Disadvantages to explosives are that the plane waves produced are less precisely controlled than is the case with guns. Moreover, a continuous range of impact pressures is very difficult to achieve. For these reasons explosives are most frequently used for equation of state measurements and for the study of other high pressure physical phenomena.

Electron beams and lasers are also beginning to be used for the production of plane waves.[19,20] These produce stress waves through thermoelastic coupling when radiant energy is absorbed in the target material in times short compared to the transit time of rarefaction waves.

Electron beams provide much higher energy densities; with electron energies in the range 0.2 to 5.0 mev the maximum fluence (energy per cm^2) varies between about 35 and 300 cal/cm^2. The corresponding stress pulses produced depend on the absorbing material but are typically ten to several hundred ns in duration, and attain peak stress amplitudes up to about 100 kbar. The area over which the flux is reasonably uniform is a few square centimeters.[19]

Lasers operated in the pulse mode give comparable pulse durations and irradiated areas, but deliver total energies one to two orders of magnitude less than do electron beams.

These methods are most useful when it is desired to observe stress wave propagation under high temperature conditions or when very short pulse durations are desirable.

B. Measurement Techniques

Parameters which are directly pertinent to a description of plane stress wave propagation are the normal stress component acting across a plane perpendicular to the direction of propagation, the density or strain, the internal energy, the mass velocity, and, in general, two phase velocities. The existence of two phase velocities is not widely recognized and indeed for steady shock fronts or isentropic rarefactions the two velocities are the same. In general, however, they are distinct, as is shown in Section III.

Three independent relations expressing conservation of mass, momentum, and energy can be written relating the above parameters; Eqs. (1)-(3) are those relations for the special case of steady flow. Consequently, three measurements are required in order to determine the state. The normal stress components parallel to the wavefront are not directly involved. They can be inferred under certain conditions, however, by comparing the compression and relief paths in the P-V plane or when a hydrostat is known independently.

The measurements which can be most accurately made at present include the normal stress component and the free-surface velocity, which can be related in many cases to the mass velocity. For some materials mass velocity can be measured directly. From measurements of these quantities at two or more locations in the sample one or both of the phase velocities can be obtained.

A variety of optical techniques using high speed cameras have been invented and used successfully to record surface velocities (and wave velocities). These include argon flash gaps, inclined mirrors, moving images, and optical lever techniques. The precision of these methods is usually about 1% in wave velocity and 5% in free surface velocity. The time resolution is generally about 10 ns.

Electrical methods are also in wide use and include electrical shorting pins, inclined resistance wires, and capacitor microphones. These also measure free-surface velocities with a precision comparable to that of optical methods.

A transducer technique in wide use at present is the quartz gage, which measures the pressure at the interface between the sample and a disc of x-cut quartz plated on both flat surfaces.[21] At stresses up to about 25 kilobars the current developed by the piezoelectric polarization of the quartz is proportional to the stress at the quartz-sample interface. Useful results have been obtained at higher stress levels but 50 kilobars is about the upper limit. It has high inherent time resolution and is convenient to use.