In the case of LiF, stress birefringence and etch-pit observations show that all four slip systems operate, generally with a definite predominance of slip on one perpendicular set. In NaCl and KCl, stress birefringence observations generally reveal strain on only one mutually perpendicular set of slip planes; the oblique set of slip systems is less likely to operate than in the case of LiF. In CsBr the crystal axis is oriented to within a few degrees of ⟨110⟩ and slip occurs on only one of the possible {110} ⟨001⟩ slip systems.[7] The specimen has {100} and {110} faces.

The interrupted loading technique employed is illustrated schematically in Fig. 2, which shows a plot of stress vs compressive plastic strain. The elastic strain is removed from the recorded traces by measuring from a line drawn parallel to the elastic part of each curve. On the first application of load the plastic strain is anomalously large due to small misalignment of the specimen on the platens but at A a steady state of work hardening is achieved. At B the load on the sample is released. Upon reapplication of the load, the sample starts to flow at a somewhat lower stress as, for example, at C. Presumably between C and D dislocations are being pushed back up against barriers from which they have been repelled by long-range interaction forces when the load was released. At D, however, a steady state of work hardening is again achieved. The condition that DE is an extension of AB, after an arbitrarily long waiting period, is taken to mean that no recovery or aging processes occur while the load is off the sample. In the normal test sequence, then, the load is released at E and the sample is subjected to hydrostatic pressure. On reapplication of the load with the sample now under pressure, the stress–strain curve may look like, for example, that between E and F. The high-pressure σ–ϵ curve is extrapolated to the fiducial strain

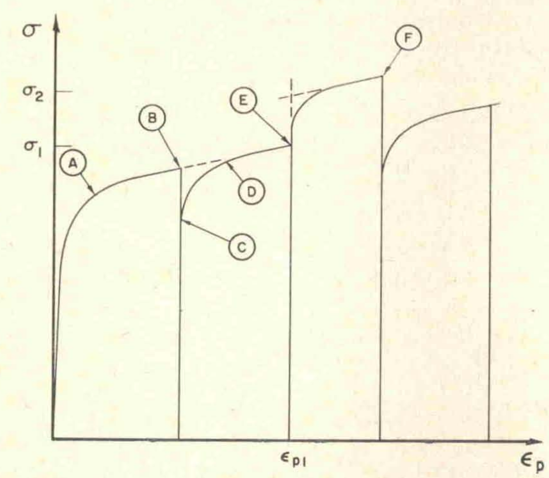

FIG. 2. Schematic stress–strain curve for repeated compression of an alkali halide single crystal. Hydrostatic pressure is applied at ϵ_{p1}.

[7] L. D. Johnson and J. A. Pask, J. Am. Ceram. Soc. **47**, 437 (1964).

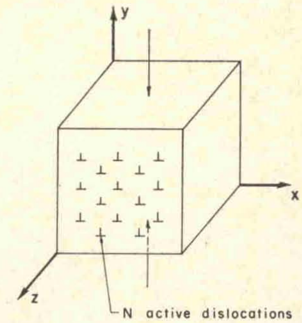

FIG. 3. A single crystal containing N active dislocations to be compressed parallel to the y axis.

as shown; the fractional change in flow stress due to hydrostatic pressure is given by $(\sigma_2-\sigma_1)/\sigma_1=\delta\sigma/\sigma$. At F the load is released, the pressure is released, and on subsequent reapplication of the load at $P=1$ atm there is a change of flow stress of sense opposite to that which occurred when the pressure was applied. In order to study the effect of prestrain, this series of tests can be repeated on a given sample. The entire test procedure is performed with the minitester in the pressure vessel and the sample is thus left undisturbed throughout. It is found that anomalous jumps of flow stress can occur when a sample is moved about on the platens of the minitester.

INTERPRETATION

In the above described experiment the change in plastic flow stress of a crystal induced by applied hydrostatic pressure is determined. Consider now to which properties of the crystal this flow stress change is related. Imagine a section of a crystal with width x_1 and height y_1 pierced by N active dislocations all of the same kind, as shown schematically in Fig. 3. Let this crystal be deformed an infinitesimal amount Δy_1 in time Δt_1 at $P=1$ atm. The longitudinal strain is given by

$$\Delta\epsilon_1=\phi_1\Lambda_1 b_1\Delta\bar{s}_1, \quad (1)$$

where ϕ_1 is an orientation factor, Λ_1 is the dislocation density, b_1 is the Burgers vector and $\Delta\bar{s}_1$ is the average distance of dislocation travel. Therefore, for this crystal,

$$\Delta\epsilon_1=\Delta y_1/y_1=\phi_1(N/x_1y_1)b_1\Delta\bar{s}_1. \quad (2)$$

Imagine now the same crystal with the same number of active dislocations to be deformed at elevated pressure an additional infinitesimal amount Δy_1 in another interval Δt_1. This is the situation which obtains in the experiment of Fig. 2 where the flow stress change is determined at a single plastic strain and the rate of compression is unaffected by pressure, since the motor speed is effectively the same at 1 atm and 4.3 kbar. Then

$$\Delta\epsilon_2=\Delta y_1/y_2=\phi_2(N/x_2y_2)b_2\Delta\bar{s}_2, \quad (3)$$

where the subscripts 2 indicate quantities at high pressure, i.e., x_2 and y_2 represent the reduced crystal

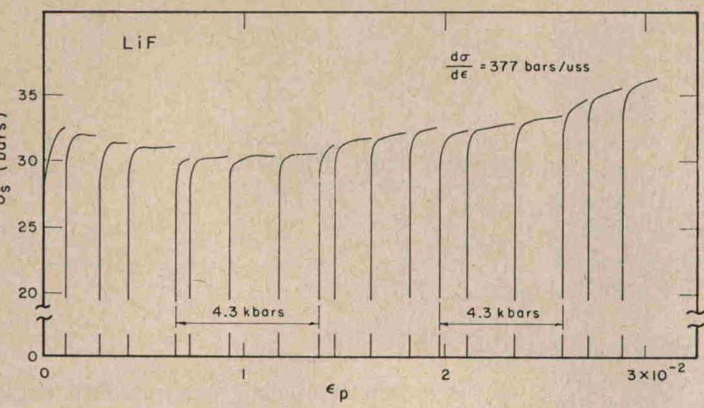

FIG. 4. A shear-stress–shear-strain curve for single-crystal LiF deformed in compression. The 4.3 kbar deformations and the steady-state rate of work hardening (at $\epsilon_p \simeq 3\times10^{-2}$) are noted. Specimen No. 25B.

dimensions at high pressure. For a cubic crystal, the ratio of b_2 to x_2 equals the ratio of b_1 to x_1 and ϕ_1 equals ϕ_2. Therefore, from Eq. (3),

$$\Delta y_1 = \phi_1 N(b_1/x_1)\Delta\bar{s}_2. \quad (4)$$

From Eqs. (2) and (4) then

$$\Delta y_1/\Delta y_1 = \Delta\bar{s}_2/\Delta\bar{s}_1, \quad (5)$$

so that $\Delta\bar{s}_2 = \Delta\bar{s}_1$ or $\bar{v}_2 = \bar{v}_1$, where $\bar{v}$ is the average dislocation velocity. The change in flow stress with pressure, therefore, is that necessary to maintain a constant dislocation velocity.

It is essential to this argument, of course, that no change in the number of dislocations occur due to application of hydrostatic pressure alone. Etch-pit observations on LiF show that no such change occurs. Also, experiments have been performed where a sample is deformed, then pressurized, without deformation, and redeformed at $P=0$. No discontinuity in flow stress before and after pressurization is found, as would be expected if pressure affected the number of active dislocations. The argument above also assumes that the mode of deformation is identical at elevated pressure and at $P=1$ atm. Etch-pit and stress birefringence observations on LiF, stress birefringence observations on KCl and NaCl, and visual observation of CsBr indicate that this is true.

The condition of constant sample compression rate also depends on the nature of the pressure-induced change in work-hardening rate of a sample. The ratio of the plastic compression rate of a sample to the total deformation rate of the sample and minitester equals $k_m/(k_m+k_s)$, where k_s is the "spring constant" for the plastic compression and k_m is the "spring constant" for the minitester. (The elastic deflection of the sample is negligible in comparison to that of the tester). While k_m is not affected significantly by pressure, it is found that $d\sigma/d\epsilon$ increases under pressure in some cases, increasing k_s, and, thus decreasing the plastic compression rate of the sample. This decrease is largest for soft crystals where, for $d\sigma/d\epsilon \simeq 500$ bar/unit shear strain at 1 atm. and $\Delta(d\sigma/d\epsilon)/\Delta P \simeq 50\%$, it amounts to about 6% to 7%. For the harder crystals either the rate of work hardening or the change of rate with pressure or both are smaller so that the effect is negligible. The 6% decrease in plastic compression rate for the soft crystals warrants an addition of 0.4×10^{-2} to $\delta\sigma/\sigma$ to correct to conditions of constant compression rate. However, as the correction is to be made only for the soft crystals, where, it will be seen $\delta\sigma/\sigma$ is large and the experimental scatter is $\sim\pm3$ to 4×10^{-2}, the correction is neglected. $\delta\sigma/\sigma$ has of course, been corrected for the change in load-cell calibration with pressure.

RESULTS

Figure 4 shows a representative interrupted shear stress-plastic shear strain curve ($\sigma_s - \epsilon_p$) for LiF. The sample is one hardened by ^{60}Co irradiation. Stress and strain are resolved as if they were homogeneous, i.e., $\sigma_s = \sigma_c/2$ and $\epsilon_p = 2\epsilon_c$, where the subscript c refers to compression. The results shown in Fig. 4 closely resemble the idealized experiment of Fig. 2; the plastic strain in each cycle is an extension of that in the previous cycle indicating that no recovery or aging has occurred. The change in flow stress due to pressure, $\delta\sigma/\sigma$, is slightly negative, but this falls within the total experimental error. ^{60}Co irradiation reduces the mobile fraction of dislocations giving rise in some cases (as

TABLE I. Typical work-hardening rate and change of work-hardening rate with pressure.

		$W=d\sigma/d\epsilon$ (bar/unit shear strain)	$\sigma_s(\epsilon_p=0)$ (bar)	$d\ln\sigma/d\epsilon$	$\delta W/W$ ($\delta P=4.3$ kbar)
LiF	soft	200	10	20	0
	hard	500	50	10	0
KI	soft	340	5.2	65	0.27
KBr	soft	380	5.4	70	0.21
KCl	soft	500	5.0	100	0.43
	hard	290	22	13	0.10
NaCl	soft	240	4.4	55	0.44
	hard	120	17	7	0.74
RbI	soft	400	10	40	0.60 (3.2 kbar)
CsBr	soft	60	10	6	0.34
	hard	110	15.7	7	0.06