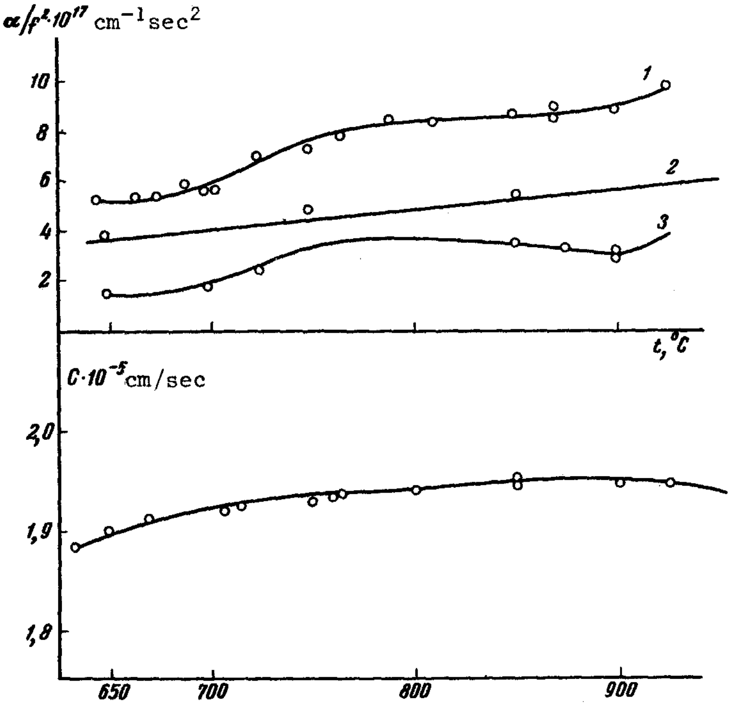

Fig.2

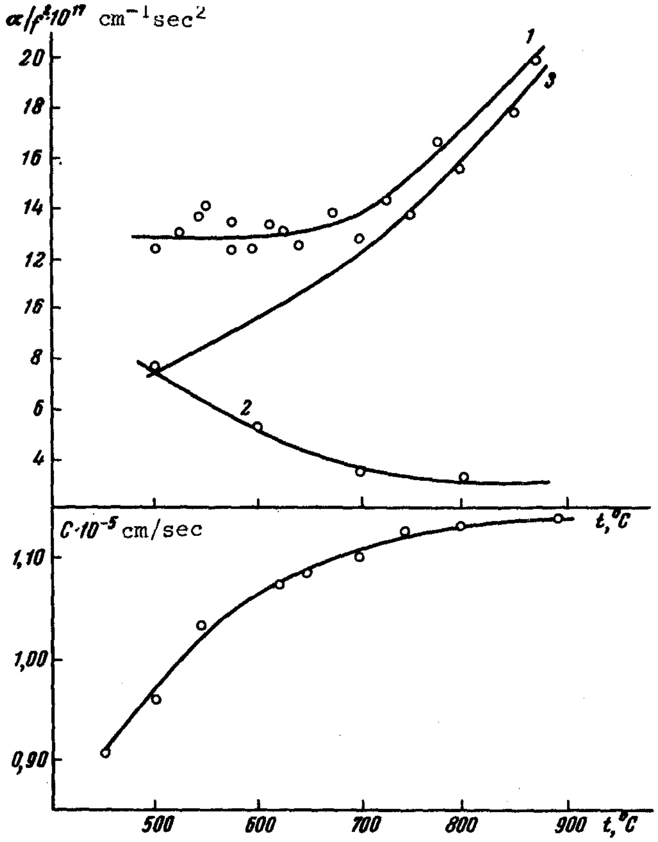

Fig.3

For comparison, Figs. 1 and 2 show the temperature dependence of the speed of sound c in molten bismuth and antimony [4]. It is readily seen that a clearly pronounced correlation is observed in the singularities of the behavior of the absorption coefficient and of the speed of sound in the investigated semimetals (the speed of sound in metals, where there is no structure realignment, decreases linearly with increasing temperature). We note incidentally that the contribution made to the sound absorption by shear viscosity in liquid bismuth and antimony is only 5 - 7%. The main contribution to the sound absorption in these semimetals is made by losses connected with thermal conduction (curves 2 on Figs. 1 and 2). The additional absorption (in excess of the Kirchhoff absorption) has in bismuth a rather pronounced maximum, but if such a maximum exists in antimony, it is very weak (the data on the viscosity and heat conduction of molten Bi and Sb were taken from [5] (curves 3 of Figs. 1 and 2)). It must be emphasized that the behavior of the absorption connected with the heat conduction is very sensitive both to the behavior of the latter and to the coefficient of thermal expansion, and neither of these has been measured with sufficient accuracy in this temperature region. It can be stated, nonetheless, that in molten semimetals, unlike in typical metals, the absorption not ocnnected with the heat conduction is not a monotonic function of the temperature. To explain the influence of structure realignment on the sound absorption, great interest attaches to acoustic measurements in molten tellurium, the melting of which is accompanied not only by an increase in the density of the structure, but also by a partial metallization (solid tellurium is a semiconductor). The sharp increase in the density of the structure and the metallization of the state continue also after melting, a fact reflected in the rapid growth of the electric conductivity [6] and of the speed of sound [7] with increasing temperature.

Curve 1 of Figure 3 illustrates the temperature dependence of the sound absorption coefficient α in molten tellurium; it follows from this curve that the total absorption of sound, at considerable degrees of superheat above the melting point, remains unchanged within the limits of the measurement errors. The speed of sound c increases rather rapidly in the same temperature interval.

Unlike the semimetals considered above, the losses connected with heat conduction in liquid tellurium amounts to several per cent of the total sound absorption, and the main contribution is made by losses due to shear viscosity (curve 2). It follows therefore that heating of the moten tellurium is accompanied by a rapid growth of the super-Stokes absorption (curve 3).

[1] M. I. Kaganov and V. G. Peschanskii, Fiz. Tverd. Tela 9, 3570 (1967) [Sov. Phys.-Solid State 9, 2810 (1968)].
[2] M. B. Gitis, I. G. Mikhailov, and S. Niyazov, Akust. zh. 14, 57 (1968) [Sov. Phys.-Acoust. 14, 42 (1968)].
[3] Ya. I. Dubchak, FMM 11, 290 (1961).
[4] M. B. Gitis and I. G. Mikhailov, Akust. zh. 11, 434 (1965) [Sov. Phys.-Acoust. 11, 372 (1965)].
[5] Z. N. Lyon, Liquid Metals Handbook, 1950.
[6] V. I. Blum and A. R. Regel', Zh. Tekh. Fiz. 23, 964 (1953).
[7] M. B. Gitis and I. G. Mikhailov, Akust. zh. 12, 17 (1966) [Sov. Phys.-Acoust. 12, 14 (1966)].