$$\chi_{pd} = \frac{H'}{E} \int_0^{\epsilon} \sigma(\epsilon')d\epsilon'$$

where E is the modulus of elasticity, ϵ is the relative elongation, σ is the stress applied, and H' is a numerical factor of the order of 1/3 (van den Beukel, 1969). If stress is linearly related to strain in the plastic region, then Saada's relation predicts that defect concentration depends quadratically on plastic strain (compare to Nabarro's models). The above models do not explicitly account for the effect of strain rate.

There are a number of empirical relations published for low strain rate deformation which suggest proportionality between

1. defect concentration and square of flow stress (Kovacs, Nagy, and Feltham, 1964; Gindin, Khotkevich, Neklyudov, Lebedev, and Bobonets, 1971);
2. defect concentration and dislocation density (Kovacs et al., 1964);
3. flow stress and square root of dislocation density (Kovacs et al., 1964; Briley and Hirsch, 1960);
4. stored energy and square of shear stress (Wolfenden, 1969; Nakada, 1965).

Relation 3 is also derived in work hardening theories for the rapid work hardening region (stage II) (Hirsch, 1967). The above relations can be incorporated into a single scheme if we assume a Saada-type relation, and linear relations between stress and strain, and between flow stress and square root of dislocation density.

Whether this scheme is descriptive of the high strain-rate deformation associated with shock waves is not known. At least, coefficients of proportionality will probably be different from those at low strain rates. For the shock case the scheme implies

$$\chi_{pd} \propto \epsilon^2 - (\epsilon^1)^2 \approx \epsilon^2 = (\ln \frac{V}{V_o})^2 \quad ;$$

ϵ^1 is the uniaxial strain at the Hugoniot elastic limit. Fig. 14 shows that this relation gives a fair fit to the data. For W3N $\chi_V = 0.36\ \epsilon^2$ and for MRC $\chi_V = 0.22\ \epsilon^2$ using Eq. (10). A plot of $\ln(\Delta\rho_D/\rho_o)$ versus $\ln(-\epsilon)$ actually shows χ_{pd} is proportional to $\epsilon^{3/2}$ (as in one of Nabarro's models) rather than ϵ^2 (Fig. 15). For the expression $\chi_V = A(-\epsilon)^n$ the results for W3N foil are A = 0.14, n = 1.58, and for MRC foil are A = 0.051, n = 1.46.

It is of interest to calculate the defect concentration predicted for silver by Saada's relation. For silver H' = 0.28 (Dawson, 1965b), E = 0.71 Mbar and $\sigma\, d\epsilon^p$ is taken from Sec. III.C and III.D. For a final strain of -0.08 the relation predicts a defect concentration of 2×10^{-5}; about two orders of magnitude below values computed from the shock data. Hence, within the framework of our assumptions that all deviation resistivity is due to vacancies, and that shock yield stress can be computed from low strain-rate tensile data, Saada's relation is not valid at the high strain rates associated with shock compression.

F. Energy Balance

One important check on the assertion that deviation from the hydrostat is due to defect resistivity is energy balance.