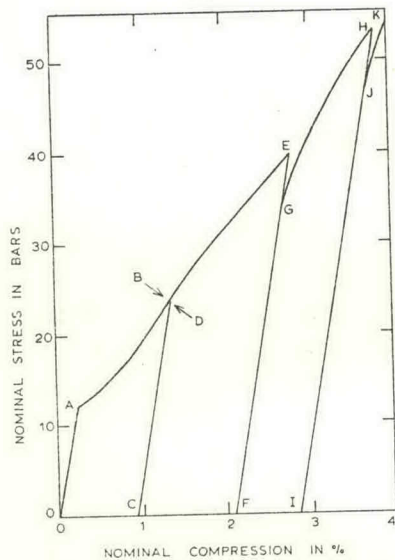Fig. 2

NOMINAL COMPRESSION IN %

The initial part (OAB) of the nominal stress–compression curve of a NaCl polycrystal tested at room temperature at a rate of $\sim 1\cdot 8 \times 10^{-4}\,\mathrm{sec}^{-1}$. The specimen was then unloaded (BC), reloaded (CDE), unloaded (EF), pressurized at 10 kbar, reloaded (FGH), unloaded (HI), repressurized at 10 kbar and reloaded (IJK). All the compressions were carried out at atmospheric pressure.

All these workers incorporate the empirical formula for the mean dislocation velocity,

$$v = \left(\frac{\sigma}{\sigma_0}\right)^n \qquad \dots \dots \dots \dots \quad (1)$$

into the relation for plastic strain rate,

$$\dot\epsilon = \Phi b \rho_Y v_Y = \Phi b \rho_Y \left(\frac{\sigma_Y}{\sigma_0}\right)^n, \qquad \dots \dots \dots \quad (2)$$

where σ is the tensile stress, Φ an orientation factor (0·5), b the Burgers vector, σ_0 and n constants and ρ_Y, v_Y and σ_Y the values of, respectively, the mean dislocation density, ρ, v and σ when macroscopic plastic flow commences. For the conditions: $b \approx 4 \times 10^{-8}$ cm, $\sigma_Y \approx 13$ bar (σ(A) of fig. 2), $\dot\epsilon \approx 1\cdot 8 \times 10^{-4}\,\mathrm{sec}^{-1}$ and (Gutmanas, Nadgornyi and Stepanov 1963) $\sigma_0 \approx 20$ bar, $n \approx 8$, ρ_Y and v_Y evaluate to $\sim 3 \times 10^5\,\mathrm{cm}^{-2}$ and $\sim 3 \times 10^{-2}\,\mathrm{cm\,sec}^{-1}$, respectively.

As macroscopic work hardening takes place at approximately constant strain rate (temperature and pressure), the product of the mobile dislocation density and their mean velocity must remain constant (Johnston and Gilman 1960, Mellor and Wronski 1970b). It has been observed by Johnston and Gilman (1960) in work hardened LiF crystals that the extra stress beyond σ_Y is just sufficient to maintain the same dislocation velocity as in the unstrained material. This behaviour has been assumed to be general (Hahn 1962, Cottrell 1963) and it follows therefore that during work hardening the mobile dislocation density and mean velocity remain approximately constant, and equal to ρ_Y and r_Y, respectively. The estimated value of ρ at E (as at B or H) of fig. 2 is therefore $3 \times 10^5\,\mathrm{cm}^{-2}$ (much lower than the total—mobile and immobile—dislocation density).

If fresh dislocations are generated during the pressurization treatment they may influence further deformation process both by moving to cause plastic flow and by acting as obstacles to gliding dislocations. Most of the dislocations present contribute to the latter process, but, in a work-hardened crystal, only a relatively small fraction (the free) take part in the former. It is therefore suggested that in a polycrystalline sample, where the grain boundaries act as specific obstacles to slip propagation, freshly nucleated dislocations, in the vicinities of these boundaries, would contribute principally to the former process—i.e. making slip easier. It will be assumed that the work-hardened structure opposing the movement of free dislocations is unaffected. Following pressurization the stress to reinitiate plastic flow (G of fig. 2) was reduced by $\Delta\sigma \approx 4$ bar; $\sigma_Y - \Delta\sigma$ was therefore substituted for σ_Y into relation (2) and the new mobile dislocation density evaluated as $\sim 5 \times 10^6\,\mathrm{cm}^{-2}$.

This result implies that probably $> 10^7\,\mathrm{cm}^{-2}$ dislocations are produced by pressurizing polycrystals of NaCl at 10 kbar (not all are expected to be mobile when a sample is reloaded), a figure an order of magnitude larger than our experiments with bicrystals (Evans *et al.* 1970) suggest. Bearing in mind the semi-quantitative nature of this analysis (Hahn 1962, Cottrell 1963, Mellor and Wronski 1970a) and that the dislocation velocity parameters, σ_0 and n, for these boules of sodium chloride have not been determined, we suggest the agreement between the experimental results and the analysis is encouraging. The etch-pit densities in the strained polycrystals were too large for quantitative (metallographic) determination of the number of the pressurization-induced dislocations.

Acknowledgments