THE MAXIMUM ON THE MELTING CURVE OF TELLURIUM

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Temperature maxima were observed on the melting curves in recent studies of the phase diagrams of various elements and compounds. By now there are already fifteen substances whose melting curves have maxima [1-13].

To explain the nature of the maxima, it is necessary to bear in mind the following. From the Clapeyron-Clausius equation

$$\frac{dT}{dp} = \frac{\Delta V}{\Delta S}$$

where ΔV and ΔS are the changes in volume and entropy during melting, it follows that $dT/dp = 0$ at the maximum, and consequently $\Delta V = 0$.

Whereas for "normal" melting curves, i. e., those increasing continuously, the volume of the liquid is always larger than the volume of the solid, in the case of melting with maxima one can conceive of two cases: 1) the volume of the liquid decreases "anomalously" along the melting curve, 2) the volume of the solid increases along the melting curve.

Inasmuch as the melting temperature of a substance depends relatively little on the pressure, the latter case reduces to an expansion of the body with almost isometric compression, which is not very likely. It is thus perfectly evident that the appearance of temperature maxima on the melting curve is due to an anomalous decrease in the volume of the liquid along the melting curve.

At present, however, it is not clear whether the compression curve of the liquid is perfectly smooth in the region of the maximum, or whether it has some singularities pointing to the localization of this anomaly in a definite region of pressures and temperatures.

In this communication we report the results of a detailed study of the melting curve of tellurium, from which we deduce a localized change in the properties of liquid tellurium along the melting curve.

The pressure was produced by compressing gasoline or silicone oil in a high-pressure multiplicator, and was measured with a manganin manometer accurate to 50 kg/cm^2. The temperature was measured with a chromel-alumel thermocouple introduced into the investigated substance. The reproducibility error in the temperature measurement did not exceed 0.2°C. The purity of the investigated substance was 99.999%.

Figure 1 shows the melting curve of tellurium up to 18,000 kg/cm^2. As seen from the

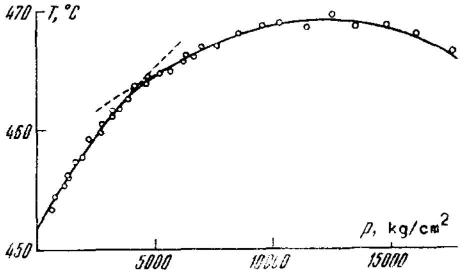

Fig. 1

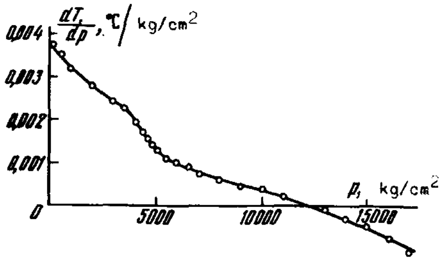

Fig. 2

figure, three sections can be clearly distinguished on the melting curve: initial, up to ~3800 kg/cm^2, the section with the maximum, and an intermediate region from 3800 to 5000 kg/cm^2. Figure 2 shows the pressure dependence of the slope dT/dp of the melting curve. It is clearly seen here, too, that the slope of the melting curve decreases quite sharply in the pressure region from 3800 to 5000 kg/cm^2. The curve then becomes fairly smooth and reaches zero at ~12,400 kg/cm^2, which agrees with our earlier paper [6].

It can be assumed that the anomalous behavior of the $\frac{dT}{dp}(p)$ curve in the region from 3800 to 5000 kg/cm^2 points to a unique phase transition in the liquid tellurium, connected apparently with a short-range change. It is interesting to note that the total volume change in this transformation is small, so that the condition for the maximum, $\Delta V = 0$, is attained only at higher pressure, because of the perfectly natural larger compressibility of the liquid compared with the solid. It must be emphasized here, however, that the latter factor alone, as can be seen from numerous examples, does not lead to maxima on the melting curves.

A recent paper [14] presents also data on the melting curve of tellurium and on the pressure dependence of the slope of this curve. According to these data, $\frac{dT}{dp}(p)$ is linear for the melting curve of tellurium.

It should be noted that we carried out six series of experiments, in each of which we obtained 20 to 50 points. The investigations were carried out in three media: gasoline, silicone oil, and a mixture of the two. For comparison we investigated in detail the melting curve of zinc, whose coordinates lie in the same region of temperatures as the melting coordinates of tellurium. The melting curve of zinc is smooth and has no anomalies. This has convinced us that our results on the melting curve of tellurium are not connected with any apparatus error or heat-exchange effects. Apparently the data cited in [14] are insufficiently accurate.

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OSCILLATORY DEPENDENCE OF THE SURFACE IMPEDANCE OF A METAL ON A WEAK MAGNETIC FIELD

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An oscillatory dependence of the surface impedance Z of a metal on a weak magnetic field H in the microwave region was observed in Sn, In, and Cd [1]. Observation of the same effect in Sn, Al, Cu [2], and W [3] was also reported. Detailed researches were recently reported on the oscillations of Z(H) in Sn, In, and Al [4]. In this letter we explain the physical causes of this effect and report some results of its investigation in Bi, chosen because its Fermi surface has been investigated in detail [5].

The existing calculations of Z(H) pertain either to the region of cyclotron resonance [6], characterized by the inequalities $\tau \ll T$ and $r \gg \delta$ (τ - time that the electron stays in the skin layer δ; $T = 2\pi/\omega$ - period of the microwave field; r - radius of the electron orbit in the field H), or else to the relaxation region [7,8], for which $\tau \gg T$ and $r \ll \delta$. The region where oscillations of Z(H) are observed in a weak field H is determined by the relations $\tau \sim T$ and $r \gg \delta$; there are no calculations for this case. So far, only electrons moving in the skin layer δ along arcs whose centers lie deep in the metal (Fig. 1A) have been considered in searches for the causes for the oscillations. A comparison, for example, of the times τ and T or of the velocities of the electron and the wave in the skin layer for such orbits gives the correct order of magnitude of the field H at which a singularity of Z(H) is possible. Such an approach, however, does not give a convincing explanation of the origin of the oscillations [4].

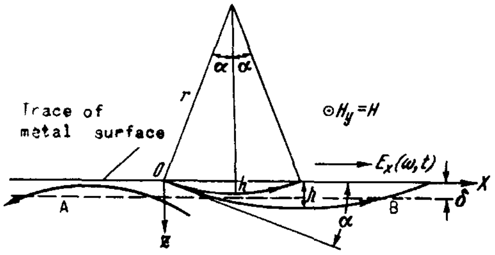

Fig. 1

The explanation of the physical causes of the