tested here exhibit an intermediate rate of work hardening. Figure 10, for irradiated NaCl, shows a reduced effect of pressure on σ_s compared to soft NaCl; $d\sigma/d\epsilon=$ 80 bar, which is less than for soft NaCl. This indicates, that hardening NaCl by irradiation results in a reduced rate of work hardening.

A σ_s–ϵ_p curve for RbI is given in Fig. 11. In this case the applied pressure is only 3.2 kbar as RbI undergoes a phase transition to the CsCl structure at about 3.6 kbar. A large effect of pressure on σ_s and $d\sigma/d\epsilon$ is evident. To correct for the change in load-cell calibration at 3.2 kbar it is assumed that the correction shown in Fig. 1 for 4.3 kbar varies linearly with pressure. Figure 12 shows a σ_s–ϵ_p curve for CsBr. For the CsBr samples $\sigma_s=0.354\sigma_c$ and $\epsilon_p\cong 2.8\epsilon_c$. Prior to pressure application $d\sigma/d\epsilon=146$ bar and after pressure release it is 60 bar. The σ_s–ϵ_p curve has not been shown for high strain but $d\sigma/d\epsilon$ remains approximately constant at 60 bar to much larger ϵ_p. It is concluded that $d\sigma/d\epsilon=60$ bar is the steady-state rate of work hardening at 1 atm and with this as a base $d\sigma/d\epsilon$ is increased by about 35% at 4.3 kbar. Figure 12 indicates that soft CsBr shows a Portevin–Le Chatelier effect (serrated σ_s–ϵ_p curve) when deformed under pressure. For soft CsBr the effect is often considerably more pronounced then in Fig. 12; in a crystal hardening by irradiation the oscillations approach 10% of the flow stress.

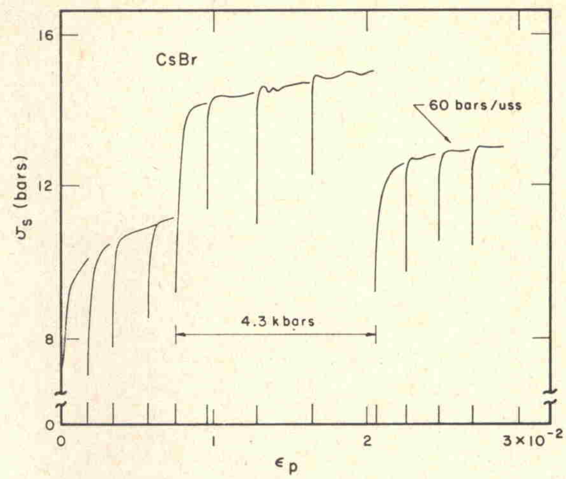

FIG. 12. Shear stress vs shear strain for single-crystal CsBr (No. 1). A serrated $\sigma_s-\epsilon_p$ curve is observed at 4.3 kbar.

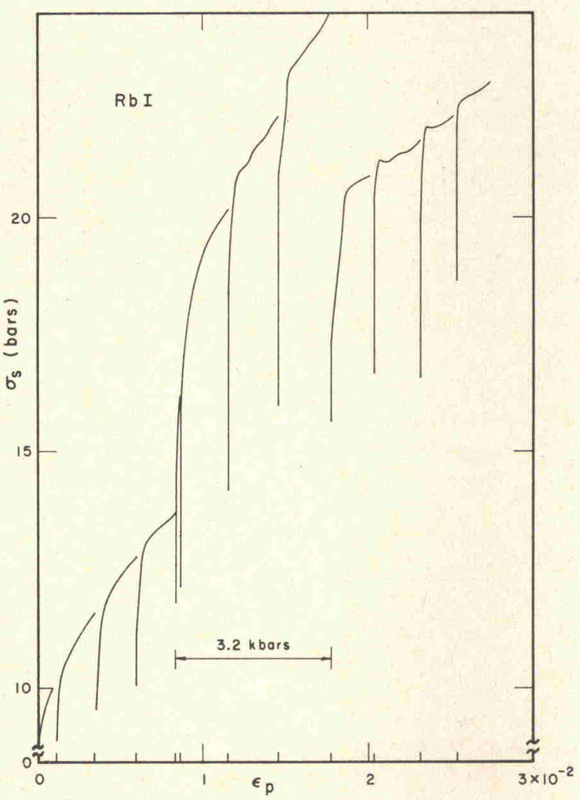

FIG. 11. Shear stress vs shear strain for single-crystal RbI (No. 1); $d\sigma/d\epsilon$ at 1 atm before pressurization is ~400 bar/unit shear strain.

The σ–ϵ curves show the magnitude of $\delta\sigma/\sigma$ to be quite variable even for one specimen. Figure 13 shows all the 4.3 kbar $\delta\sigma/\sigma$ data for KCl plotted vs the low-pressure, shear flow stress resolved in the shear direction. The figure, representing the results obtained on twenty specimens, shows two symbols for each specimen. The open symbol corresponds to the value of $\delta\sigma/\sigma$ on the initial application of pressure. (The open symbol for No. 7 is missing as the initial pressure application was inadvertently made before a steady state of work hardening was achieved.) The shaded symbol is for the value observed on the following release of pressure and for the values on subsequent pressure cycles if they were made. In so far as possible, the shear strain at the points where $\delta\sigma/\sigma$ is measured is kept approximately constant, generally falling in the range of 0.5% to 2% ($\epsilon_s=2|\Delta l|/l_0$). The shear stress of the samples tested ranged from approximately 5 to 40 bar; most high flow-stress values were produced by subjecting samples to ^{60}Co radiation. It is apparent that $\delta\sigma/\sigma$ falls rapidly in a small range of stress from a maximum value of 25×10^{-2} to a value which remains constant at about 8×10^{-2} to much higher stresses. All the samples which were unirradiated, except Nos. 11, 16, and 23, fall on the nearly vertical part of the curve. The latter samples were work hardened considerably before pressure was first applied and thus show flow stresses intermediate to the softest (as received) and hardest (heavily irradiated) crystals and correspondingly intermediate values of $\delta\sigma/\sigma$. Crystals for which irradiation is lighter show intermediate flow stresses and corresponding $\delta\sigma/\sigma$. It is apparent, therefore, that there is a relationship between shear stress and $\delta\sigma/\sigma$; that is, $\delta\sigma/\sigma$ decreases with σ regardless of whether a crystal is hardened by irradiation or work hardening.

A considerable range of $\delta\sigma/\sigma$ exists for the soft crystals. This is probably due in part to slight differences in the crystals, i.e., harder crystals show a

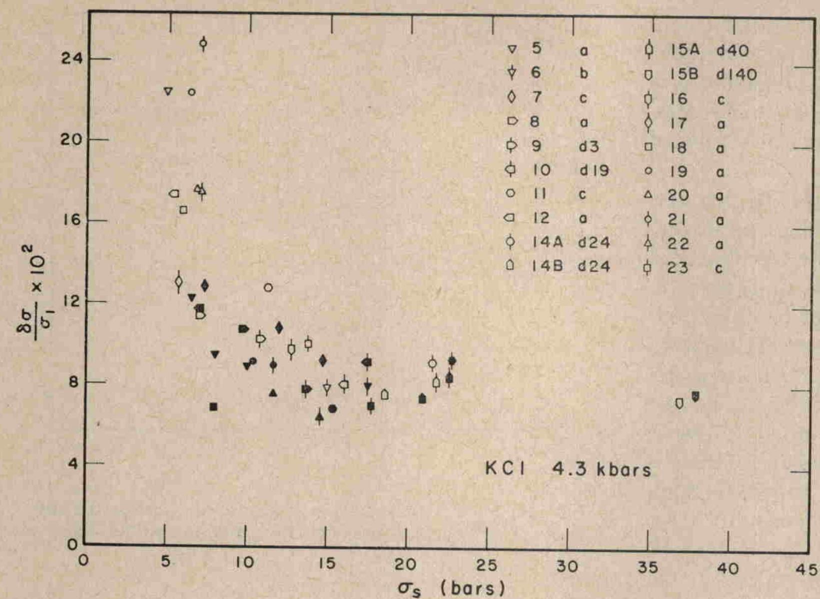

FIG. 13. The 4.3-kbar data for KCl showing the dependence of $\delta\sigma/\sigma$ on shear stress. The data for each specimen are distinguished by a different symbol; unshaded symbols correspond to the first application of pressure and shaded symbols correspond to the release of pressure and to other pressure cycles if they were made. In the legend: a=as-received crystal, b=as-received 1959 (this crystal is hard mainly due to impurity—it was irradiated for ~0.5 h, however), c=work hardened substantially before pressurization, dx=γ-ray irradiated x hours (0.1 MR/h).

smaller effect, and partly because the rate of work hardening in these crystals (relative to the slope of the elastic portion of the stress–strain curve) is very large. The latter phenomenon makes the extrapolation of the high-pressure stress–strain curve to the fiducial strain less reliable. For the harder KCl crystals, or, more generally, for all those experiments where $\delta\sigma/\sigma$ shows little stress dependence, the maximum scatter in $\delta\sigma/\sigma$ is $\pm 2\times 10^{-2}$ about its average at a given stress. The probable error in $\langle\delta\sigma/\sigma\rangle_{av}$ due to random causes is $\pm 1\times 10^{-2}$. This uncertainty arises from three sources; extrapolation of the σ_s–ϵ_p curve to the fiducial strain, load-cell variability, and slight variation in the motor speed from test to test. There is a systematic uncertainty in $\delta\sigma/\sigma$ of $\pm 1\times 10^{-2}$ due to uncertainty in the effect of pressure on the load-cell calibration. The limits of absolute error are, therefore, about $\pm 2\times 10^{-2}$ when $\delta\sigma/\sigma$ has a low stress dependence. We estimate limits of 3 to 4×10^{-2} for $\delta\sigma/\sigma$ when determined for a soft crystal with rapid work hardening. The variation in $\delta\sigma/\sigma$ with stress in KCl is too large to be accounted for by a combination of random and systematic errors.

Figure 14 shows the dependence of $\delta\sigma/\sigma$ on σ in LiF. Within experimental error, $\delta\sigma/\sigma=0$ for this material in all conditions. The $\delta\sigma/\sigma$ vs shear stress data for NaCl are shown in Fig. 15. Over the yield stress range of 5 to 35 bar a decrease in $\delta\sigma/\sigma$ from about 13×10^{-2} to $\sim 3\times 10^{-2}$ is observed. The experiments on the other alkali halides considered are limited to two each for KI, KBr, and CsBr and one for RbI. As noted above, for the RbI sample $\delta\sigma/\sigma=0.30$ and 0.19 on pressure application and release, respectively. In Fig. 16 $\delta\sigma/\sigma$

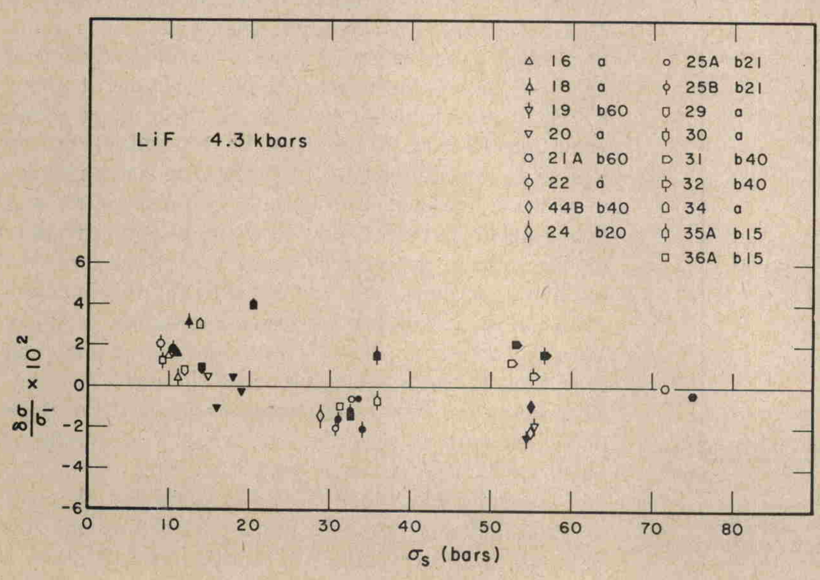

FIG. 14. The 4.3-kbar $\delta\sigma/\sigma$ data for LiF. In the legend: a=as received, bx=γ-ray irradiated x min.