Table 1 shows the spreading of values of the 12 cases analysed. In all, 36 cases have been investigated and the mean value of the measured delay including both the rising and falling period is ~120 sec.

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METALLURGY

Dependence on Temperature of Elastic Moduli of Tin

The crystalline structure of tin changes from cubic (grey tin) to body-centred tetragonal (white tin) at 18° C. These structural changes were examined as reflected in the thermoelastic behaviour of polycrystalline tin.

The composite piezo-electric oscillator method[1] has been employed in the present investigation, the frequency-range being 100–145 kc./sec. Specimen rods of rectangular and cylindrical cross-sections are cut from 99 per cent pure tin. The composite oscillator with its holder is placed at the centre of an electrical furnace and the temperature is controlled by varying the current using a variac. For study in the low-temperature region, the crystal holder sealed in a container is maintained in a Dewar flask containing freezing mixtures.

The observed variations of Young's modulus (Y) and rigidity modulus (G) with temperature are represented graphically in Fig. 1. The elastic moduli decrease linearly with temperature. A sudden change in the gradient of the curves occurs at about 18° C. in both the cases. This transition is due to the structural changes.

In addition to the above transition, the Young's modulus versus temperature curve shows another sudden change in the gradient at 80° C. It is quite possible that this phenomenon is due to the stress relaxation at grain boundaries. It is known that the temperature at which the grain boundary slipping takes place varies with the frequency of excitation.

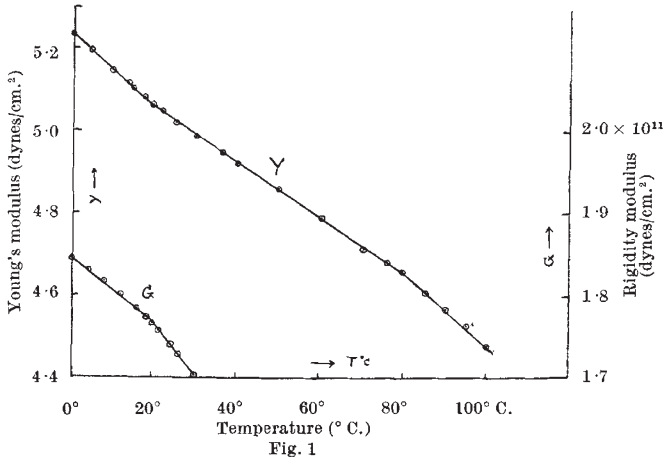

Fig. 1

Experimental investigations to study the thermoelastic behaviour of tin at low frequencies (3–10 kc./s.) are in progress. Such a study enables us to explain the mechanism responsible for the transition occurring at 80° C.

The volume compressibility of cubic tin at 0° C. is calculated making use of the values of the elastic moduli of polycrystalline tin at 0° C. The value works out to be $8{\cdot}31 \times 10^{-13}$ cm.²/dyne.

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Distortions in Metallic Structures

A puzzling feature of the Periodic Table has been that certain of the elements, such as indium, cadmium and zinc, while possessing typically metallic properties, have structures which are slight distortions of close-packed metallic structures.

Experimental[1] and theoretical[2] work on indium shows that the tetragonal distortions in this metal, and its alloys with various solutes, can be ascribed to a lowering of Fermi energy brought about by the distortion. The energies of the {002} overlaps for the face-centred cubic Brillouin zone are identical, and provided that the total number of electrons in these overlaps is below a certain value, this particular 'degeneracy' can be removed or lowered, with a lowering of Fermi energy, by orthorhombic or tetragonal distortions, at constant volume, of the metal lattice. The energetics of these distortions are similar to those presented by Dunitz and Orgel[3] for the Jahn-Teller distortions which have been so successful in explaining the structures of transition-metal oxides, though without the corresponding bonding and anti-bonding implications.

The energy scheme of Fig. 1*a* will enable this to be readily visualized; the levels shown are those corresponding to the initiation of the overlaps on (002) and (200) for a face-centred cubic structure, and for the tetragonally distorted structures with axial ratios respectively less than and greater than 1. The sequence of phases indicated by this scheme is observed in the systems indium–tin and indium–lead[4], in which the volume differences between the phases are very small.

It should be emphasized that in each structure the continuous energy band of the lower level actually overlaps that of the higher level; calculations (Wood, V. E., private communication) show that some states in the higher-energy overlap may be occupied without greatly affecting the stability conferred on the structure by the Fermi energy. The energy distribution curves in Fig. 1*b* are approximated by rectangles, so that the total energy of the electrons in these overlaps (proportional to the area below the Fermi surface) can be easily visualized. In this scheme, the first structure would become unstable when the band was filled to level A, and the stability of the cubic structure would equal that of the other two at level B.