0.1 mm/μs to 1.5 mm/μs. Higher velocities are exceedingly difficult to reach in a single stage gun, except that use of hydrogen could increase the velocities to about 2 mm/μs. Velocities lower than 0.1 mm/μs can be achieved but non-reproducible frictional losses tend to make the projectile velocities erratic in this range. Table I shows some pressures produced by impact at 1.5 mm/μs.

The barrels are evacuated ahead of the projectile to prevent a gas cushion from distorting the wave shape. Hard vacuums are evidently not necessary; Barker was able to detect no effect at residual gas pressures below 0.6 torr in the Sandia 3 meter gun.[16] Impact with the target usually takes place an inch or two in front of the muzzle to provide space for expansion of the projectile while still maintaining a maximum degree of alignment of projectile and target.

The tilt angle between the projectile and target must be precisely controlled if true plane waves are to be produced, particularly at lower impact velocities. The angle of the wavefront with respect to the target surface is frequently an order of magnitude or more larger than the misorientation of the projectile with the target because of the large difference between wave velocity and impact velocity.

Large tilt not only produces two-dimensional flow but reduces the time-resolution of the recording instrumentation. Thus if the recording gauge has finite dimensions in the plane parallel to the impact surface, the time resolution achieved may be controlled by the time required for the wave front to sweep across the gauge.

In practice angular misorientations of a few tenths of a milliradian are commonly achieved. A tilt of this magnitude would typically result in a time resolution, for a gauge whose lateral dimensions are 1/4 inch, of about 5 nanoseconds. Since this is comparable to the resolution of typical fast oscilloscopes the desirability of small tilt is obvious.

The recoil of guns of this type can be difficult to contend with while maintaining the precise orientations required. Where the target is mounted rigidly to the barrel, vibrations can precede the projectile and cause anomalous signals. A convenient solution incorporated into the gun of the Shock Dynamics Laboratory at Washington State University is to allow the gun to move freely while holding the target rigidly on a separate support.[14] The motion of the gun greatly reduces the recoil forces and does not seem to adversely affect the tilt provided the barrel is maintained nearly torque-free. A drawing of the WSU gas gun is shown in Fig. 4. This gun has a 4" bore, a length of 46', and operates on nitrogen or helium to 6000 psi. It is typical of many guns of this type.

Guns that use gunpowder as the propellant are in limited use. Although they can be shorter for a given velocity, and therefore are less expensive, the problems of cleanliness and high recoil forces make them somewhat less desirable for studies of constitutive relations.

For very high velocities, two-stage, light-gas guns can be used.[17,18] The velocities of these guns can reach 8 mm/μs; however, the projectile diameters are generally less than two inches. This is a severe restriction since useful one-dimensional information is obtained from the target only before the effects of free lateral surfaces influence the wave shape. Accordingly only simple measurements of shock velocity, from which equation of state points are determined, have been attempted with these guns.

High explosives have been used to produce plane waves and are useful for extending the pressure range available from single-stage guns. These systems utilize a plane-wave lens to produce a plane detonation wave at the target interface.[2] In some cases useful information has been obtained from two-dimensional steady state waves produced by a running detonation.[11]

In addition to producing higher pressures, explosives are convenient in that precise synchronization with recording instruments can be achieved. This is important when high speed cameras are used because they frequently record only over a small time interval and cannot be triggered by the event to be observed.