GEBB HA60 0133

(*Reprinted from Nature*, *Vol.* 188,
December 24,

Pressure Dependence of Resistivity of Indium Antimonide to 70,000 Atmospheres

THE pressure dependence of the resistivity of indium antimonide has been measured by Keyes[1] up to 12,000 atmospheres. We have extended the range to 70,000 atmospheres. In addition to the type of change found by Keyes we have observed a resistance change on melting when the temperature was considerably below the zero pressure melting-point of 796° K.

The measurements were made in a tetrahedral apparatus constructed at the National Physical Laboratory following a design of the National Bureau of Standards[2]. This allows the use of a standard hydraulic press. In our apparatus the pyrophyllite

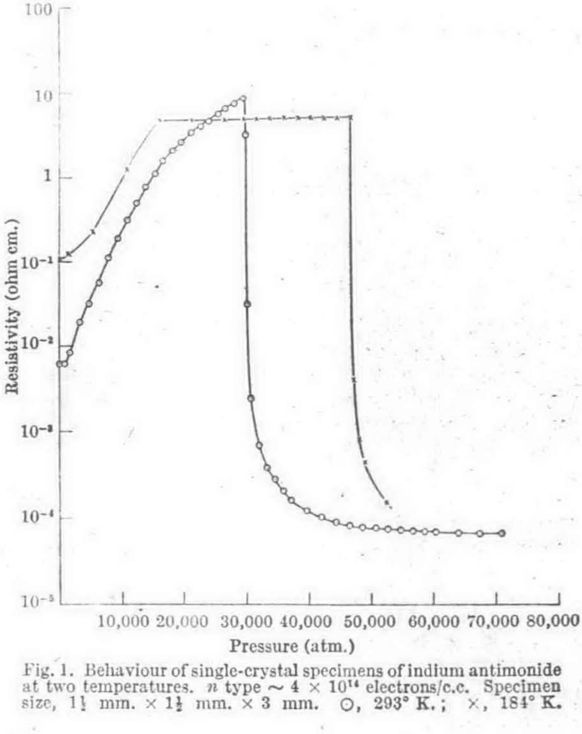

Fig. 1. Behaviour of single-crystal specimens of indium antimonide at two temperatures. n type $\sim 4 \times 10^{14}$ electrons/c.c. Specimen size, 1½ mm. × 1½ mm. × 3 mm. ○, 293° K.; ×, 184° K.

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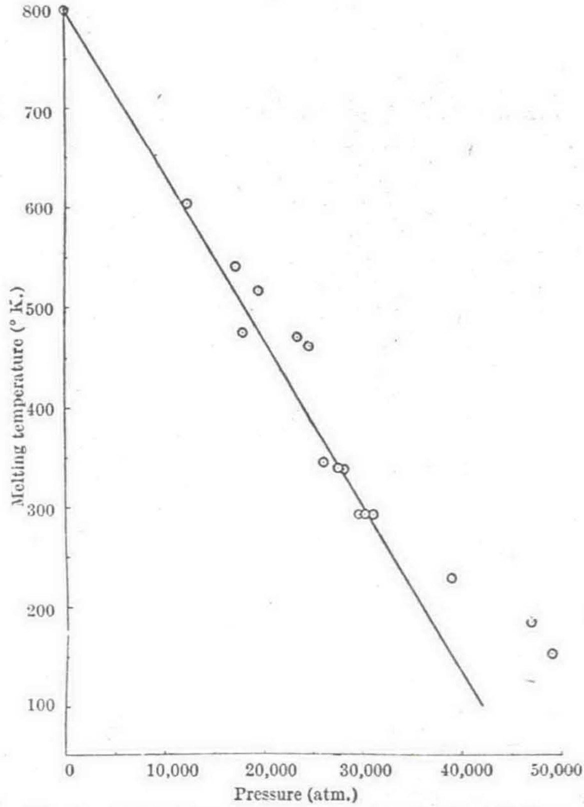

Fig. 2. Effect of pressure on the melting point of indium antimonide

tetrahedron had a side of $\frac{3}{4}$ in. and electrical connexions were made by the techniques described by Hall[3]. Cooling coils allowed the temperature to be lowered to 120° K. Pressure-versus-load calibration was made by measuring resistance changes in bismuth, thallium and barium specimens and using Bridgman's electrical data[4].

Fig. 1 shows typical behaviour of single-crystal specimens of indium antimonide at two temperatures. Initially, the resistance increases with pressure as found by Keyes, who showed that this effect comes mainly from a widening of the energy gap. In our room-temperature experiments, the resistance dropped sharply at a pressure of 30,000 atmospheres. This is attributed to melting, with a transition from semiconduction in the crystal to metallic conduction in the liquid phase. In support of this, the ultimate resistivity reached here is close to the value obtained by Busch[5] for liquid indium antimonide at zero pressure. The small pressure dependence of the resistivity in the liquid phase is also consistent with the metallic behaviour demonstrated by Busch.

Fig. 2 shows the melting point, as measured by the sharp fall in resistance, plotted as a function of pressure. It shows a decrease with increasing pressure which, qualitatively, is consistent with the known contraction in volume on melting shown by this compound. The decrease varies linearly with pressure to about 30,000 atmospheres, but significantly departs from this behaviour at higher pressures. By inserting a value of the slope of our melting curve at zero pressure in the Clausius–Clapeyron equation with a known value[6] of the volume contraction on melting ($\Delta v/v_{solid} = 0{\cdot}13$) a value for the latent heat of fusion can be found. This value of 27 cal./gm. does not agree with an experimentally determined value[7] of 47·2 cal./gm. The disagreement between these values might arise from the presence of complex phases in the liquid near the melting point[8]. In our experiments results are lacking below 10,000 atmospheres because the pyrophyllite gasket technique is not reliable.

It is interesting to compare the corresponding work on the melting of germanium by Hall[9]. In this he finds a variation of melting point with pressure which is substantially linear over the range 0–180,000 atmospheres. When his value of the slope of the melting curve is used to calculate the latent heat of fusion, using a measured value[10] of the volume change, a value of 84 cal./gm. is found which is in fair agreement with the experimentally determined value of 110 cal./gm.[11].

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H. A. Gebbie
P. L. Smith
I. G. Austin
J. H. King

Basic Physics Division,
National Physical Laboratory,
Teddington, Middlesex.

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