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PATH OF TRIPLE POINT FOR SPHERICAL SHOCKS ABOVE A RIGID PLANE

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ABSTRACT

Paths of triple points of Mach reflections produced by 0.5-oz pentolite detonations have been observed for various burst heights. The slopes, X , at points on the curved path are found to vary from values of X predicted from plane shock wave data. This discrepancy is attributed to the shock strength conditions at the early inception of the Mach reflection, which later influence the triple point equilibrium, and in lesser degree to radius of curvature effects.

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Path of Triple Point for Spherical
Shocks Above a Rigid Plane

Studies of Mach reflections of plane shocks impinging on a wedge in a shock tube have been made by Smith¹, Taub², and White³. Figure 1-A depicts the propagation of these Mach reflections where i is the incident shock, r is the reflected shock, M is the Mach stem, S is the slip stream, T is the triple point; α is the angle between the incident shock and a line through T parallel to the wedge wall, and χ is the angle between the wall and a straight line following the forward and upward movement of T . It is noted that the Mach stem is vertical or slightly concave forward with respect to the wall.

Spherical shock Mach reflection studies have been reported by BRL⁴. A typical configuration from present studies appears in Fig. 1-B in which is shown the rearward concave curvature of the Mach stem and the variation in χ along the triple point path. In this case χ and α vary continually with distance from the burst. Here D_B is the horizontal distance from the burst, H_B is the burst height, H_m is the height of Mach stem, and R is the distance from the burst to the triple point. Knowing R , the pressure P can be found from a curve of peak pressure versus distance in free air as published by Brinkley and Kirkwood⁵, and corrected to 12 psi for ambient pressures. ξ is calculated as shown and is defined as the shock strength at the given point. Thus, knowing α and ξ , values of χ can be found for the case of plane shock waves from plots of χ versus α at various constant values of ξ as determined by Smith¹.

The shock waves studied in this report were produced by firing 0.5-ounce pentolite spheres at 8-inch, 16-inch, 20-inch, and 30-inch heights above an aluminum table 3 feet in width. The method of photography employs a typical shadowgraph arrangement using a zirconium lamp for illumination, two 20-inch diameter, f-8 mirrors producing a parallel light path through which the shock wave travels, and a Fastax 8-mm camera which records the image from the second mirror. A number of the photographic shock records are shown in Figure 2. These are titled indicating the experimental conditions under which they were obtained.

1. OSRD-6271, Lincoln G. Smith
2. R.M. P., Vol 21, No. 4, Oct. 1949, A. H. Taub and Walker Bleakney
3. P. U., TR II-10, D. R. White
4. BRL Report No. 809, E. J. Bryant, R. A. Eberhard, C. N. Kinzery
5. OSRD-5137, U.C., S. R. Brinkley and J. G. Kirkwood

Measurements of D_b and H_m were made from the prints with the aid of a fiducial appearing in the photographs. Figure 3 shows curves of D_b versus H_m at various burst heights which depict the path of triple points. Also included are points scaled from BRL Report No. 809 in two available cases. These were obtained from bursts fired over hard-packed dirt and compare quite favorably with those of this report although one would expect them to be generally lower due to the softer surface over which they were produced.

Assessable photographs at the beginning of the Mach stem have been very difficult to obtain due to blast products obscuring the shock in low-burst heights, and to inadequate resolution at very low Mach stem heights. Therefore, the curves in Figure 3 have been extrapolated to $H_m = 0$ as determined from the limits for regular reflection found in BRL Report No. 809. Values of α , R , P and ξ were calculated at various points on the curves of Figure 3 and used to determine the value of χ at these points from data by Smith for plane shock waves. χ_{meas} is the slope at these points as actually measured on the curves of Figure 3.

Figure 4 shows these values of χ versus D_b for each burst height. It is noted that there is a much faster increase in the measured values of χ than in those predicted by plane shock data for low Mach stem heights. For the 8" and 16" burst-height curves particularly this effect may be due in part to radius of curvature effects. If this were the only effect it should be much smaller by the time the 30" high burst is reached. The discrepancy is, however, not reduced but if anything proportionately increased for this curve. The one remaining possibility is that the conditions prior to the measurement point influence the equilibrium conditions at the triple point. In order to check this the value of ξ found at the inception of the Mach stem was used at all points along the respective curves. This leads to the curves labeled χ' . It will be noticed that early behavior of the measured 20-inch and 30-inch high burst curves is much closer to these although there remains a residue which must be attributed either to experimental error or to curvature effects.

Further study is planned for the near future in which observation is to be extended to greater Mach stem heights. Results of 4" high burst studies will also be reported at this time.

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5 Fig-1

Figure 1

$$\xi = \frac{P}{P + \Delta P}$$

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Figure 2 (d)

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10 Fig-3

Figure 3

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