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[54] **DETONATING DEVICES**

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[58] **Field of Search**................................102/28, 70.2

[56] **References Cited**

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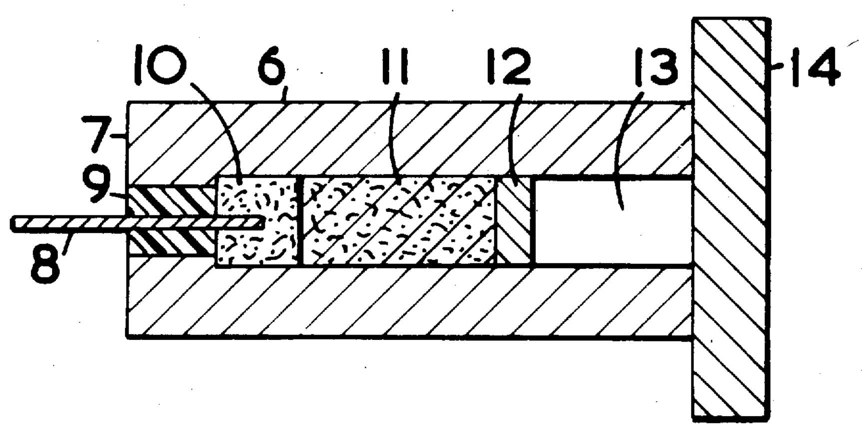
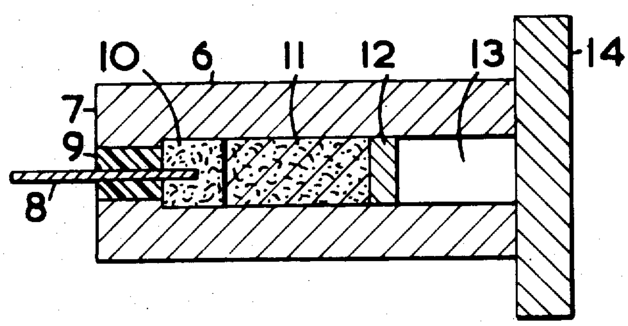
[57] **ABSTRACT**

A detonating device consisting of a container closed at one end and having a barrier at the other end, a secondary explosive within the container spaced by a gap from the barrier and means for ignition whereby after ignition the explosive composition is impelled against the barrier before it is completely burnt and thereby detonated.

10 Claims, 1 Drawing Figure

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DETONATING DEVICES

The present invention relates to devices which carry out the initiation of explosives.

It is known that explosives can be initiated by the direct action of a shock wave of adequate strength, as for instance the explosive wave of a detonator, or by the physical impact of a solid projectile having sufficient mass and velocity.

It is also known that substantially most of the widely used high explosives cannot ordinarily be caused to detonate by a directly applied stimulus of thermal energy alone especially in those cases in which the amount of explosive is small, as for example one-tenth of a gramme and/or when the thermal stimulus is weak, for example a tenth of a calorie. The term 'secondary explosive' is normally used to distinguish these high explosives from the class of primary explosives which readily generate an explosive shock wave in response to a directly applied thermal stimulus.

In general, the established practice for the initiation of secondary explosives relies upon the use of primary explosives, thermally initiated, to produce an explosive shock to which the secondary explosive responds. Other methods include the use of exploding bridgewires. The correct functioning of the latter types are dependent on special control of the packing-density and other features of the explosive used, and they cannot be used with fully consolidated secondary explosive.

Hitherto, the initiation of detonation of a solid secondary explosive has been explained in terms of a physical shock-front moving rapidly through the explosive and a region of chemical reaction (the reaction front) in progress behind the shock front contributing energy which enables the shock-front eventually to achieve and maintain those conditions of exceptional pressure, temperature and speed which are characteristic of detonation. It therefore follows that all the techniques of initiation now in use produce a detonation wave which passes through the secondary explosive in the same direction as the force of impact delivered on this explosive by the explosive wave or metal plate or other means of initiation.

In contradistinction to the known techniques of initiation, it has now been found that initiation can occur by a different mechanism which arranges for a compression wave to be produced which moves to meet the advancing reaction-front to produce those conditions which can change the lower rate of reaction to detonation. Initiation utilising this mechanism has been achieved by consolidating a small quantity of secondary explosive composition in a suitable container, closed at one end, and placing a barrier, distanced so that there is a small gap between the end face of the explosive composition and the barrier, in the path of the explosive. On ignition at or near to the closed end, gases are produced and the pressure rises in a manner dependent on the interplay between the rate of gas production and the resistance of the various component parts against deformation and displacement. As a consequence, accelerating motion of the column of explosive takes place in a direction away from the closed end and the column is projected against the barrier. A compression wave originating at the collision interface, travels back through the explosive column to coincide with the reaction front and produce the conditions necessary for detonation. The ensuing detonation thus travels in the opposite direction to that of the compression wave.

The single FIGURE of the drawing shows a cross-sectional diagram of the detonating device.

According to the invention, there is provided a detonating device comprising a tubular container closed at one end and having a barrier at the other end, a secondary explosive composition within the said container spaced by a gap from the barrier, and means for igniting the explosive composition at or near to the closed end so that after ignition the explosive composition is impelled against the barrier before it is completely burnt whereby the resulting impact of the remaining composition against the barrier produces a compression wave to travel back through said composition enabling it to detonate.

The explosive composition would normally be ignited at or near the closed end of the container. Ignition may be effected by any known means. For instance, it may be effected directly by electrical means or by mechanical impact energy or indirectly by contact with the reaction products from a different composition, hereinafter called the igniter composition, to which the originating stimulus is applied. The igniter composition may be enclosed within the container into which the secondary explosive composition is also consolidated or may be contained in a separate component part of the device, in which case the two parts of the device must be situated substantially in contact with one another.

The container may conveniently comprise a metal tube or channel.

The secondary explosive composition may consist of any high explosive falling within this definition, as for instance pentaerythritol tetranitrate (P.E.T.N.), cyclotrimethylene trinitramine (R.D.X.), cyclotetramethylenetetranitramine (HMX) and nitrocellulose. The length of the column of this composition may be in the order of five millimetres or less. With such a length of explosive column, pressures within the device can be raised within a few micro seconds to exceed the yield strength of the metal within which the explosive is contained.

The barrier may consist of a rigid solid, a liquid barrier or a material of consistency intermediate between a liquid and a rigid solid. In a specific embodiment, it may consist of a substance capable of explosion and can therefore undergo detonation consequent on the detonation produced in the column of secondary explosive which collides with it. In all cases, the barrier must present sufficient impedance to the projected column of secondary explosive to originate a compression wave at the collision interface which travels back through the projected column.

In one embodiment of the invention, the detonating device comprises an electroexplosive device wherein the closed end of the container is provided with means for igniting the explosive composition by passing an electric current through it. The secondary explosive composition for use in the embodiment may consist in part or in whole of a mixture of a secondary explosive and conducting fibres or filaments as described in copending U.S. application Ser. No. 7,239.

The invention is illustrated by the following examples in which the container used for the explosive was a steel tube 6.3 mm. outside diameter and 15 mm. in length with a cavity 13 mm. long closed at one end through which passed a steel wire **22** S.W.G. securely fitted and insulated to serve as an electrode extending internally and axially less than 4 mm. The cavity diameters given are nominal corresponding to the drill sizes used.

EXAMPLE 1

The cavity in this case being 1.66 mm diameter, two milligrammes of a mixture of PETN with carbon fibres in accordance with application No. 38497/66 was introduced and then a further eighteen milligrammes of PETN alone. The successive increments were consolidated by mechanical pressure exceeding 10,000 lbs. per square inch, then a disc of steel 1 mm thick was pressed on top. A mild steel plate 2 mm thick was placed in contact with the open end of the cavity leaving an air-gap of 5.5 mms. between the explosive and the plate. The electrical resistance between the central electrode and the body was found to be eight ohms. The device was fired by the discharge from a condenser, 1μF, at an initial voltage 300V. A hole 2.5 mm diameter was punctured through the steel plate in less than 25 microseconds from closing the firing switch.

The device used in example **1** comprises a steel tube **6** closed at one end **7** through which passes a steel wire **8** insulated by a suitable insulator **9** from the steel end **7**. The steel wire **8** extends internally and axially to serve as an electrode. The cavity of the tube **6** was packed with two milligrammes of a mixture of PETN with carbon fibres **10** in accordance with copending U. S. application, Ser. No. 7,239, and then a further 18 milligrammes of PETN alone 11. A disc of steel plate **12** was placed in contact with the PETN **11** and a steel plate **14** placed in contact with the open end of tube **6** forming an air gap **13**.

EXAMPLE 2

A similar experiment in which a layer of inert powder (talc) was introduced between the explosive and the metal disc, the depth of the said layer being 1.5 mm after pressing. The air-gap was 4.2 mms. The electrical resistance was found to be 65 ohms and on firing in the manner above described, a hole 2.25 mm diameter was punctured in the steel plate 2 mm thick.

EXAMPLE 3

The cavity in this case being 2.38 mm diameter, 8 milligrammes of the aforesaid admixture of PETN and carbon fibres was introduced, then a further 42 milligrammes of PETN alone, and finally a brass disc 0.75 mm thick. The air-gap was 3.0 mms. On firing by connecting to a 36-volt battery, a hole 3.5 mm diameter was punctured in the steel plate 2 mm thick.

EXAMPLE 4

The cavity in this instance being 3.18 mm diameter, 15 milligrammes of admixture of RDX and carbon fibres was introduced, then a further 75 milligrammes of RDX alone, and finally a steel disc **1** mm thick, the successive increments being pressed as stated above. The air-gap was 5.2 mm. On firing from a condenser as in example 1, a hole 4 mm diameter was punctured in the steel plate 2 mm thick, in less than 30 microseconds after closing the firing switch.

EXAMPLE 5

A similar experiment to example 4, using HMX in place of RDX and firing by connecting to a 36-volt source of current, gave a hole 4 mm diameter in the steel plate 2 mm thick. The air-gap was 5.1 mm. The electrical resistance before firing was 80 ohms.

Other examples illustrating the invention are:

EXAMPLE 6

An igniter component was made comprising a steel block with a cavity 2.4 mm. diameter containing 20 mg. of an intimate mixture of antimony sulphide, 30 percent, with potassium chlorate, 70 percent, together with means of igniting the mixture electrically.

A second component comprising a steel tube 15 mm. long and 3.2 mm. bore, with 100 mg. pentaerythritol tetranitrate (PETN) occupying 7 mm. of the length at one end, was attached directly to the igniter component aforesaid so that the PETN in the one and the chlorate mixture in the other were in contact and coaxial. A steel disc 1 mm. thick was pressed onto the end of the PETN column, leaving 7 mm. of the tube unoccupied. A flat steel plate 2 mm. thick was placed over the end aperture of the tube.

On firing the igniter electrically, the **2** mm. plate was perforated with a hole 4.5 mm. diameter.

EXAMPLE 7

In a precisely similar experiment to that described in example 6 the metal components were kept 0.1 mm. apart by means of a perforated disc of paper, the explosive charges being directly in contact as in Example 6. On firing, the 2 mm. plate was not perforated, but only bulged and cracked with the steel disc remaining embedded in it.

EXAMPLE 8

Using the same conditions as example 6, 20 mg. of silver picrate was substituted for the chlorate mixture. On firing, the plate was perforated as before.

EXAMPLE 9

Using the same conditions as in example 6, 18 mg. of lead dinitroresorcinate was substituted for the chlorate mixture. On firing, the plate was perforated.

An assembly of two component parts as described in the above examples was equally successful when PETN admixed with conducting fibres as described in application No. 38497/66 took the place of the igniter compositions above-mentioned.

The following example illustrates an embodiment of the present invention using a mechanical impact as the originating stimulus leading to detonation by the mechanism claimed in the present Application.

EXAMPLE 10

A steel tube 6.3 mm. outside diameter and 15 mm. long with internal cavity 3.2 mm. diameter and 13 mm. long was fitted with a steel rod 1 mm diameter passing through a clearance aperture in the end closure of the tube. The end of the rod inside the tube penetrated less than 1 mm. into a small charge of PETN, approximately 15 mg., which was put in and consolidated with the rod already in position. The said charge of PETN contained an admixture of gritty particles as a means of rendering the explosive more sensitive, in accordance with general knowledge. A metal disc next to the charge also assisted in obtaining the desired result. Additional PETN, in which no grit was necessary, made up the total of explosives to approximately 80 mg. At the end of the column was a second metal disc and 5 mm. of the tube remained unoccupied.

The device was placed with the open end down resting on a 2 mm. steel plate supported on a steel annulus. By striking the rod projecting from the opposite end, the PETN charge was caused to detonate and the steel plate was punctured. Mechanical energy for striking the rod was provided by dropping a 56 gramme mass from 30 cm. height.

In the following example, it was demonstrated that water can be used as the barrier to produce the conditions necessary for detonation and the detonation then transmits a powerful shock wave into the water whereby known physical effects such as deformation of metals may be produced.

EXAMPLE 11

Eight milligrammes of a mixture of PETN and carbon fibres was introduced into a tube 6.3 mm. outside diameter and 15 mm. in length with a cavity 2.38 mm. diameter, then a further 42 mg. of PETN alone and finally a brass disc 0.75 mm. thick. This device was held vertically with its open end downwards and dipping below the surface of water in a metal tank. The only barrier in the path of the explosive charge was the water surface just within the open end of the tube, approximately 5 mm. distant from the end of the explosive charge. On firing, the PETN charge detonated and the shock wave transmitted through the water deformed the tin plate base of the tank to correspond with the embossings on the metal blocks supporting it.

EXAMPLE 12

An electroexplosive device constructed in accordance with this invention comprises a short cylinder or disc of metal supporting an electrode which extends axially through an aperture in an end face of a hollow metal tube. The longitudinal axes of the cylinder or disc and the metal tube are substantially coincident and the two members are rigidly connected by a non-conducting means such as, for instance, an insulating cement. A tubular extension from the hollow metal tube extends from the open end of the tube remote from the apertured end face of the tube and is substantially coaxial therewith. The tubular extension is conveniently detachably attached to the hollow metal tube.

In assembling the electroexplosive device, a chosen mixture of explosive and conducting fibres is loaded under compression into the hollow tube to surround the electrode and make electrical contact with both the electrode and the hollow tube. Further explosive may, if desired, by loaded into the hollow tube adjacent to the mixture. The total amount of explosive so loaded into the hollow tube is chosen so that a portion of the bore of the hollow tube is left empty at a position adjacent to the point for attachment of the tubular extension to the hollow tube. The tubular extension is loaded, before attachment to the hollow tube, with a further charge which may be of the same or different explosive, suitably consolidated and the tubular extension is then attached to the hollow tube so as to leave a minimum air gap between the charges in respectively the tube and the tubular extension measuring at least 3 mm and preferably about 5–7 mm.

The assembled electroexplosive device is fired by applying an electrical potential between the electrode and the hollow tube. The explosive component of the mixture is ignited and there is a rapid rise in the rate of explosive decomposition (transmitted through any charge adjacent to the mixture) to a speed of the order of 1,000 metres per second in terms of the linear propagation of the reaction front towards the tubular extension. Products of this swift propagation or low order detonation then impinge upon the explosive charge in the tubular extension with a combined effect of heat and pressure sufficient to produce a high order detonation in this explosive charge.

Electroexplosive devices of this type, when loaded with a PETN/10 percent carbon fibre mixture, an adjacent charge of PETN and a PETN charge in the tubular extension have given action times between application of firing current and detonation in the tubular extension as low as 15 microseconds when fired by a condenser charged at about 400 volts.

What we claim is:

1. A detonating device comprising a tubular container closed at one end, a secondary explosive composition adjacent said closed end, means for igniting said composition near to said closed end and thereby impelling said secondary explosive composition away from said closed end, and means for enabling said ignited secondary explosive composition to detonate comprising a barrier at the other end of said tubular container and spaced by a gap from said secondary explosive composition, said ignited secondary explosive composition being impelled bodily before it is completely burnt against said barrier whereby the impact of the remaining secondary explosive composition against the barrier produces a compression wave which travels back through said secondary explosive composition to enable it to detonate.

2. A detonating device according to claim 1 wherein the barrier comprises a liquid.

3. A detonating device according to claim 1 wherein the barrier comprises a rigid solid.

4. A detonating device according to claim 1 wherein the barrier is a substance capable of explosion which may be detonated consequent on the detonation produced in the column of explosive in the detonating device.

5. A detonating device according to claim 1 wherein the secondary explosive composition is selected from a group consisting of pentaerythritol tetranitrate, cyclotrimethylene trinitramine, cyclotetramethylene tetramine and nitrocellulose.

6. A detonating device according to claim 1 wherein the secondary explosive composition comprises at least in part a mixture of a secondary explosive and an electrically conducting fibre, and the means for ignition comprise electrical means.

7. A detonating device according to claim 1 wherein the means for ignition comprises the reaction products from an igniter composition.

8. A detonating device according to claim 7 wherein the igniter composition is enclosed within a separate component part of the device, said separate component part being situated substantially in contact with the tubular container in which the secondary explosive composition is consolidated.

9. A detonating device according to claim 1 wherein the means for ignition comprise mechanical impact means.

10. A method of detonating a secondary explosive composition comprising the steps of

a. placing said secondary explosive composition in a tubular container adjacent a closed end, said container having a barrier at the other end spaced from said secondary explosive composition by a gap,

b. igniting said secondary explosive composition near to said closed end thereby producing a reaction front moving toward said barrier and impelling said secondary explosive composition bodily whilst still burning against said barrier, the impact of the remaining secondary explosive composition against the barrier producing a compression wave which travels back through said secondary explosive composition, and

c. detonating said secondary explosive composition, said detonation being produced by said compression wave travelling back through said secondary explosive composition when it coincides with said reaction front moving in the opposite direction.

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