β_2 may be approximated at small compressions by implicit differentiation. This approximation probably does not give very good average values over the extended range of compressions involved, but it should at least suffice to indicate whether or not observed discrepancies are of the sort to be expected because of variation in composition. The required relations are

$$1/\rho_0\alpha = (X_1/\rho_0\alpha_1) + (X_2/\rho_{02}\alpha_2), \tag{25}$$

and

$$\frac{\beta}{\rho_0\alpha^3} = \frac{X_1}{\rho_{01}\alpha_1^2}\left[\frac{\beta_1}{\alpha_1}+1-\frac{\rho_0 X_1}{\rho_{01}}\right] + \frac{X_2}{\rho_{02}\alpha_2^2}\left[\frac{\beta_2}{\alpha_2}+1-\frac{\rho_0 X_2}{\rho_{02}}\right]. \tag{26}$$

EXPERIMENTAL TECHNIQUES

The essential details of the experimental technique for the necessary velocity determinations may be visualized by reference to Fig. 1. The material to be studied is machined into the form of a plate perhaps 8 inches in diameter and of a thickness governed by considerations to be discussed. A shock wave is induced in this plate by means of a large block of high explosive (H.E.) detonated simultaneously at all points of its upper surface by means of a suitably designed high explosive lens. Detonation of the latter is initiated electrically in the usual way. At the upper surface of the plate, a high pressure pulse is produced, the magnitude of which depends on the type of high explosive used, and the duration of which depends on the size and shape of the high explosive. In order to achieve a condition of fairly constant pressure at the upper surface of the plate for an appreciable length of time the block of H.E. must be large. For although the instantaneous pressure in the detonated H.E. depends primarily on its chemical and physical properties, the pressure generated by the detonation is immediately relieved at the free surfaces by rarefaction waves. These rarefactions limit the time available for the measurements to a few microseconds and also mean that portions of the plate near the sides never receive the full detonation pressure.

Since the block of high explosive is necessarily of finite thickness (usually 3 to 4 inches), the shock wave in the plate resulting from impact by the detonation wave in the explosive is not quite flat-topped. The shock front is followed immediately by a rarefaction from the back surface which results in an exponential decay. This unloading wave, moving through the plate more rapidly than the shock front, is continuously whittling down the peak pressure. In consequence it is necessary to measure the parameters as a function of thickness of the material.

The free surface velocity at the bottom of the plate (Fig. 1) is ascertained by means of externally placed electrical contactors. These contactors, or "pins," shown in Fig. 1, may be arranged to measure either free surface velocity, by spacing them out behind the plate as shown, or compression wave velocity through the plate by insulating and imbedding the pins in holes drilled to various depths. In either case, the oscillograph records the time at which each pin first touches the metallic surface. In order to synchronize the oscillograph, an extra pin is imbedded in the plate at some convenient level, thus providing an electrical pulse for initiation of the sweep.

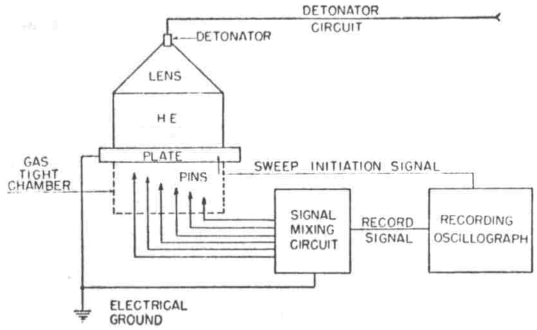

FIG. 1. Apparatus for determining free surface velocity.

Pressure may be measured independently by means of probes made from z-cut tourmaline disks. The calibration constant of the crystals, for the geometry and conditions of these tests, was determined from measurements of u and D in steel. It is advantageous to make these crystals thin. Ours are thicker, about 0.5 mm, than desired but this choice was dictated by practical consideration of existent constructional limitations. Several reverberations are required for equilibrium to be attained between target and crystal and therefore a useful crystal life of about 0.5 μsec is required. If the crystal becomes short circuited before this time a correction factor must be applied for the acoustic mismatch of crystal and specimen plate.

Most of the experimental work on which the present paper is based was performed in 1945. At that time it was realized that elaborate precautions would be required in order to improve the precision of the data. The recent work on Duralumin is inclusive of various improvements in technique which have been discovered over the course of the last five years.

In the first place, if the pins are spaced out behind the plate as shown in Fig. 1, they may be prematurely connected to the plate, and to one another, by ionization of the gas with which they are surrounded. Attempts to insulate the pins from this ionization tend to result in erratic conduction when the metallic surface itself arrives. After much investigation, which included attempted evacuation of the space surrounding the pins, and all sorts of insulations for the pins themselves, it was discovered that little or no preconduction occurs if the gas surrounding the pins is one of the light hydrocarbons, i.e., methane, ethane, propane, or butane. The "gas-tight chamber" in Fig. 1 is always, in the more recent work, filled with one of these gases.

Furthermore, the plane wave of compression as it proceeds through the plate must be exceedingly regular. It is known that in such a compression the pressure rise