III. SOLID STATE PHYSICS

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A. ELASTIC CONSTANTS OF ZINC

The five elastic constants of zinc have been measured from 4.2° K to 77.6° K by an ultrasonic pulse technique. The relations between the elastic constants and ultrasonic velocities are the same as those given by Slutsky (1), with the exception that c_{13} was obtained by measuring the velocities of quasi-longitudinal and quasi-transverse waves propagated in a direction at 30° to the hexagonal axis instead of 45°. This measurement required new expressions for $\rho U_{q\ell}^2$ and ρU_{qt}^2. The results are given in Figs. III-1, 2, and 3. The smooth curve values at 0° K, obtained by extrapolation, are: $c_{11} = 1.7696$, $c_{33} = 0.6848$, $c_{44} = 0.4589$, $c_{66} = 0.7108$, $c_{13} = 0.5366$, all in units of 10^{12} dynes/cm^2. The relation $c_{66} = (c_{11} - c_{12})/2$ gives $c_{12} = 0.3483$.

Measurements of the low-temperature thermal expansion of zinc were made by Gruneisen and Goens (2). Their work indicates negative values of the coefficient of expansion perpendicular to the c-axis below 80° K. This effect might be attributed to

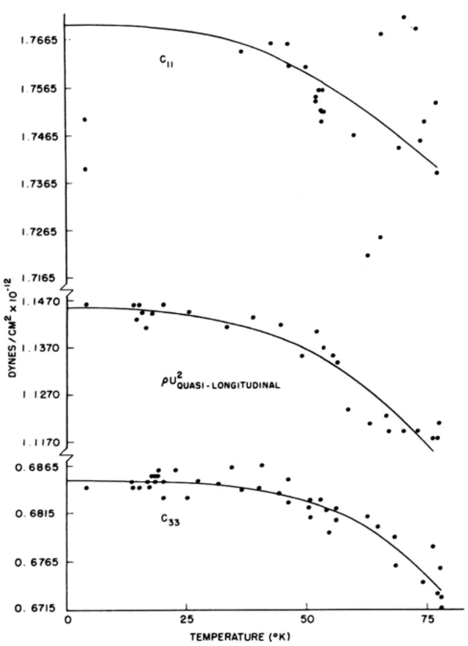

Fig. III-1.

Adiabatic elastic constants c_{11} and c_{33}, and $\rho U^2_{\text{quasi-longitudinal}}$ for zinc.

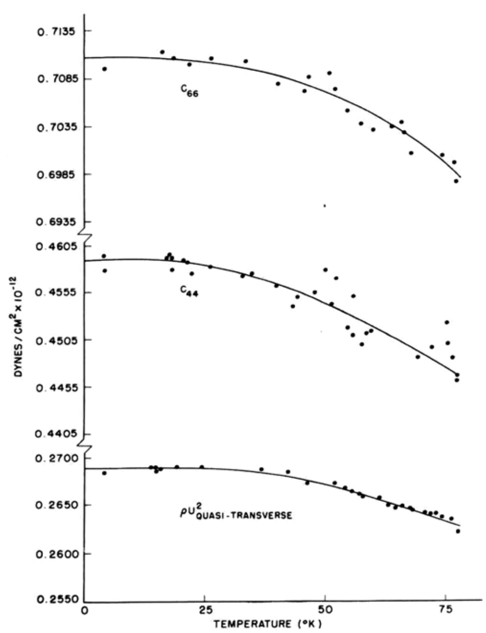

Fig. III-2.

Adiabatic elastic constants c_{44} and c_{66}, and $\rho U^2_{\text{quasi-transverse}}$ for zinc.

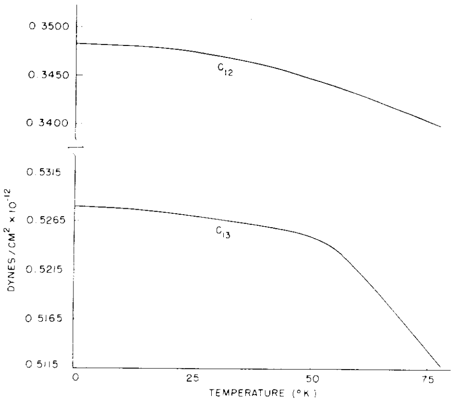

Fig. III-3. Adiabatic elastic constants c_{12} and c_{13} for zinc.

an anomalous change in the atomic force constants over the low-temperature range. Such an anomaly should be reflected in the temperature variation of the elastic constants; however, our data on elastic constants versus temperature show no unusual behavior. The absence of an anomaly is confirmed by the very recent thermal expansion data of Smith (3), which shows no expansion reversal in the perpendicular direction. The atomic forces in zinc are more complex than in an ideal hexagonal close-packed metal like magnesium. The central force model (4) which worked well for magnesium is not adequate to describe the elastic data for zinc.

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References

1. L. J. Slutsky, Quarterly Progress Report, Research Laboratory of Electronics, M.I.T., April 15, 1957, pp. 18-20.

2. E. Gruneisen and E. Goens, Z. Physik 29, 141 (1924).

3. J. F. Smith, Ames Laboratory, Atomic Energy Commission, private communication, Feb. 18, 1958.

4. L. J. Slutsky and C. W. Garland, Quarterly Progress Report, Research Laboratory of Electronics, M.I.T., July 15, 1956, pp. 10-11.