LETTERS TO THE EDITORS

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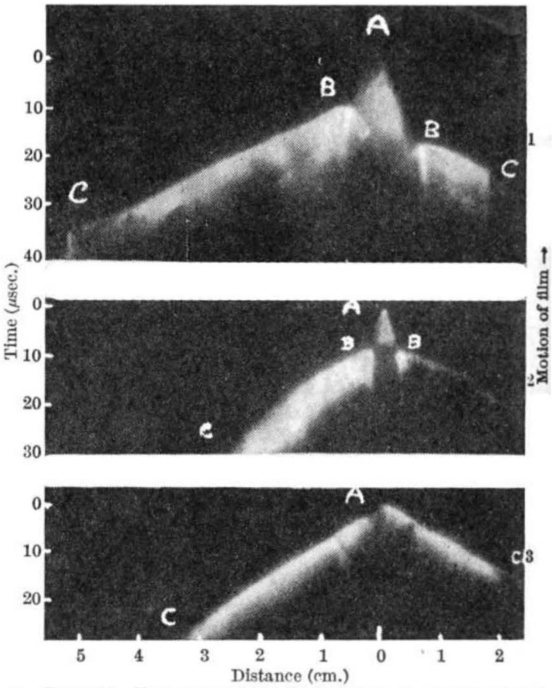
Birth and Growth of the Explosion in Solids Initiated by Impact

It has been shown that when liquid explosives such as nitroglycerine are initiated by impact, the explosion begins as a comparatively slow burning which spreads for a short distance from the point of initiation at a speed of *c.* 400 metres per second, and is then suddenly transformed into a faster propagation at *c.* 1,800 m./sec., which has the property of a detonation wave[1,2,3]. This two-stage propagation occurs when the initiation is caused by impact and compression of a small included bubble, or by sparking, and is observed with all the liquid explosives which have so far been investigated.

A recent study of the initiation of solid explosives by impact reveals a similar effect. If a thin film of the solid explosive is distributed on the anvil as an annulus, so that a small gas space is included during the impact, the sensitivity is increased[4]. Photographic experiments show that initiation begins at the gas space. This gives a convenient method of ensuring that the point of initiation is on the slit of the camera, and high-speed photographic studies of the growth of the explosion in the immediate vicinity of the point of initiation have been made both for secondary and for primary explosives. A typical result for a thin film of solid *P.E.T.N.* is given in Fig. 1. The initiation begins at *A* at the small included gas space, and the flame spreads from this point at a comparatively slow rate. In Fig. 1 this initial rate of burning (*AB*) is 450 and 300 m./sec. We should expect this rate to be dependent on film thickness, density of packing, etc., and in these experiments the rate varied from 100 to 600 m./sec. After a short distance (at the point *B*), this burning was transformed into a detonation, the speed of which varied from 1,000 to 2,500 m./sec. according to the density and film thickness of the explosive. In Fig. 1 this second stage (*BC*) is spreading at 1,620 m./sec. The transition from low-speed to high-speed propagation usually occurred at a physical discontinuity, that is, at the edge of the hammer, but this was not always the case. Films of cyclonite and tetryl gave similar results; but the initial burning was slower (100–300 m./sec.), and the thin film of explosive surrounding the hammer did not propagate.

A similar study has also been made of the initiation of primary explosives by gentle impact, both with and without added grit; when a grit particle was present, initiation began at the particle. The result for mercury fulminate initiated without grit is shown in Fig. 2. The two-stage propagation is again apparent. After initiation, the explosion spread for a short distance at a speed of 250–300 m./sec. before passing over to a high-speed detonation. Lead azide, on the other hand, usually showed no slow initial stage (see Fig. 3); detonation set in immediately unless extremely thin low-density films were used. It is interesting to note that for the *thermal* initiation of unconfined trains of these two primary explosives, Patry[5] found that fulminate gave an initial burning and azide did not.



1. *P.E.T.N.* From the point of initiation *A*, the explosion spreads as a slow burning *AB*, followed by a detonation *BC*. 2. Mercury fulminate. Similar to 1. 3. Lead azide. No initial burning

A parallel series of experiments was carried out with thin films of *P.E.T.N.*, mercury fulminate and lead azide confined between two surfaces and initiated at the centre by a spark instead of by impact. The growth of the explosion initiated by the spark was very similar to that obtained by impact. *P.E.T.N.* and mercury fulminate both gave an initial slow burning which changed over to a detonation (the photographs were similar to Figs. 1 and 2). With lead azide, the burning stage was not observed and the photograph was similar to Fig. 3.

It is clear that for a number of solid explosives the first stage of the initiation by impact is a burning, and that the general behaviour is very similar to that observed in liquids under similar conditions. It is probable that under the impact, many explosives, particularly the softer ones, are compressed and flow like liquids. The results again suggest that, for solids as well as for liquids, the initiation under impact is essentially thermal in origin, and that the explosion begins at a hot spot which can be generated either by the adiabatic compression of a gas pocket, or by friction on a particle of grit, or (under extreme conditions) by viscous heating of the rapidly flowing explosive.

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