Attempts to measure temperature of the shocked state by means of the thermoelectric effect have thus far been unsuccessful.[46] Anomalously large signals have been observed whose physical origin is not understood. Some success has been achieved, however, in measuring free-surface temperatures.[47,48] These provide at least a consistency check on some of the assumptions employed in interpreting equation of state experiments.

By using porous samples R-H curves centered on different initial states (V_0,E_0) can be determined and the Gruneisen coefficient measured.[3,49] Thouvenin has questioned the assumption that equilibrium states can be achieved by this method,[50] but later work by Hofmann et al indicates that they are possible.[51]

B. Constitutive Relations

At shock stresses comparable to the yield stress, the effects of stress anisotropy and strain rate cannot be neglected. Not only does the elastic wave carry a significant fraction of the total stress, but the structure of the plastic shock and the rarefaction wave that relieves the shocked state are more complex. Figure 11 shows an example of the compressive portion of the wave shape in single crystal Lithium Fluoride. It would clearly be a coarse assumption to consider these waves as simply two discontinuities in stress separated by a constant region. Much more detailed analysis of the wave structure than simple application of the jump conditions is required.

Where strain-rate effects can be ignored, elastic-plastic theory can be applied to predict the differences between the one-dimensional constitutive relation and the hydrostatic equation of state.[11,52] This theory predicts the curves shown as Fig. 12. Above the yield point the difference between the normal stress in the direction of propagation and the hydrostatic pressure is just (2/3)Y, where Y is the yield stress in simple compression. Work-hardening can be incorporated. The release curve representing the states through which a rarefaction wave carries the material is also offset from the hydrostat by (2/3)Y once the yield stress in the reverse direction is attained.

Several attempts have been made to verify this model.[11,53] Measurements of the compressive state in aluminum indicate reasonably good agreement as indicated in Fig. 13. The rarefaction portion of the curve for the lower range of shock stresses shows poorer agreement, evidently because of Bauschinger effect.[36,54]

The Hugoniot elastic limit, indicated by P_o in Fig. 12, is frequently observed to be time-dependent and, as would be expected, is also dependent on the history of the specimen. Nevertheless, the values observed are approximately characteristic of the material and a useful tabulation of measurements to date has been given by Graham and Jones.[55]

At shock stresses of 100 kbar or more the difference between Hugoniot and hydrostat is difficult to resolve; moreover, good hydrostatic data do not exist. Measurements of the rate of decay of a shock pulse of finite width, however, permit inferences to be made about the yield stress and shear modulus under shock conditions.

The first experiments to observe shock decay were performed by Altshuler[56] and Curran[57] on aluminum. Curran's results indicated that shock decay is more rapid than would be predicted by the elastic-plastic model with constant yield stress. He postulated that yield stress increases with compression, attaining a value of 12 kbar at a relative volume, V/V_o, of 0.86. The initial yield stress was 0.5 kbar.

These results were verified, at least qualitatively, by Erkman.[58] He found similar behavior in copper and epoxy.

Recently, van Thiel and Kusubov have measured the shape of the rarefaction portion of an initially square pulse induced in aluminum by impact with a thin plate.[28] They used manganin gauges to interpolate between the peak pressure of the pulse and zero pressure. The impact pressure (130 kb) was higher than in Barker's similar experiments.[36] Their conclusion is that the yield stress is a peculiar function of pressure in the rarefaction wave and approaches values as high as 28 kbar, or nearly five times the static strength. (Fig. 14)