LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in phyiscs may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the eighteenth of the preceding month, for the second issue, the third of the month. Because of the late closing dates for the section no proof can be shown to authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Communications should not in general exceed 600 words in length.

Internal Friction at High Temperatures*

The internal friction of metals is known to increase rapidly at high temperatures.[1–3] The only type of internal friction which has been thoroughly investigated is that associated with thermal currents flowing back and forth between stress inhomogeneities,[4–8] and this can be shown to vary only comparatively slowly with temperature. Thus a new type of internal friction is apparently introduced at high temperatures. Before one can profitably speculate as to the origin of this internal friction, it is necessary to find how it depends upon certain parameters. In this letter the dependence upon temperature and grain size is given.

In order to reduce the temperature range necessary to obtain a large variation of internal friction, a metal with a low melting point was chosen, namely zinc. The specimens (dimensions $30\times1\times0.45$ cm^3) were from a set of zinc samples furnished by Gerald Edmunds of the New Jersey Zinc Company. They contained less than 0.5 percent of alloying elements. Their approximate grain sizes of 0.04 mm, 0.04 mm, 0.06 mm and 0.4 mm were obtained by annealing at 175°C, 225°C, 275°C and 400°C, respectively. A complete description of this set will be given elsewhere, together with a detailed analysis of their internal friction. Measurements were made at the lowest frequency for transverse vibration, 180 cycles per second, in order to eliminate as far as possible the effects of intercrystalline thermal currents. The temperature was measured by letting the two supports, placed at nodes of vibration, and the specimen form the hot junction of a thermocouple.

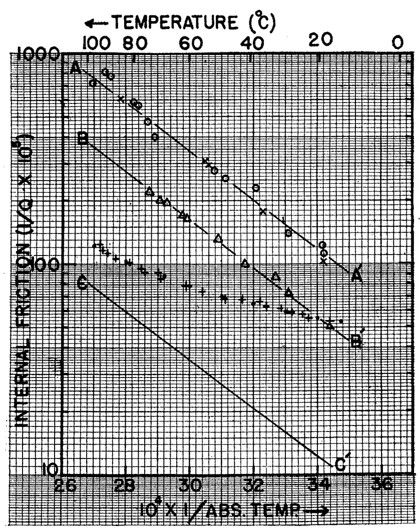

FIG. 1. *Variation of internal friction of zinc with temperature.* All measurements were made at a frequency of 180 cycles per second. 0, X, Δ, $+$ refer to specimens with the approximate grain sizes 0.04 mm, 0.04 mm, 0.07 mm and 0.4 mm, respectively. The three straight lines AA', BB' and CC' are parallel to each other. The dots lie a constant value of 44×10^{-5} above CC'. This coincidence with the experimental points $+$ shows that the internal friction of the 0.4-mm grain size specimen is given by CC' plus the constant value 44×10^{-5}.

The measurements are plotted in Fig. 1 on semilog paper against $1/T$. The measurements on the three smallest grain size specimens lie upon a straight line, indicating that the internal friction has a heat of activation. For all three specimens this is 5200 calories per gram atom.

The measurements for the largest grain size specimen do not lie upon a straight line. For this specimen the adiabaticity parameter[6]

$$\frac{\text{frequency}\times(\text{grain size})^2}{\text{thermal diffusion constant}}$$

is 0.8, as against 0.008, 0.008, 0.02 for the other three specimens. Since the intercrystalline thermal currents have a maximum effect when this parameter is of the order of magnitude of unity, it is to be expected that their contribution to the internal friction of this specimen be not negligible. Our measurements are consistent with the assumption that this contribution is 44×10^{-5} over the temperature range studied, and that the temperature dependent part of the internal friction has the same heat of activation as have the other three specimens.

To within experimental error in grain size estimates, the temperature-dependent part of the internal friction varies inversely with grain size. Now the area of the grain boundaries per unit volume is also inversely proportional to grain size. Hence this experiment indicates that the source of this high temperature internal friction lies on the grain boundaries, rather than in the interior of the grains.

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