neutron irradiation[21] and by quenching from elevated temperatures[22] also result in dislocation pinning.

ACKNOWLEDGMENTS

One of the authors (R. B. G.) received partial financial support during the course of this work from fellowships of the General Electric Company and the Dow Chemical Company. The basic equipment for the measurement of elastic constants was purchased through the Higgins Fund.

This paper represents part of a dissertation submitted by R. B. Gordon in partial fulfillment of the requirements for the degree of Doctor of Engineering in the School of Engineering at Yale University.

Appendix

The factor ξ' which appears in equation (1) is given by[9]

$$\xi' = \frac{3}{\zeta\pi} \ln\left(\frac{r_1}{r_0}\right)$$

where $\zeta = 1$ for a screw dislocation and $\zeta = 1 + \nu$ for an edge dislocation, ν being Poisson's ratio. This result applies to an isotropic medium. The quantities r_0 and r_1 are the radii of the inner and outer surfaces, respectively, of the doubly connected region used in calculating the stress field around a dislocation line. Since in the case of a short segment of dislocation of length l the calculation of the stress field should only be carried out to a distance of about l from the dislocation line, r_1 may be taken as approximately equal to l. The value to be taken for r_0 is somewhat more uncertain, but according to Cottrell[23] should be chosen to be several times the Burgers vector, i.e. about 10^{-7} cm. In a real crystal the dislocation network will be made up of segments having partly a screw character and partly an edge character; nevertheless, ζ will still be of the order of unity, since $\nu \simeq 0.3$. Because it is but a slowly varying function of l, ξ' is taken to be a constant in the present calculations. In the specimens being considered, l has values ranging between 10^{-5} and 10^{-6}, so that ξ' will be approximately equal to 3.

The elastic modulus which is measured in the present case is s_{11}^{-1}, whereas the shear modulus μ on the $\{110\}$ slip planes is given by

$$\mu^{-1} = \tfrac{1}{2}s_{44} + s_{11} - s_{12}$$

It is this shear modulus which properly belongs in equation (1) if an attempt is to be made to introduce anisotropy. Even though it is known that the motion of dislocation loops does not affect the cubical compressibility $3(s_{11} + 2s_{12})$, there is not enough information about the effect of dislocation motion on the compliance constant s_{44} to make possible a calculation of the relation between a change in μ and a change in the measured compliance s_{11}. Detailed analysis of the atomic forces which surround the dislocation loops would be required to obtain this information.

Instead, it seems desirable to adhere to an isotropic approximation. The measured modulus s_{11}^{-1} corresponds to Young's modulus, Y, and

$$\frac{\Delta Y}{Y} = \left(1 - \frac{\mu}{\mu + 3k}\right)\frac{\Delta\mu}{\mu}$$

where k is the bulk modulus. Thus, by analogy to equation (1),

$$-\frac{\Delta s_{11}}{s_{11}} = \frac{Nl^2}{\xi}$$

where

$$\xi = \left(1 - \frac{\mu}{\mu + 3k}\right)\xi'$$

Using the measured values of s_{11}, s_{12}, and s_{44} to obtain values for μ and k, it is found that $\xi \simeq 2.5$.

REFERENCES

1. F. SEITZ *Rev. Mod. Phys.* **26,** 7 (1954)
2. W. D. KUSNETZOW and W. A. SEMENTZOW *Z. Exper. Theor. Physik* (Russ.) **2,** 199 (1932)
3. M. N. PODASCHEWSKY *Phys. Z. Sowjet.* **8,** 81 (1935)
4. YIN-YUAN LI *Acta Met.* **1,** 455 (1953)
5. D. R. WESTERVELT *Acta Met.* **1,** 755 (1953)
6. R. B. GORDON and A. S. NOWICK *Phys. Rev.*, **101,** 977 (1956)
7. D. R. FRANKL *Phys. Rev.* **92,** 573 (1953)
8. N. F. MOTT *Phil. Mag.* **43,** 1151 (1952)
9. J. FRIEDEL *Phil. Mag.* **44,** 444 (1953)
10. J. MARX *Rev. Sci. Instrum.* **22,** 503 (1951)
11. W. H. DUERIG and J. J. MARKHAM *Phys. Rev.* **88,** 1043 (1952)
12. K. SAKAGUCHI and T. SUITA *Tech. Repts. Osaka Univ.* **2,** 177 (1952)
13. ESTERMANN, LEIVO, and STERN *Phys. Rev.* **75,** 627 (1949)
14. T. A. READ *Trans. Amer. Inst. Min. Met. Eng.* **143,** 30 (1941)
15. J. WEERTMAN and J. S. KOEHLER *J. Appl. Phys.* **24,** 624 (1953)
16. A. S. NOWICK *J. Appl. Phys.* **25,** 1129 (1954)
17. A. S. NOWICK *Acta Met.* **3,** 312 (1955)
18. MADOR, WALLIS, WILLIAMS, and HERMAN *Phys. Rev.* **96,** 617 (1954)
19. S. HARPER *Phys. Rev.* **83,** 709 (1951)
20. D. R. FRANKL, private communication.
21. D. O. THOMPSON, D. K. HOLMES, and T. H. BLEWITT *J. Appl. Phys.* **26,** 1188 (1955)
22. R. MADDIN and A. H. COTTRELL *Phil. Mag.* **46,** 735 (1955)
23. A. H. COTTRELL *Dislocations and Plastic Flow in Crystals* (Oxford Univ. Press, London, 1953)