July 9, 1963 A. McLELLAN YUILL 3,096,714

ELECTRIC DETONATORS

Filed Oct. 3, 1960

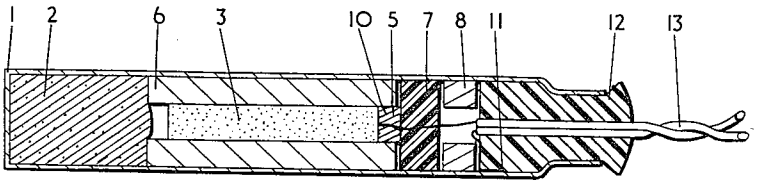


FIG. 1

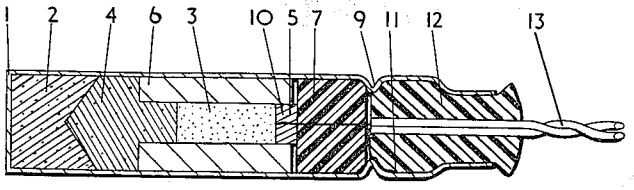


FIG. 2

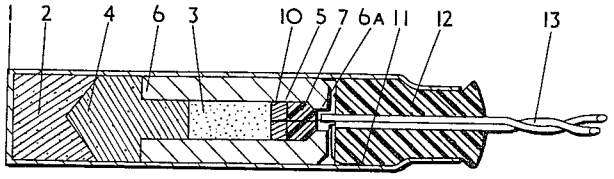


FIG. 3

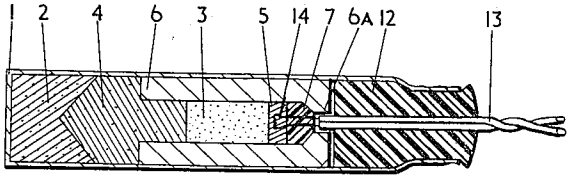


FIG. 4

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United States Patent Office 3,096,714 Patented July 9, 1963

3,096,714

ELECTRIC DETONATORS

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Filed Oct. 3, 1960, Ser. No. 59,782
Claims priority, application Great Britain Oct. 2, 1959
17 Claims. (Cl. 102—28)

The present invention relates to electric detonators having reduced hazard of accidental detonation of their explosive charges during their manufacture and in normal handling.

The explosive charge of a detonator normally comprises a charge of a detonating explosive highly sensitive to ignition by flame, which can be ignited in the case of a plain detonator by the end spit of a safety fuse cord, or in the case of an electric detonator by the flame from an electric fusehead or the like, and which also has the property of detonating almost immediately after it starts to burn, superposed on top of a base charge of a less sensitive but more powerful detonating explosive. This base charge requires the impulse produced by the detonation of the more sensitive explosive charge to bring about its detonation, and serves in turn to initiate the still less sensitive explosive charge outside of the detonator casing that is to be caused to detonate by the detonator. The highly sensitive explosive in the top charge is frequently referred to as a primary initiating explosive, and the less sensitive explosive on which the primary initiating explosive charge is superposed in the detonator casing is frequently referred to as a secondary initiating explosive.

The primary initiating explosives most frequently used in detonators are lead azide and mercury fulminate, and the secondary initiating explosives most commonly used are tetryl and pentaerythritol tetranitrate. As the primary initiating explosives are much more sensitive to friction and mechanical shock their storage and manipulation requires even more circumspection than that of the secondary initiating explosives, and they are always stored under water and require to be dried very cautiously before they are used.

From the point of view of safety in manufacture and handling of electric detonators it would be desirable to eliminate the use of primary initiating explosives and use only charges based on secondary initiating explosives. However the secondary initiating explosives as ordinarily loaded into detonator casings do not possess sufficient facility for burning to detonation when loaded into a detonator casing in the ordinary way and subsequently exposed to the flame from an electric fusehead or the like disposed within the detonator casing in the usual manner, and so far as we are aware no electric detonators based on the use of a secondary initiating explosive such as pentaerythritol tetranitrate without a primary initiating explosive charge have hitherto been available.

According to the present invention an electric detonator having no primary initiating explosive contains an electric fusehead of high or low tension characteristics having a gas-producing matchhead composition pellet in which at least one of the pole pieces or the resistance bridgewire as the case may be is embedded, located within the end of a stout rigid metal walled tube within the detonator casing nearer to the mouth of the casing and confined so that there is no outlet for the flame gases produced on firing the said fusehead permitting them to bear on the seal at the mouth of said casing, with a column of a composition containing a preponderant proportion of pentaerythritol tetranitrate substantially uniformly compressed against the aforesaid pellet in incremental

fashion at a loading pressure not less than 1500 kilograms per sq. cm. occupying a substantial part of the length of said tube, and a base charge of a secondary initiating explosive compressed into the detonator casing at a pressure not exceeding about 350 kg. per sq. cm. of such length that a space remains between the end of the highly compressed column of pentaerythritol tetranitrate in the said stout rigid metal tube and the top of the more lightly compressed base charge, which space is preferably wholly or partly filled with uncompressed pentaerythritol tetranitrate.

Owing to the lack of any substantial outlet for the flame gases to escape from the end of the stout rigid metal tube nearer to the mouth of the casing they are brought to bear with great intensity on the highly compressed column of pentaerythritol tetranitrate in contact with the electric fusehead, which is thereby ignited and burns violently down the column. The abrupt reduction in charge density encountered by the propagating flame on reaching the end of the column of the highly compressed material and the sudden release of the hot compressed reaction gases has the result that the less highly compressed base charge detonates.

If desired the stout rigid metal tube may have the end containing the electric fusehead partially closed so as to present the form of a cup with a stout cylindrical end wall having an axial channel through it, and in this case a plug having embedded in it so as to protrude from it uninsulated portions of the conductor or conductors to be embedded in the matchhead composition, may be introduced through the open end of the tube to provide the necessary means for preventing the escape of the flame gases from the match composition through the said axially disposed channel. The matchhead composition may either be already formed around the protruding conductor or conductors or it may be subsequently formed by compression of the matchhead composition within the stout metal tube against the plug.

If on the other hand the bore of the stout metal tube is the same throughout its length the gas stop may be provided by a plug external to the stout metal tube and capable of fitting tightly within the detonator casing and being retained therein preferably by means independent of the sealing member for the mouth of the detonator casing, this plug having embedded in it so as to protrude from it an uninsulated portion of at least one of the electric conductors so that the electric fusehead can be formed by compressing the matchhead composition around the protruding portion of the conductor or conductors within the stout metal tube. In the case of a low tension fusehead, the whole of the resistance bridgewire must be embedded in the matchhead composition, but in the case of a high tension fusehead it is preferable that only one of the conductors forming the pole pieces should be embedded in the matchhead composition, the other conductor being advantageously earthed to the metal of the detonator casing nearer to the mouth, the wall of the stout metal tube and the detonator casing being in physical contact, to ensure completion of the circuit when the necessary potential difference is applied.

The said plug providing the means of preventing the escape of the flame gases from the end of the stout rigid metal walled tube may conveniently be constructed from a plastic material, such as polyethylene or polystyrene.

The composition containing a preponderant proportion of pentaerythritol tetranitrate may conveniently consist entirely of pentaerythritol tetranitrate but it is sometimes advantageous to include minor proportions of other ingredients for example, of aluminium powder to modify the burning characteristics of the composition.

In loading the column of composition containing a pre-

ponderant proportion of pentaerythritol tetranitrate to be highly compressed within said stout rigid metal tube it is pressed in increments against the electric fusehead and the number of increments should be sufficient to provide a thickness of not more than 2 millimetres per increment to ensure practically uniform compression of the material. With a rigid metal tube of about 3 millimetres internal diameter and 6 millimetres external diameter the number of increments providing a thickness of 2 millimetres each should be not less than 4, so that the column would be at least 8 millimetres long.

In the case of high tension fuseheads the matchhead composition must contain an ingredient capable of rendering the composition conducting, and this is conveniently graphite. It may be conveniently formed by compression, but it is also possible to employ a bonding agent such as nitrocellulose in known manner. Matchhead compositions consisting of pentaerythritol tetranitrate and graphite, potassium chlorate and graphite or mixtures of all three of these ingredients are preferred. The inclusion of potassium chlorate results in compositions which may be ignited by the application of lower voltages. A mixture of meal gunpowder and graphite may also be used. The amount of graphite in these compositions is advantageously about 10% by weight. In the case of low tension fuseheads, which may also be formed by compression or with the aid of a solution of a bonding agent in known manner, the matchhead composition is not of a conducting nature since the current is carried by the resistance bridgewire. Compositions consisting of potassium chlorate and charcoal in the ratio 87 to 13 by weight, pentaerythritol tetranitrate and potassium chlorate and pentaerythritol tetranitrate alone may conveniently be used. It will generally be preferable to use pentaerythritol tetranitrate alone as it may be compressed with a greater degree of safety than the chlorate containing mixtures and it may be normally loaded into the aforesaid rigid metal walled tube with the incrementally compressed column of composition containing a preponderant proportion of pentaerythritol tetranitrate in one operation.

The invention is further illustrated by reference to FIGURES 1 to 4 of the drawing accompanying the specification, of which FIGURES 1 to 3 are axial sections of high tension electric detonators and FIGURE 4 is an axial section of a preferred form of a low tension electric detonator in accordance with the invention. In the drawing **1** is the metal wall of the detonator tube which may conveniently be made of a copper alloy or aluminium of the usual thickness of about 0.325 mm. and may be a length of about 41 mm. and an internal diameter of about 6 mm. **2** is the base charge of about 0.2 g. pentaerythritol tetranitrate compressed into the detonator tube at a pressure not exceeding 350 kilograms per sq. cm., **6** is a rigid metal walled tube about 17 millimetres long made from brass or steel providing a push fit within the detonator tube **1** and has an internal diameter about 3 millimetres and an external diameter of about 6 millimetres. In the form of the invention shown in FIGURE 1 and FIGURE 2 the tube **6** is cylindrical throughout its length and into one end of it there is first compressed the high tension matchhead composition **5** around the uninsulated extremity of one of the insulated leading wires **13**, a plug **7** of polystyrene or other plastic being formed around an immediately adjacent uninsulated portion of this leading wire previously or subsequently. **3** is the incrementally compressed charge of pentaerythritol tetranitrate which is at least 8 millimetres in length loaded preferably in 6 increments at a pressure not less than 1500 kilograms per sq. cm. on top of the matchhead composition **5** and as will be seen it does not extend quite to the end of the tube **6**. Preferably the rigid metal tube **6** extends beyond the highly compressed charge by about 4 millimetres. Referring to FIGURE 1 the loaded tube **6** with the plug **7** at its end is now pressed down into the casing **1** firmly upon the pentaerythritol tetranitrate charge **2**, as a result of which the top portion of the charge **2** in the axial region becomes somewhat loosened and at least partly fills the space at the end of the tube **6**. Into the mouth of the detonator tube and around the leading wires **13** there is now introduced a collar **8** preferably of metallic construction which is a force fit within the detonator tube **1** and finally an axially channeled sealing plug **12** about 10 millimetres long made from resiliently easily deformable material such as neoprene, the uninsulated terminal portion of the second leading wire being caught between this plug and the metal wall of the detonator tube **1**. The end of the detonator tube **1** is finally crimped down on to the material of the plug **12** in known manner in order to provide a waterproof seal.

Referring to FIGURE 2, a loose charge **4** of about 0.1 g. of pentaerythritol tetranitrate is poured on top of the base charge **2** and the loaded tube **6** is pressed down on top of this loose charge so that the space at its end becomes completely filled. In the electric detonator illustrated in FIGURE 2 the plug **7** is push fit within the detonator tube **1** and is positively located in position by means of a cannelure or crimp **9** formed in the wall of the latter but in other respects the procedure is the same as for the detonator illustrated in FIGURE 1.

In the form of the invention illustrated in FIGURE 3 there is a loose charge of pentaerythritol tetranitrate **4** on top of a compressed base charge **2** as in the form of the invention shown in FIGURE 2, and the tube **6** is partially closed by a cylindrical end portion **6A** having an axial channel cut through it. This channel has a uniform diameter of about 2 millimetres over the portion extending to about 1 millimetre from the end of the tube **6** and thereafter its walls diverge at an angle of about 50° from the axis. In this case the plug **7** which is conveniently of polystyrene, is shaped to conform with the internal contour of this end of the tube **6** and is introduced into the said tube **6** before the high tension matchhead composition **5** is pressed into it and the pentaerythritol tetranitrate charge **3** is incrementally compressed on top of the matchhead composition. In this case no further means for preventing the escape of the gas from the end of the tube **6** is nearer to the mouth of the detonator tube **1** is required, but in other respects the manufacture is as in the form of the invention illustrated in FIGURE 2.

For the manufacture of the low tension electric detonator illustrated in FIGURE 4 the procedure is the same as for the high tension detonator illustrated in FIGURE 3, except that the matchhead composition **5** is a nonconducting matchhead composition which may consist of highly compressed pentaerythritol powder and is formed around the resistance bridgewire **14** attached to the uninsulated end portion of the leading wires **13** protruding from the plug **7**. This bridgewire may conveniently be made from a nickel/chromium/iron alloy and be about 0.024 millimetre diameter and 1 millimetre long. It connects both leading wires **13** so that there is no connection from a leading wire to the detonator tube **1**.

A high tension electric detonator as illustrated in FIGURES 1 to 3 wherein the matchhead composition consists of a mixture of 90% potassium chlorate and 10% graphite may be caused to detonate by applying a discharge from a 6 microfarad condenser charged to 500 to 1500 volts, and a low tension electric fusehead as illustrated in FIGURE 4 in which the matchhead composition consists of compressed pentaerythritol tetranitrate or of a mixture of 87% potassium chlorate and 13% charcoal with a bridgewire **14** as normally used in the fuseheads of electric detonators will detonate when a current of one ampere is passed through the bridgewire for one fiftieth of a second. Detonation of the base charge occurs almost instantaneously after the application of the firing voltage.

What I claim is:

1. An electric detonator comprising: a detonator casing having a mouth end; a rigid metal walled tube within said casing; an electric fusehead having a gas-producing matchhead composition pellet located within the end of said tube which is nearer said mouth end of said casing; sealing means within said mouth end of said casing; means for preventing flame gases produced by said pellet from bearing on said sealing means; a column of a uniformly highly compressed composition consisting essentially of pentaerythritol tetranitrate compressed against said pellet at a loading pressure of at least 1500 kilograms per sq. cm., said column occupying a portion of the bore of said tube; a base charge of a compressed secondary initiating explosive compressed into said casing at a pressure up to about 350 kilograms per sq. cm., said base charge occupying a position in said casing such that a space remains between the end of said highly compressed column in said tube and the more lightly compressed base charge.

2. An electric detonator as claimed in claim 1 wherein said highly compressed composition consists entirely of pentaerythritol tetranitrate.

3. An electric detonator as claimed in claim 1 wherein the base charge consists of pentaerythritol tetranitrate.

4. An electric detonator as claimed in claim 1 in which the space between the end of the highly compressed column of pentaerythritol tetranitrate in the rigid metal walled tube and the top of the base charge is at least partly filled with pentaerythritol tetranitrate.

5. An electric detonator as in claim 4 wherein said plug is retained within said casing by an inward crimp in said casing between said plug and said sealing means.

6. An electric detonator as claimed in claim 1 wherein the bore of the rigid metal walled tube is the same throughout its length and escape of the flame gases from the end of the said tube nearer the mouth of the detonator casing is prevented by a plug external to the said tube fitted tightly within the detonator casing between said pellet and said mouth end of said casing, said plug having embedded in it so as to protrude from it an uninsulated portion of an electric conductor of the electric fusehead.

7. An electric detonator as in claim 6 wherein said plug is retained within said casing by a collar between said plug and said sealing means and tightly fitting the interior of said casing.

8. An electric detonator as claimed in claim 6 wherein the plug preventing the escape of flame gases from the end of the rigid metal walled tube nearer the mouth of the detonator casing is made from plastic material.

9. An electric detonator as claimed in claim 8 in which the plug is made from polyethylene.

10. An electric detonator as claimed in claim 8 in which the plug is made from polystyrene.

11. An electric detonator as claimed in claim 1 in which the exterior of said rigid metal walled tube frictionally engages the interior of said detonator casing.

12. An electric detonator as claimed in claim 1 containing an electric fusehead of high tension characteristics having an electrically conducting matchhead composition.

13. An electric detonator as claimed in claim 12 wherein the ingredient rendering the matchhead composition conducting is graphite.

14. An electric detonator as claimed in claim 12 in which the matchhead composition consists of a mixture of pentaerythritol tetranitrate and graphite.

15. An electric detonator as claimed in claim 1 containing an electric fusehead of low tension characteristics having a matchhead composition which does not conduct electricity.

16. An electric detonator as claimed in claim 15 in which the matchhead composition consists of compressed pentaerythritol tetranitrate powder.

17. An electric detonator comprising: a detonator casing having a mouth end; a rigid metal walled tube within said casing; an electric fusehead having a gas-producing matchhead composition pellet located within the end of said tube which is nearer said mouth end of said casing said end of said tube being partially closed so as to present the form of a cup with a cylindrical end wall having an axial channel through it; a plug within said tube at its partially closed end for preventing escape of flame gases through said channel, said plug having embedded in it so as to protrude from it an uninsulated portion of an electric conductor of the electric fusehead; sealing means within said mouth end of said casing; a column of a uniformly highly compressed composition consisting essentially of pentaerythritol tetranitrate compressed against said pellet at a loading pressure of at least 1500 kilograms per sq. cm., said column occupying a portion of the bore of said tube; and a base charge of a compressed secondary initiating explosive compressed into said casing at a pressure up to about 350 kilograms per sq. cm. and occupying a position in the end of said casing which is opposite said mouth end.

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