(p_0, V_0). This region, AF in Fig. 14 *b*), is defined by extending the Rayleigh line OA until it intersects the Hugoniot AB at the point F. Pressures in this region will be reached by a double shock, illustrated in Fig. 15. The first

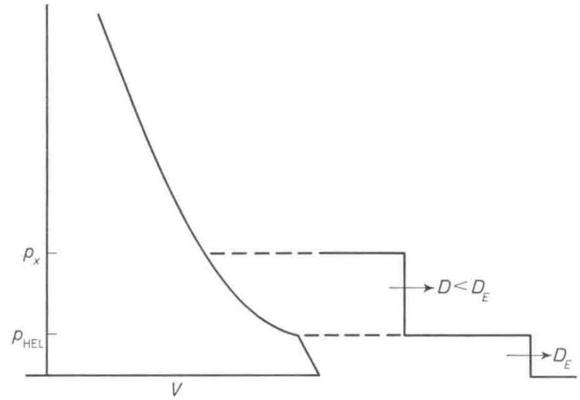

Fig. 15. – Double shock in elastic-plastic material.

shock is called the « elastic precursor »; it travels with elastic velocity, and its amplitude is p_{HEL}.

The unloading wave following an elastic-plastic shock also consists of two waves, but these are not always clearly distinguishable because of the spreading of the rarefactions. The decay process for an elastic-plastic shock is accelerated, however, by an elastic wave running back and forth between the shock front and the plastic rarefaction [4].

An example of an elastic-plastic shock in aluminum is shown in Fig. 16.

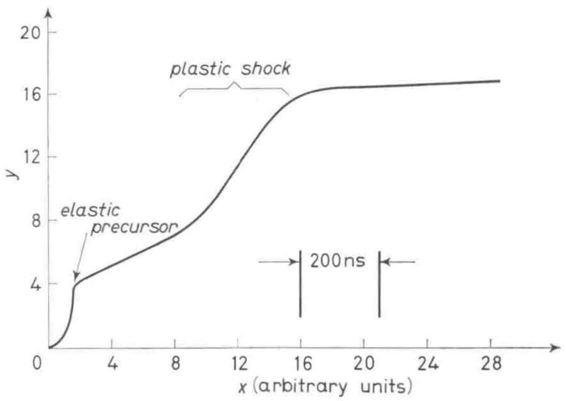

Fig. 16. – Shot no. 68-015. 6061-T6 Al target $\frac{1}{2}$ in. thick, recorded with 1 $\frac{1}{4}$ in. quartz gauge in Graham configuration. Peak pressure: 19 kb. Elastic precursor: 5.2 kb. (R. Mitchell, W.S.U.).

This record was obtained with a quartz gauge on the surface of a 6061-T6 Al target struck by a half-inch thick plate of the same material. The elastic precursor and plastic shock are readily distinguished.

A number of experiments on wave shape and shock decay have established that in aluminum, at least, and probably in other metals as well, the elastic-plastic model is substantially correct, though there are significant deviations due probably to Bauschinger effect and stress relaxation [5].

5. – Solid-solid phase transitions.

Another source of instability in shock waves is the solid-solid phase transition. A schematic diagram of a first-order transition in the (p, V) plane is shown in Fig. 17. An isotherm crosses the mixed phase region at constant pressure; an adiabat has, typically, a small negative slope. The change in slope of the adiabat on crossing the phase boundary can be readily calculated by straightforward application of thermodynamics [6]. In terms of sound velocity in phase 1, c_1, and equilibrium sound velocity in mixed phase, c_m, the change of slope is given by

$$(53)\qquad (c_1^2 - c_m^2)/c_1^2 c_m^2 = (C_p/V^2 T)[(\partial T/\partial p)_s - \mathrm{d}T/\mathrm{d}p]^2 ,$$

where all quantities are evaluated at the phase boundary. Numerical computations for iron and bismuth show that the mixed phase adiabat is almost flat. Since the Hugoniot for the second shock and the mixed phase adiabat have a second order contact at the phase boundary, the Hugoniot is similarly flat.

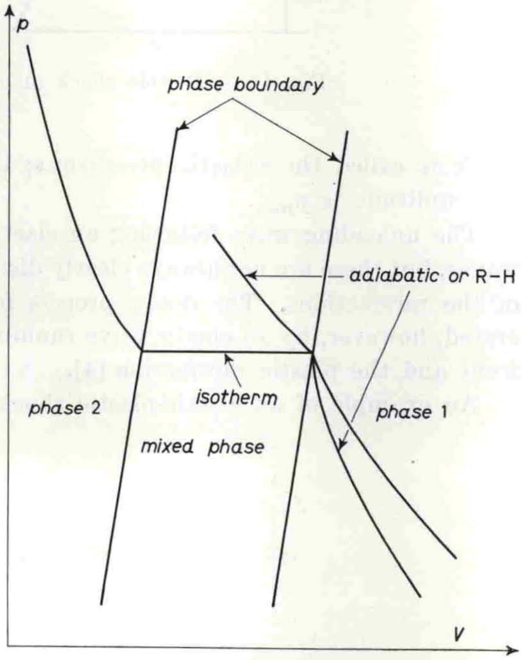

Fig. 17. – Reversible transition.

In preparing a formal representation of a set of constitutive relations for use with the flow equations, eqs. (1)-(3), it is useful to keep in mind their mode of application. The most widely used procedure for integrating the flow equations is a staggered-difference scheme developed by VON NEUMANN and