greater pressure should give free-surface velocities greater than that of the projectile velocities.

Attenuation started between 4.1 and 5.2 plate thicknesses, implying a sound velocity behind the 340-kbar shock of 0.93 cm/μsec. More data are needed for determining if the elastic relief wave and the plastic wave are separated. Because of the results obtained for the lower-pressure experiments, it is doubtful if there is a separation.

IV. CALCULATION OF SHOCK-WAVE ATTENUATION

The attenuation experiments can be simulated by the use of a computer code. Two methods were used to solve the flow equations. One, using the method of characteristics, was restricted to cases in which rigidity was neglected. The equation of state in this code was

$$P=A[(\rho/\rho_0)^\gamma-1], \qquad (1)$$

where P is the pressure, ρ is the density, and ρ_0 is the density at zero pressure. When A, γ, and ρ_0 are given the values 0.196 mbar, 4.1, and 2.785 gm/cc, respectively, Eq. (1) satisfactorily represents the Hugoniot data for 24ST aluminum.[8,9]

The other method for solving the flow equations made use of a computer code based on the method developed by von Neumann and Richtmyer in which an artificial viscosity is used to smooth discontinuities in the flow.[10] When material rigidity is neglected, the code uses the equation

$$P=A\mu+B\mu^2+C\mu^2, \qquad (2)$$

to represent the equation of state, where P is the pressure in megabars, and $\mu=\rho/\rho_0-1$. In such a case, the Hugoniot and the expansion adiabats are assumed to coincide and are all described by Eq. (2).

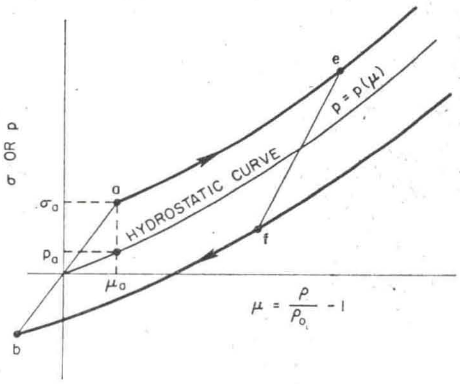

FIG. 6. Schematic diagram of elastoplastic stress–strain relations.

[8] S. Katz, D. G. Doran, and D. R. Curran, J. Appl. Phys. **30**, 568 (1959).

[9] M. H. Rice, R. G. McQueen, and M. Walsh, in *Solid State Physics*, F. Seitz and D. Turnbull, Eds. (Academic Press Inc. New York, 1958) Vol. 6.

[10] J. von Neumann and R. D. Richtmyer, J. Appl. Phys. **21**, 232 (1950).

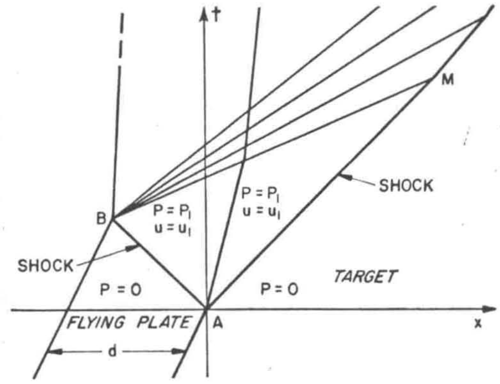

FIG. 7. Physical plane for plate-impact experiment.

A. The Constant Poisson's Ratio Model

An elastoplastic relation is diagrammed in Fig. 6. The hydrostatic curve is represented by Eq. (2), and the upper and lower curves are given by

$$\sigma_x=P\pm 2Y/3, \qquad (3)$$

where σ_x is the stress in the direction of propagation of the shock and Y is the yield stress in simple tension, i.e., twice the maximum resolved shear stress. The upper, or loading, curve is made to coincide with the Hugoniot curve just as Eq. (1) was forced to do. Calculated results agreed more closely with experimental results when Y was made to vary with the hydrostatic pressure as

$$Y=Y_0+M(P-P_a), \qquad (4)$$

where Y_0 is the initial yield stress, P_a is as defined in Fig. 6, and M is a constant. Values of the various parameters for the elastoplastic equations of state for aluminum are given in Table II. These data are derived from the Hugoniot data given in Ref. 9.

In the derivation of the elastoplastic relations, stress, σ_x, is related to density, ρ, by

$$d\sigma=(K+4G/3)\,d\rho/\rho \qquad (5)$$

for an elastic event. In Eq. 5, K is the bulk modulus, G is the rigidity modulus, ρ is the density, and the subscript x has been dropped. In the constant Poisson's ratio model, K is replaced by $-VdP/dV$, where V is the specific volume, P is the hydrostatic pressure, and G is replaced by

$$G=3K\frac{(1-2\nu)}{2(1+\nu)}=\frac{-3V(1-2\nu)}{2(1+\nu)}\frac{dP}{dV} \qquad (6)$$

where ν is Poisson's ratio. Combining Eqs. (5) and (6) gives

$$\frac{d\sigma}{d\rho}=c^2=\frac{3(1-\nu)}{(1+\nu)}\frac{dP}{d\rho}, \qquad (7)$$

where c is the sound speed and $dP/d\rho$ is the slope of the