Nov. 22, 1960 G. H. SCHERRER 2,960,933

DETONATOR

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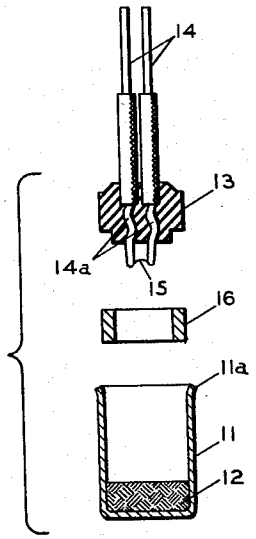


FIG. 1

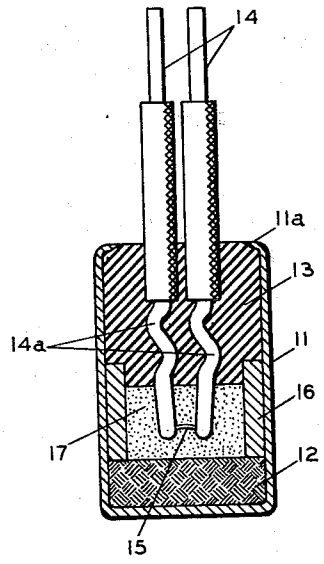


FIG. 2

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DETONATOR

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7 Claims. (Cl. 102—28)

This invention relates to electric firing devices and more particularly to instantaneous electric detonators having a low energy requirement for firing and of sturdy construction.

In the prior art electric firing devices, a variety of constructions have been employed to produce what is commonly termed electric blasting caps. These caps are constructed sufficiently rugged to withstand handling and conditions imposed upon the caps for detonating explosive charges which are statically disposed. Moreover, these caps are usually constructed having a bridge wire greater than 0.001 inch in diameter and having an energy requirement for firing the caps in the order of 90,000 ergs. As a result of the requirements of conventional blasting caps, the selection of materials of construction and their arrangement are quite liberal. For example, in the ignition assembly, compressible plug materials or cast plug materials may be used or materials which may be heated and rendered compressible for purpose of securing the plug in the shell as by crimping may be used. In addition, since the bridge wire is of large diameter and sturdy a certain amount of flexing between the leg wires in the vicinity of the bridge connection is permissible during assembly and is of no consequence in subsequent utilization of the device.

However, electric firing devices for certain military uses must be extremely rugged and must have extremely low energy requirements as constrasted to conventional blasting caps. For example, detonators for military purposes in accordance with this invention must be sufficiently rugged to withstand damage from force produced by an acceleration of 20,000 *g*, and must have an energy requirement of less than 4,000 ergs. To meet this energy requirement a bridge wire in the order of 0.0004 inch in diameter is necessary and the entire device must be capable of mechanical assembly with a minimum of defective devices as well as capable of withstanding the above-mentioned force.

Therefore, the primary object of the invention is to provide an instantaneous electric detonator having a low energy requirement for firing and of sturdy construction.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

Generally described, the present invention comprises a tubular shell containing a detonating charge and a rigid electric ignition assembly pressed up on the detonating charge, said ignition assembly having a low ignition energy requirement and the entire detonator being of sturdy construction.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawing forming a part of the specification.

In the accompanying drawing wherein reference symbols refer to like parts wherever they occur:

Fig. 1 is a cross-sectional view of the separate elements of the detonator (the ignition charge is omitted) in accordance with this invention indicating the order in which they are to be assembled; and

Fig. 2 is an enlarged cross-sectional view of the assembled detonator.

Referring now to the drawing in detail, a metallic tubular shell **11** has a detonating composition **12** pressed therein. A bridge plug **13** of hard dielectric material is provided about leg wires **14** which have the uninsulated portion thereof extending from the plug and kinked within the plug as illustrated at **14***a*. A bridge wire **15** having a resistance in the order of 4 ohms is connected across the leg wires **14**. A ferrule **16** is pressed upon the plug **13** and an ignition composition **17** is buttered into the cavity created by the ferrule and plug. The ignition assembly consisting of plug **13**, leg wires **14**, bridge wire **15**, ferrule **16**, and ignition composition **17** is pressed upon the detonating composition **12**. The plug **13** is of sufficient diameter and hardness to expand the sheel **11**, thereby forming a secure connection and waterproof seal when fully inserted into the shell. The upper end **11***a* of the shell **11** is crimped over the plug **13** to complete the assembly.

An example of producing the detonator in accordance with the invention is given in the following: A copper shell having an outside diameter of 0.272 inch, length of 0.406 inch, and wall thickness of 0.0065 inch was slightly flared at its open end to give an inside diameter of 0.269 inch. A loose detonating charge of a uniform mixture consisting of 75 parts of diazodinitrophenol and 25 parts of potassium chlorate and weighing 0.06 gram was charged into the bottom of the shell. A pair of leg wires of #22 gage and having an uninsulated portion thereof kinked had a Bakelite (a phenolic thermosetting type resin) bridge plug of approximately 0.265 inch diameter molded thereabout, the kinked portion being embedded in the plug material. The plug had a 0.040 inch protrusion having a diameter of 0.189 inch with a slight taper toward the bridge end. The leg wires were spaced in the plug at approximately 0.060 inch center to center. A bridge wire of 0.0004 inch in diameter was soldered to the leg wires and the leg wires were then bent inwardly to give an end spacing of approximately 0.015 inch between the inner surface of the leg wires. This relieved tension on the bridge wire and the wire was bowed inwardly toward the plug. A ferrule 0.140 inch long having an outside diameter of 0.250 inch and an inside diameter of 0.187 inch was pressed upon the bridge plug protrusion thereby forming a cavity about the bridge connection. The ferrule was cut from medium hard vulcanized fiber tubing. An ignition charge consisting of 75 parts of diazodinitrophenol and 25 parts of potassium chlorate, milled with a solution of approximately 2.4 parts of nitrostarch dissolved in butyl acetate was buttered into the cavity, all parts by weight. The ignition assembly was then stored for a sufficient length of time and under conditions to permit the ignition charge to thoroughly harden. The ignition assembly was then pressed into the shell at a pressure in the order of 2,000 pounds per square inch, whereby the plug expanded the shell and the loose detonating charge was compressed to a height of about 0.070 inch. After the loose powder was compressed by insertion of the ignition assembly into the shell, the excess metal of about 0.036 inch at the top of the shell was crimped over the plug, completing the assembly. Thus, it is seen that the entire assembly was loaded and maintained under pressure. This prevents any movement within the detonator in subsequent rough handling and utilization.

Detonators produced in accordance with the preceding example had an energy requirement for firing of less than 4,000 ergs, an average bridge resistance of approximately 4 ohms, and filament breakage at an acceleration of 20,000 *g* was in the order of 0.2%. The method of firing

was by condenser discharge using either a 1.0 mfd. condenser charged at 38½ volts with 4 ohms line resistance added or a 0.94 mfd. condenser charged at 28 volts while maintaining very low line resistance.

In accordance with the present invention, the shell material is preferably of metal such as copper or aluminum; however, other material may be employed providing sufficient tensile stress is available in the shell wall to maintain the assembly under pressure as well as render it waterproof. The loose detonating charge is preferably diazodinitrophenol although other high explosives such as pentaerythritol tetranitrate, tetryl, cyclonite, and the like may be utilized in combination with a suitable primer. The leg wires may be of any of the conventional conductive and insulating materials commonly employed in blasting cap manufacture. The plug material is preferably of a thermosetting resin although thermoplastic materials may be employed, materials such as urea- or phenol-aldehyde and polystyrene resins have been found suitable as they do not exhibit cold flow and, therefore, maintain a waterproof joint and compressed detonator assembly under severe storage conditions. The bridge wire may be either noble metal or base metal resistance wire such as platinum alloys or iron alloys. Bridge wires which have been found to be particularly suitable are those made from metal alloys of high specific resistivity such as those known to the trade as Nichrome (a nickel chromium iron alloy containing 60% nickel, 24% iron, 16% chromium, 0.1% carbon), Chromel C (a nickel chromium iron alloy containing 60% nickel, 16% chromium, and the balance mainly iron), and Ohmax (a chromium iron aluminum alloy containing 20% chromium, 8.5% aluminum, and the balance mainly iron). The bridge wires are affixed to the leg wires by swaging, welding or soldering. The ferrule is preferably of vulcanized fiber tube although other rigid materials such as the thermosetting or thermoplastic resins may be utilized.

It will be seen, therefore, that this invention may be carried out by the use of various modifications and changes without departing from its spirit and scope. However, certain features are essential in accordance with the present invention to produce a detonator having a low energy requirement for firing and of sturdy construction.

The construction as between plug and shell is made as disclosed and claimed in copending application Serial No. 428,801, filed January 30, 1942, now U.S. Patent 2,389,086, wherein the plug is of hard dielectric material and of sufficient size to expand the shell when inserted therein. The expansion of the shell creates a slight bulge in that portion of the shell in contact with the plug. The bulge is preferably so slight as to be imperceptible and, therefore, is not illustrated in the drawings. This provides a strong, friction joint and maintains subjacent elements of the assembly in compression.

The ignition composition is a sensitive, hard solid mass formed in a protective ferrule. This mass surrounds the bridge wire and thus protects the bridge wire from breakage. For low energy requirements, bridge wire with a diameter of the order of 0.0004–0.0006 inch, and with an average resistance of 4–6 ohms is preferably utilized. Bridge wire of smaller diameter may be used. Such wire is not preferable because it cannot be obtained in quantity, its cost is excessive, and the loss due to broken bridges during and after assembly is too great. However, the present invention contemplates the utilization of bridge wire with a diameter of not more than 0.0006 inch, the fragility of which requires an ignition mixture which will set to a hard solid mass and thereby protect the wire.

Primary explosives such as mercury fulminate, lead styphnate, barium azide, and tetracene have been found suitable for use in the ignition composition in addition to the diazodinitrophenol set forth in the example. However, these explosives should be finely comminuted in admixture with from about 5 to about 50 parts by weight of an oxygen-containing material such as potassium chlorate, potassium nitrate, sodium chlorate, and the like. When using potassium chlorate with mercury fulminate, it has been found preferable to have the potassium chlorate present in amount from 10 to 20 parts by weight of the mixture. On the other hand, when using potassium chlorate with diazodinitrophenol, it has been found preferable to have the potassium chlorate present in amount from 25 to 45 parts by weight. Thus, the explosive and oxygen-containing material may be employed in various combinations in which proportioning of the mixture may be varied to obtain optimum performance of the ultimate ignition composition.

The mixture may be finely comminuted by grinding in a ball mill with a suitable liquid such as butyl acetate to reduce the particle size so that a major proportion thereof has a particle size of not more than about 20 microns. In addition, a nitric ester binding material such as nitrostarch, nitrocotton, and the like is incorporated with the finely-comminuted mixture to complete the ignition composition. The binding material should be present in amount from about 0.5 to about 6 parts by weight of the mixture. Bridge wire of small diameter as used in the present invention will sometimes fuse without igniting the ignition composition if the particles of the composition are large. Moreover, if only large particles contact the bridge wire, more energy is required for ignition. The binding material is added to give an increased bond to the ignition composition and thereby prevents the composition from breaking during manufacture or usage.

The advantages of the detonator made in accordance with the present invention are multifold. The detonator is adapted for mechanical assembly and economical mass production. The ignition plug is made of hard dielectric material which prevents movement of the leg and terminal wires. Terminal wire movement would break the small diameter, bridge filament. A cavity is formed by forcing a hard ferrule on the lower portion of the hard dielectric plug after bridging. The ignition composition is packed wet with solvent into the cavity and around the bridge wire and dried there as a solid mass, thereby protecting the bridge wire. The loaded plug is pressed into the detonator shell which contains a loose detonating charge of powder, thereby eliminating an additional step of pressing the detonating charge in the shell. The seal between plug and shell is waterproof as the plug is larger than the inside diameter of the shell and the shell is expanded where contacting the plug, thereby eliminating any subsequent operations for insuring a waterproof seal between the plug and shell. The loose detonating charge is pressed by the plug insertion and excess metal at the top of the shell is crimped over the plug thereby increasing ruggedness. Thus, the entire detonator is loaded under pressure which insures positive contact of the internal elements and prevents any movement of these internal elements in subsequent rough handling and stringent usage.

What I claim and desire to protect by Letters Patent is:

1. An electric firing device having in combination a tubular shell, a detonating charge, and an ignition assembly pressed upon the detonating charge, said ignition assembly comprising a plug of hard dielectric material having a pair of leg wires extending therethrough and of sufficient hardness and size to expand the shell, thereby providing a waterproof seal; a bridge wire having a diameter of not more than 0.0006 inch connected to the leg wires; a solid, sensitive, ignition charge surrounding the bridge wire; and a rigid member surrounding the ignition charge, said plug, said ignition charge, said solid member, and said detonating charge, each being disposed in rigid compressed relationship with each adjacent internal element in the device.

2. An electric firing device having in combination a tubular shell, a detonating charge, and an ignition assem-

bly pressed upon the detonating charge, said ignition assembly comprising a plug of hard dielectric material having a pair of leg wires extending therethrough and of sufficient hardness and size to expand the shell, thereby providing a waterproof seal; a bridge wire having a diameter of not more than 0.0006 inch connected to the leg wires; a solid ignition charge surrounding the bridge wire, a major proportion of said solid ignition charge having a particle size of not more than about 20 microns; and a rigid member surrounding the ignition charge, said plug, said ignition charge, said solid member, and said detonating charge, each being disposed in rigid compressed relationship with each adjacent internal element in the device.

3. An electric firing device having in combination a tubular shell, a detonating charge, and an ignition assembly pressed upon the detonating charge, said ignition assembly comprising a plug of hard dielectric material having a pair of leg wires extending therethrough and of sufficient hardness and size to expand the shell, thereby providing a waterproof seal; a bridge wire having a diameter of not more than 0.0006 inch connected to the leg wires; a solid ignition composition surrounding the bridge wire comprising a mixture of from about 50 to about 95 parts by weight of a primary explosive and from about 5 to about 50 parts by weight of an oxygen-containing material, and from about 0.5 to about 6 parts of a nitric ester binding material by weight of the mixture, a major proportion of said solid ignition composition having a particle size of not more than about 20 microns; and a rigid member surrounding the ignition charge, said plug, said ignition charge, said solid member, and said detonating charge, each being disposed in rigid compressed relationship with each adjacent internal element in the device.

4. The electric firing device of claim 3 wherein the primary explosive comprises diazodinitrophenol.

5. The electric firing device of claim 3 wherein the primary explosive comprises mercury fulminate.

6. The electric firing device of claim 3 wherein the primary explosive comprises lead styphnate.

7. An electric firing device having in combination a tubular shell, a detonating charge, an ignition assembly pressed upon the detonating charge, and a portion of the tubular shell folded over the top of the ignition assembly, said ignition assembly comprising a plug of hard dielectric material having a pair of leg wires extending therethrough and of sufficient hardness and size to expand the shell, thereby providing a waterproof seal; a bridge wire having a diameter of not more than 0.0006 inch connected to the leg wires; a solid ignition charge surrounding the bridge wire comprising a mixture of from about 55 to about 75 parts by weight of diazodinitrophenol and from about 25 to about 45 parts by weight of potassium chlorate, and from about 0.5 to about 6 parts of nitrostarch by weight of the mixture, a major proportion of said solid ignition charge having a particle size of not more than about 20 microns; and a ferrule of hard dielectric material affixed to the plug and surrounding the ignition charge, said plug, said ignition charge, said solid member, and said detonating charge, each being disposed in rigid compressed relationship with each adjacent internal element in the device.

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