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THE SHAPE OF A SHOCK WAVE DERIVED FROM A SPHERICAL
SHOCK WAVE INCIDENT ON A CONCAVE WEDGE

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ABSTRACT

When a one-half ounce spherical charge of high explosive is detonated over a flat plane bounded by a 5° incline, the type of phenomenon encountered depends on the distance from ground zero to the beginning of the incline. If this distance is 48" the wave assumes a smooth contour on the plane. Detailed investigation of the shock velocity above the plane reveals that there is a pressure gradient along the shock front for a considerable region which replaces the usual triple point.

Case No. 407.02

Photostat Price \$ 3.30

Microfilm Price \$ 2.40

Available from the
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During the course of the study of the interaction of spherical shock waves with their surroundings a number of phenomena have been observed, one of which is presented here. Small charges of high explosives were detonated above a metal table 3 feet wide and 80 inches long. At one end of the table there was a second plane making an angle of 5.7° with the first plane as shown in Figure 1. Small quantities of high explosive were detonated at A, 8 inches high and a horizontal distance of 48 inches from the beginning of the rise. Pictures were taken of the shock profile as it progressed up the hill. The basic optical system is shown in Figure 2. Two types of cameras have been used to make these photographs. Firstly, a Bowen R-3 camera was used as a recording mechanism and the light delivered in two short pulses of less than a microsecond duration (photographically speaking) by means of a spark gap. The time between sparks was determined by the Bowen camera using a Hewlett Packard low-frequency standard as a reference. The time system has been checked against a Potter chronograph to less than 1 per cent, the actual accuracy not being known closer than this.

The optical system consisted of two parabolic mirrors with a light source at the focus of the first mirror and a recording camera after the second (see Figure 1).

The second method of photography was to use a Pointolite .003 inch zirconium arc as a continuous light source and record of an 8 mm Fastax camera at a frame speed of about 16,000 frames per second. Times can be determined by small marks on the side of the film which are related to a crystal controlled oscillator. The exposure time is roughly $1/6$ the time interval between frames so that extremely precise velocities can not be determined in this way, but the time history of events is recorded very clearly. Figure 3 shows a shock passing up a 5.7° slope. Note the gradual relative advance of the lower portion of the wave with respect to the upper part, but the absence of anything corresponding to a traditional Mach stem. These pictures were taken at about 16,000 frames per second. They are, however, rather indistinct because the exposure time was about 11 μ sec, long enough so that the wave had progressed nearly $1/4$ inch, thus causing the blurriness. Returning now to the pictures recorded on the Bowen camera, two pictures, made at accurately determinable short time intervals, were taken of each shock wave thus permitting the accurate determination of shock velocity. Figure 4, consisting of a superposition of the two pictures, made possible by the two fiducial markers, again shows the lack of a Mach stem as such although the presence of a reflected wave is indicated by these marks. The two waves are not, however, everywhere parallel but are farther apart at the bottom than the top. Measurements, made as accurately as possible, gave shock velocities which were then converted to pressures directly behind the shock front. When plotted as a function of height above the table they are as shown in Figure 5. Note the constant pressure for the first 0.4 inch above the model and the region of constant pressure above 1.5 inches. These regions correspond to the undisturbed wave above 1.5 inches and to a pseudo Mach stem region near the surface. The region of constant rate of change of pressure is interesting in that it represents the disintegration of a triple point.

Figure 6 is similar but taken up the slope a few inches farther and with a smaller overpressure in the incident wave. Note the pronounced curvatures in the shock front. In Figure 7 you will note the region of constant pressure at the surface of the model is much shorter than previously. The region of constant rate of change of pressure is somewhat longer, as might be expected. This shot is anomalous in that it was derived from a low-order detonation but the exaggerated nature of this picture called our attention to this phenomenon.

It suffices to say that the phenomenon is not found when the incline is steeper, nor is it found when the shock overpressure is higher.

There is a marked contrast between this behavior and that of a plane shock of almost any finite shock strength incident on an incline or wedge. For in a plane shock a Mach stem is formed and remains nearly constant in pressure along its length, independently of how far it has traveled up the incline.

I will propose the following explanation for the difference:

The spherical shock reacts with the intersection of the two planes at a single point then gradually widens the region of intersection. At all points except at the original intersection the interaction is of less magnitude because the incident wave has decreased in amplitude, and because the angle of the shock has deteriorated to the point where a three-shock system is not in equilibrium wave has deflected less. For these reasons the shock wave will decay much faster than it would for a plane wave. In a short distance the shock has deteriorated to the point where a three-shock system is not in equilibrium but the main shock front again tries to find its equilibrium shape, -- a spherical surface.

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FIGURE 1

FIGURE 2

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FIGURE 3
Fastax pictures of a shock wave on a 5° slope.

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FIGURE 3 (Cont'd)

Fastax pictures of a shock wave on a 50° slope

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FIGURE 3 (Cont'd)
Fastax pictures of a shock wave on a 5° slope.

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FIGURE 4
Double spark shadow graph of a shock on a 5° slope

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SHOCK OVERPRESSURE
AS A FUNCTION OF
DISTANCE ABOVE SURFACE
SHOCK 2.5" FROM BREAK IN SLOPE

FIGURE 5

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FIGURE 6

Double spark picture of a weak shock about 17" up a 5° slope

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FIGURE 7

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