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DETONATOR

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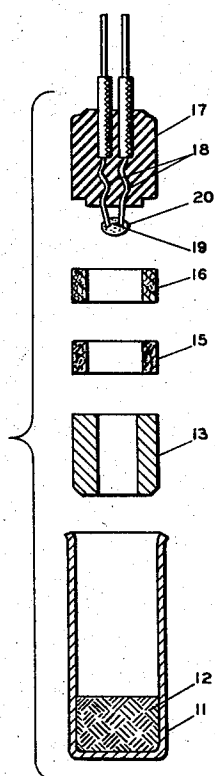


FIG. 1

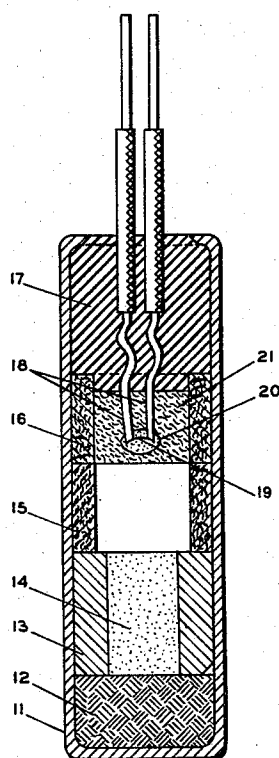


FIG. 2

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DETONATOR

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This invention relates to electric firing devices and more particularly to delay electric detonators.

In the prior art of delay electric firing devices, the desired delay action has been accomplished by various means. In one type of electric detonator a slow-burning material is placed between the ignition element and the detonating charge. This material may be nongaseous and burn at a rate of about five-tenths of an inch per second. In a second type of delay electric detonator, a faster-burning, gas-producing material is used between the ignition element and the detonating charge. In such cases, a vented shell is required or an unusually large free space must be provided to prevent bursting of the shell before the device is detonated and to prevent irregular burning of the fuse. In still a third type, a slow-burning material is ignited directly from the bridge wire, a sufficient quantity of the material being used so that the desired delay time is consumed in burning down to the detonating charge.

These prior art devices are not adaptable to give firing devices which have a short, yet reliably definite, time of delay, such as of the order of 0.10 second or more; which are of relatively small dimensions; which are of sufficiently rugged construction to withstand acceleration tests in the order of 20,000 g; and which have a very low energy requirement for firing, such as in the order of 4,000–6,000 ergs.

An object of the present invention is to produce an electrical firing device having a very low energy ignition requirement.

Another object is to produce a delay electric detonator which is rugged and highly resistant to damage from force produced by acceleration.

Still another object is a delay electric detonator having a delay time of about 0.15 second or more.

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

Now, in accordance with this invention, delay electric detonators have been prepared which are highly sensitive to electrical ignition energy, which are highly resistant to damage from force produced by acceleration, and which have a short delay time.

Generally described, the delay electric detonator of this invention comprises: A closed-end tubular shell containing therein a detonating charge in the bottom or closed end, a fuse element placed above the detonating charge and comprising a heating charge pressed within an annular lead fuse tube or retainer member, and an electric ignition assembly of low ignition energy requirement sealed within the open end of the shell and spaced from the fuse element by means of a cylindrical spacer or annular member whereby a free space is provided between the ignition assembly and the heating charge, the shell wall surrounding the free space is reinforced by the spacer, and the spacer improves the lengthwise rigidity of the combination of elements in the shell.

Having now described the invention in general terms

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and indicated the nature and purpose thereof, there follows a more detailed description of a preferred embodiment with reference to the accompanying drawing, wherein like numerals refer to like parts wherever they occur in the figures, and in which: Fig. 1 is a cross-sectional view of the structural parts of the device in disassembled form but indicating the order of assembly, and Fig. 2 is an enlarged cross-sectional view of a completed detonator.

Referring now to the drawing, and with particular reference to Fig. 2, the delay electric detonator of this invention has the following construction and characteristics. A closed-end metal tubular shell 11 contains in the bottom thereof a detonating charge 12 of a composition, such as diazodinitrophenol, diazodinitrophenol-potassium chlorate, mercury fulminate, or tetryl, pentaerythritol tetranitrate, and the like in combination with a suitable primer, such as the primary explosives aforementioned. On top of the detonating charge is a fuse element made up of a lead cylinder 13 filled with a suitable burning or heating charge (fuse charge) 14, such as an admixture of an oxidizing agent, like barium peroxide, and a fuel, such as selenium, the lead tube and heating charge being firmly pressed against the detonating charge. A cylindrical spacer 15, such as a hard vulcanized fiber annular member, is pressed against the upper annular surface of the lead fuse tube, a second cylindrical spacer 16 is pressed against the spacer 15, and an electric igniton assembly comprising a hard, dielectric, bridge plug 17 is held rigidly in place against the spacer 16 and sealed in the open end of the shell by friction and expansion and crimping of the shell over the end of the plug.

The ignition assembly is made up of a hard, dielectric plug 17 carrying leg wires 18 bridged by means of a bridge wire 19 of small dimensions and which has a very low energy requirement for heating to a suitable ignition temperature. The bridge wire 19 and terminal tips of the leg wires are covered with a bead 20 of highly sensitive ignition composition, such as an admixture of diazodinitrophenol and potassium chlorate, forming a matchhead igniter. The spacer 16 is fitted over the bridge wire end of the bridge plug and forms a cavity around the matchhead. This cavity is filled with a burning ignition mixture 21, such as lead-selenium-nitrostarch.

The device of this invention will be understood better from the following example which describes the device in the order of assembly with particular reference to Fig. 1.

A closed-end tubular shell 11 of bronze, approximately one inch long, an inside diameter of 0.252 inch at the lower (closed) end and tapered to 0.257 inch near the open end and flared slightly at the open end periphery to facilitate assembly, was filled to a height of about 0.14 inch and about 0.11 gram of a loose detonating charge 12 of a mixture of diazodinitrophenol-potassium chlorate, 75–25 parts by weight. An annular lead fuse member 13 was made by loading a 36 inch long x 0.29 inch outside diameter x 0.16 inch inside diameter lead tube with a burning or heating charge (fuse powder) of barium peroxide-selenium, 80–20 parts by weight. The loaded tube was then swaged to about 0.256 inch outside diameter, and cut to a length of 0.24 inch. The lower end was beveled to facilitate assembly. The outside diameter of about 0.256 inch was slightly less than the inside diameter of the tubular shell 11 near its open end but slightly larger than its inside diameter in the lower portion thereof. The prepared delay fuse was forced into the shell and pressed against the loose detonating charge 12. A cylindrical spacer 15, of a medium hard vulcanized fiber composition, 0.14 inch

long, 0.25 inch outside diameter, 0.19 inch inside diameter, was placed on top of the lead fuse tube 13. Then the electric ignition assembly was inserted and sealed into the shell. The ignition assembly was made and assembled in the detonator as follows: A pair of insulated leg wires 18 having the lower portion thereof uninsulated were molded into a plug 17. The uninsulated wires projecting from the ignition end of the plug were bent inwardly to provide a spacing of about 0.02 inch in order to concentrate the heat of ignition. A bridge wire 19 was welded to the leg wires 18. The bridge wire was about 0.0005 inch in diameter, of Nichrome wire, and had a total resistance of about 4-5 ohms. The plug 17 was of a thermosetting resin which was sufficiently rigid to cause expansion of the shell 11 when pressed thereinto, and which thereafter was not subject to cold flow due to the pressure exerted by the expanded shell 11 to an extent sufficient to cause loss of waterproof quality. The plug was formed to have an outside diameter of about 0.26 inch and an overall length of about 0.31 inch. A slight shoulder and bevel were provided at the upper end for crimping the shell thereover to give a good closure, and a shoulder was provided at the ignition end to fit tightly a fiber sleeve 16, 0.14 inch long, 0.25 inch outside diameter, 0.19 inch inside diameter, and of a medium hard vulcanized fiber composition.

After bridging the leg wires, the bridge wire and terminal tips were dipped in a slurry of a very sensitive ignition composition containing diazodinitrophenol and potassium chlorate, whereby a small matchhead was formed. The matchhead was allowed to dry and then provided with a protective coating of nitrocellulose from a solution of it in butyl acetate. It is important to point out that an ignition composition should be used which has a high sensitivity to ignition energy when the detonator must be fired with very small energy requirements such as of the order of a few thousand ergs, e.g., 4,000-6,000 ergs. The diazodinitrophenol-potassium chlorate mixture has been found to be very satisfactory for this purpose, a mixture containing about 25-40 parts potassium chlorate by weight being preferred. However, being gaseous and violent, the quantity must be kept at a minimum when used in a delay device. Otherwise, it may burst the shell instantaneously. The matchhead preferably will contain less than about 0.005 gram of the composition. A large matchhead may create sufficient pressure to force a flame past a short fuse, causing an instantaneous shot, or past the plug causing slow burning of the fuse, or may blow the plug out of the shell and cause the burning fuse to be extinguished because of the sudden drop in pressure.

The fiber sleeve 16 was forced on the plug 17 to form a cavity around the matchhead. This cavity was loaded with a burning ignition mixture of lead-selenium-nitrostarch, 71-27-2 parts by weight, wet with butyl acetate, and dried. This charge in the plug cavity serves several purposes: It adds mechanical support to the matchhead which alone has insufficient contact with the terminal wires to withstand setback in the event of use where it is subjected to high acceleration, and it forms a hot-burning mass upon ignition which readily ignites the fuse. The matchhead alone is unsuitable for this purpose in the device of this invention. About 2 parts by weight of nitrostarch with the heavy lead-selenium mixture is sufficient binder to prevent powder from falling out of the cavity even under extreme conditions. Too large an amount is to be avoided since it increases the pressure unnecessarily.

The completed ignition assembly, including the fiber sleeve and cavity charge, was forced into the shell until the sleeve 16 was pressed against the spacer 15. The shell was caused to bulge slightly but there was no tendency of the shell to split. The portion of the shell extending beyond the plug was crimped over and pressed

against the upper circumferential edge of the plug. The resulting closure was rigid and waterproof.

In the thus assembled device the elements were rigidly secured in a compact form. The matchhead was supported by the cavity charge; the pressure effect resulting from the burning of the complete ignition charge was minimized by providing the free space defined partially by the spacer element; the spacer element supported the cavity sleeve thus preventing setback displacement; and the spacer element, as well as the cavity sleeve element, supported the shell wall minimizing shell wall cracks from the matchhead pressure which would result in leakage of the gases and unreliable delay times.

It will be well understood that modifications of details of the device described hereinabove may be made within the scope of the invention. For example, the fuse tube may have other dimensions and the heating charge therein may be selected from other compositions so long as it may be ignited by the ignition assembly and may be adjusted to give the desired delay time. Lead is a very satisfactory metal from which to make the fuse tube for the device of this invention as will be understood from the character of lead and the requirements of the device; however, other selected materials may be used for the fuse tube.

It is preferred to utilize a substantially hard vulcanized fiber tube, cylinder, or annular spacer for providing the free space in the device, maintaining the assembled elements in a rigid relationship, and reinforcing the shell tube wall. However, it will be appreciated that many types of materials may be utilized for these purposes. It is preferred, too, that this spacer make a substantially close, sliding fit with the interior of the shell wall.

The upper spacer (cavity-forming element or sleeve) may be selected from familiar materials which satisfy the requirements made upon it. It is preferred that this sleeve be a part separable from the bridge plug so as to facilitate manufacture of the ignition assembly. However, it may be of the same composition as the plug and may be formed therewith into a single structural element, as by molding the plug with an initial cavity. Variations of this type will be well understood in the art.

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 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.

It will be seen, therefore, that in accordance with the foregoing description of this invention, a compact, rugged, highly energy-sensitive, electric firing device has been produced. This device is of particular utility where a substantially short delay time is desired, e.g., about 0.10 second or more; where the available electrical energy for firing is very small, such as, for example, only a few thousand ergs, of the order of about five thousand; and where it may be subjected to large internal forces as in a high gravity field, such as produced by high acceleration.

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

1. A delay electric detonator having in combination a tubular shell, a detonating charge in the bottom thereof, a delay fuse element superimposed upon the detonating charge, a highly energy-sensitive, electric ignition assembly spaced apart from the delay fuse element, and an annular sleeve disposed endwise between the fuse element and ignition assembly and in contact therewith; said detonating charge, delay fuse element, annular sleeve, and ignition assembly, each being disposed in rigid, com-

pressed relationship with each adjacent internal element of the device.

2. A delay electric detonator according to claim 1 in which the delay fuse element comprises a delay fuse powder packed within a metal tube.

3. A delay electric detonator according to claim 1 in which the ignition assembly comprises a bridge plug, lead wires passing through said plug, a bridge wire having low energy requirement disposed between the terminal ends of said lead wires, a matchhead of highly energy-sensitive igniter composition formed about the bridge wire, an annular sleeve engaging the under surface of the plug and surrounding the matchhead, and a solidified ignition mixture disposed within said sleeve and surrounding the matchhead.

4. A delay electric detonator having in combination a tubular shell, a detonating charge in the bottom thereof, a delay fuse element superimposed upon the detonating charge and consisting of a fuse powder packed within a lead tube, an annular, cylindrical, spacing and shell-reinforcing member disposed upon the fuse element, and an ignition assembly disposed upon said spacing member which comprises a bridge plug sealed within the shell, lead wires passing through said plug, a bridge wire having low energy requirement disposed between the terminal ends of said lead wires, a matchhead of highly energy-sensitive igniter composition formed about the bridge

wire, an annular sleeve engaging the under surface of the plug and surrounding the matchhead, and a solidified ignition mixture disposed within said sleeve and surrounding the matchhead; said detonating charge, delay fuse element, annular member, and ignition assembly, each being disposed in rigid, compressed relationship with each adjacent internal element of the device.

5. A delay electric detonator according to claim 4. in which the bridge plug is formed from a hard dielectric material and has a diameter slightly in excess of the original diameter of the shell; said plug expanding the shell slightly and forming a rigid waterproof seal when forcibly inserted into the shell.

6. A delay electric detonator according to claim 4 in which the bridge wire has a diameter of about 0.0005 inch.

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