Gupta I & Li J C M. Stress relaxation, internal stress, and work hardening in some Bcc metals and alloys. *Metall. Trans.* 1:2323-30, 1970.
[Res. Ctr., Inland Steel Co., East Chicago, IN; Henry Krumb Sch. Mines, Columbia Univ., New York, NY; and Strength Physics Dept., Materials Res. Ctr., Allied Chemical Corp., Morristown, NJ]

The stress-time relation during stress relaxation is interpreted in terms of a power relation between dislocation velocity and the effective stress. Such interpretation gives not only the velocity-stress exponent, but also the internal stress in the work-hardened state. The velocity-stress exponents thus obtained agree with those obtained from etch pit dislocation velocity measurements. [The *SCI®* indicates that this paper has been cited in over 105 publications since 1970.]

An Attempt to Verify the Orowan Equation

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In the late 1960s, we witnessed the speedy development of dislocation theory—direct observations by transmission electron microscopy, etch pitting of surfaces, X-ray topography, and so on. International conferences were held almost every year. While the objective of the study of dislocations was to understand the mechanical properties of crystalline materials, there was very little connection between the mobility of dislocations and the observed strain rate. The Orowan equation, which relates the strain rate to dislocation velocity, proposed in 1940,[1] still had not been verified despite all the papers published in the 30 years after the proposal of the dislocation concept. Our paper represented an attempt to verify the Orowan equation. It received some attention because the method was simple, the analysis was straightforward, and all the assumptions used were accepted at the time. It stimulated many similar measurements. Some did not work because of violations of some assumptions involved, but most measurements were positive.

Although the work was part of I. Gupta's thesis at Columbia University, the experiments were done at the E.C. Bain Laboratory for Fundamental Research, US Steel Corporation, Monroeville, Pennsylvania. At the time of submission of the paper, both of us had left the laboratory. Gupta moved to Inland Steel in East Chicago, Indiana, and I took up a manager's position at Allied Chemical in Morristown, New Jersey. We had some difficulty publishing that paper under the sponsorship of US Steel because the paper had to be approved by the US Steel management. The first comments we got were:

> It should be shortened considerably. The section on materials and specimen preparation can be condensed and put into an appendix; alternatively, it could be greatly shortened with most of the data put into a table. Also, they wonder why you don't use stresses throughout instead of using stresses and loads, seemingly at random....

We did not follow all the suggestions, and, when it had not been approved six months later, we got another letter that said in part:

> Several of us have read it again, and, as you will see by the marginal comments and notes, several changes are suggested and questions raised. I must say that I am convinced that the appropriate changes should be made if the paper is to be submitted from this laboratory.... Otherwise I would suggest...that you go ahead and submit it, if you wish, without any mention of this laboratory and without any approval of US Steel.

So we submitted the paper under the sponsorship of Columbia University. The reviewer's comments were all favorable, and the key reader recommended publication without revision.

The Orowan equation still has not been verified. A major question is how to measure the density of mobile dislocations. Recently we made some attempts with ionic crystals.[2,3] Around the 50th anniversary of dislocation theory, we should redouble our efforts in that direction.

1. **Orowan E.** Problems of plastic gliding. *Proc. Phys. Soc. London* 52:8-22, 1940. (Cited 120 times since 1945.)
2. **Kataoka T & Li J C M.** Mobile dislocation density during the deformation of KCl single crystals. *Phil. Mag. A* 51:1-14, 1985. (Cited 5 times.)
3. **Chaki T K & Li J C M.** Mobile dislocations and internal stresses in the latent hardening of LiF crystals. *Phil. Mag. A* 55:317-27, 1987.

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