PHOTOGRAPHIC OBSERVATIONS ON SHOCK WAVES IN LIQUIDS

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Summary

A simple method of photographing shock waves in liquids and of observing the absorption spectra of solutions under the extreme pressure and temperature conditions of shock waves is described. A thin layer of argon, compressed and heated by a shock wave, is used as a high intensity, short duration (0·2 μsec) flash source. The absorption spectra of the uranyl and neodymium ions are shown to be altered under these conditions.

I. Introduction

Shock waves generated in liquids by means of explosives can be utilized in experiments aimed at measuring the effects of very high pressures and temperatures. It is possible to make such measurements directly in the shock wave using apparatus which has a response time short compared with the duration of the shock wave (e.g. David and Hamann 1959*a*; or for general reviews Cook 1958; Sykes 1959). Alternatively, one can take direct photographs of the event and derive properties of the medium from the shape, position, density, etc. of the shock wave. The present paper describes two applications of the second technique.

II. Procedure

Cole (1948) describes various methods of photographing shock waves in water and their application in the study of underwater detonations. The present work is on a much smaller scale than that described by Cole and in most experiments only about 60 g of explosive is used. Two small charges are mounted at right angles as shown in Figure 1. One charge launches a shock into the liquid contained in a small cell with plane windows. The second charge launches a shock wave into a thin layer of argon gas (1·5 mm thick) and, by compressing and heating the gas, provides the short duration (0·2 μsec) high intensity illumination required in order to "freeze" the motion of the shock front on the photograph (Winning and Edgerton 1952). The argon is contained in a Perspex cap slipped over the end of the explosive charge and is continuously blown into the cap during the experiment. The two main charges are connected by a bridge (David and Hamann 1960), cast of the same explosive, and are fired by a priming charge via this bridge. The flash is timed in relation to the compressive shock by placing the priming charge a suitable distance from the centre of the connecting bridge. This distance is calculated from the known detonation velocity of the explosive and the known propagation of the shock wave in water (David and Hamann 1959). By carefully shaping and assembling the explosive

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components and by making the two halves of the detonation path as far as possible symmetrical the flash can be timed to within ± 1 mm of travel of the shock wave.

The intensity of the flash is so great compared with the background that the camera shutter can be opened for the whole duration of the experiment, in the present work a shutter speed of 1/10 sec is used at an aperture of f/36. The flash-light contact in the camera shutter is used to close the detonating circuit.

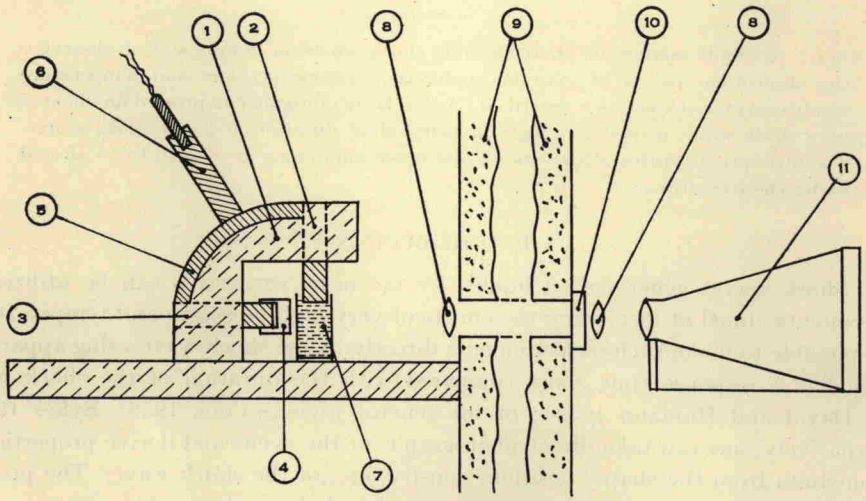

Fig. 1.—General arrangement.

1, Thick wooden block to hold compressive charge 2, which is connected by explosive bridge 5, to illuminating charge 3; 6, priming charge with detonator; 7, cell with windows of cellulose acetate film; 4, cap for argon gap; 8, lenses used in spectrographic work only; 9, concrete blast wall; 10, $\frac{3}{8}$ in. Perspex window; 11, camera.

The explosive charges are made of cast 60/40 RDX/TNT ("Composition B") and are 70 mm long with a diameter of 15 mm; the connecting bridge is cast of the same explosive and has a 1 cm square cross section.

III. Results

(*a*) *Photographs*

Plate 1, Figure 1, shows a cell full of water before detonation. In this experiment two dummy electrodes were placed into the cell in order to observe their behaviour when a shock wave passes between them (David and Hamann 1959). The end of the compressive charge is seen above the electrodes and the argon cap behind them. The scale at the left shows lines 5 mm apart.

Plate 1, Figure 2, shows the shock wave just entered between the electrodes. The shock front appears as a dark line due to refraction and reflection at the refractive index discontinuity caused by it. A few millimetres behind the shock front one can see the cloud of opaque explosion products. The shock front in this case has travelled about 6 mm from the end of the compressive charge. The unchanged appearance of