ABSTRACT

A pressure transducer technique using the shock polarization effect described by Eichelberger and Hauver\(^1\) has been utilized to study shock initiation of detonation in liquid explosives. Shock-initiated detonation in a physically homogeneous explosive is a thermal explosion process. A shock wave entering the explosive compresses and heats it. Chemical reaction proceeds slowly at first, but as the temperature rises the rate of reaction increases ever more rapidly until detonation occurs, starting where the liquid was first shocked. This detonation wave sweeps through the compressed explosive traveling at a super velocity and overtakes the shock wave.

Experimental elucidation of these phenomena has been described in earlier papers\(^2-3\). A subsequent paper by Mader\(^4\) presents a theoretical study which supports this model.

The initiation behavior of several liquid explosives has been investigated. All of the phenomena observed are qualitatively the same except for one. Nitromethane, shocked to a pressure at which it will detonate within a few microseconds, is transparent. Light from the detonation in the compressed nitromethane can be photographed, but is less bright than light from detonation of uncompressed nitromethane. In some explosives, Dithekite 13 (nitric acid, nitrobenzene), for example, no light
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from the detonation in the compressed liquid has been detected. Additional experiments have demonstrated that an opaque layer forms in the shock-compressed Dithekite shortly before it detonates.\(^3\) The nature of this layer has not been determined, nor is it known whether this layer obscures the light from the detonation in the compressed liquid.

Because of this effect important phenomena cannot be observed with the usual high-speed camera techniques. An independent method is necessary to elucidate the initiation behavior of explosives which behave like Dithekite.

The shock polarization effect can be used for this. The experimental arrangement is simply an uncharged parallel plate capacitor with the explosive as dielectric. One plate is connected to an oscilloscope. The other, grounded, plate is struck by a shock wave. When the shock wave hits the explosive a charge is generated on the capacitor and a pulse is displayed on the oscilloscope.

Other experimenters\(^1\) have shown that this effect is observed when the dielectric, Plexiglas, for example, is composed of polar molecules and they have attributed the charge to polarization of the material by the shock waves. They have calibrated the height of the pulse as a function of shock pressure. The pulse shape as well as height recorded for an explosive dielectric is dependent on the input shock pressure.

When an inert dielectric such as Plexiglas is used, the pulse appearing on the oscilloscope rises sharply to a well defined peak, levels off, then gradually increases until the shock wave hits the second plate when the pulse drops to zero.

When nitromethane is used as the dielectric, an 85 kbar shock causes a positive pulse which rises sharply to a peak value, then returns to
zero in a few tenths of a microsecond. A second positive pulse of approximately the same height appears 1.4 μsec later. This pulse decays slowly until 0.6 μsec later a sharp negative pulse occurs.

These pulses correspond to the following events as determined by optical methods from an identical experiment. The first positive pulse occurs when the shock wave enters the nitromethane, the second when detonation occurs at the plate-nitromethane interface, and the negative pulse occurs when the detonation in the compressed nitromethane overtakes the shock wave. Experiments were done with several different initiating shock pressures. The induction time, the time from the initial shock to the onset of detonation, changed appropriately. Very accurate measurements of the time of occurrence of the initiation phenomena can be made from these records.

Experiments of this kind have been done with molten TNT and solutions of TNT in nitromethane, all of which show behavior like that of Dithekite. The oscilloscope trace from each has the same qualitative appearance as that from the nitromethane. From measurements of the two time intervals in each picture the velocity of the detonation in the compressed liquid can be deduced. This cannot be determined with simple camera techniques since light from this wave cannot be observed in these explosives.

Quantitative measurements of some of the important parameters of initiation phenomena for dielectric liquid explosives can be measured easily and quickly with this technique. The initiation behavior of poly-crystalline explosives is quite different. To date, records obtained from transducers using such explosives have not been reproducible and no
correlation has been found between polarization effects and initiation behavior.

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REFERENCES


