April 18, 1961 G. A. NODDIN 2,980,019

ELECTRIC INITIATOR

Filed Sept. 9, 1957

Fig. 1

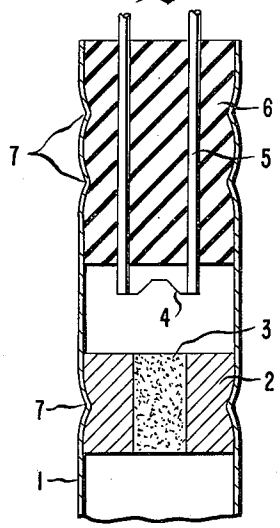



Fig. 2

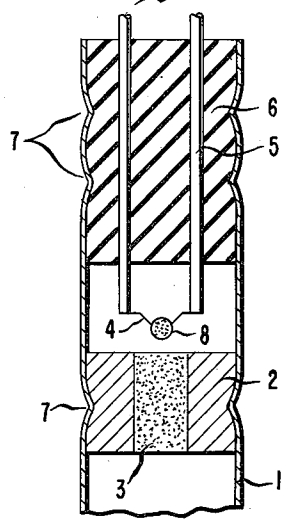



Fig. 4

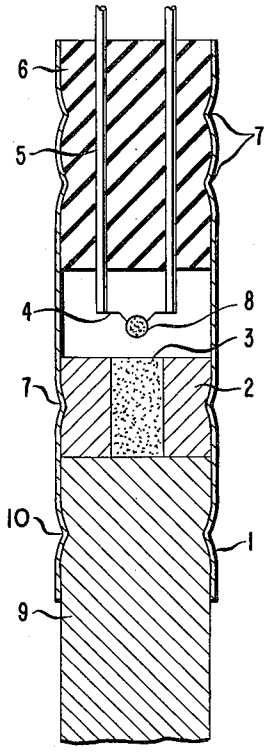
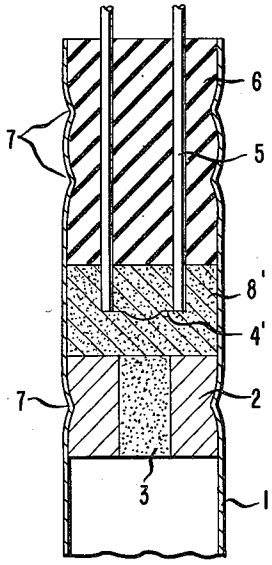



Fig. 3




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# ELECTRIC INITIATOR

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5 Claims. (Cl. 102—28)

The present invention relates to a novel electric initiator. More particularly, the present invention relates to a novel electrically actuated nonviolent initiator stable at high temperatures.

In many applications of explosives, a nonviolent initiator, i.e. an initiator which is substantially noiseless in operation and produces no shattering or disruptive effects, is highly desirable. For example, in the novel blasting method and arrangement described in detail in copending application Serial No. 618,217, filed October 25, 1956 and now abandoned by G. A. Noddin and assigned to the present assignee, explosive connecting cord, which is essentially noiseless in operation and comprises a core of from 0.1 to 10 grains per foot of length of a high explosive within a metal sheath, is used as the above-surface explosion conducting means, i.e. trunk line, in blasting operations. The cord is used instead of the conventional "Primacord" trunk line in order to decrease the noise produced by the operation, because when "Primacord" is used the noise it produces constitutes a nuisance which on occasion has provoked law suits or injunctions which impede the operation. The trunk line of explosive connecting cord, however, has been initiated by conventional electric initiators which produce an annoying loud bang or snap, and the elimination or reduction of such noise is much desired.

In addition, in the novel seismic prospecting method described in detail in copending application Serial No. 618,509, filed October 26, 1956 and now abandoned by D. L. Coursen and N. G. Johnson and assigned to the present assignee, improved seismic records are obtained by use of a length of the explosive connecting cord to conduct the initiating impulse from the surface of the ground to the explosive charge in the borehole. The detonation of the cord does not produce seismic waves of sufficient magnitude as to interfere with the recording of the desired reflected or refracted waves from the detonation of the main charge in the borehole. When a conventional electric initiator on the surface of the ground is used to actuate the cord, such an initiator produces interfering shock waves and is noisy in functioning. The noise produced, aside from the effect on seismic recording instruments, is of little import when the exploration is being carried out in remote regions. However, in populated or industrialized sites, such a disturbance becomes an important problem to the seismic surveyors.

Moreover, in the method of joining metallic elements by means of a wrapping of high explosives, which method is described in detail in U.S. Patent 2,367,206, a conventional initiator has been used to actuate the high explosive. Consequently, the violence and metal fragments of such initiators has caused undesirable metal-working and deformation in the area of the metallic elements adjacent the initiator.

Obviously, a need exists for a nonviolent initiator, substantially noiseless in operation and producing no shattering effects, in all of the afore-mentioned applications. Furthermore, the substantially noiseless action of



such an initiator would make its adoption very desirable in many other applications of explosives.

Accordingly, an object of the present invention is to provide a nonviolent electric initiator. Another object of the present invention is to provide an easily assembled electric initiator characterized by substantially noiseless operation and the absence of shattering effects. A further object of the present invention is to provide a nonviolent initiator suitable for use in numerous applications of explosives.

I have found that the foregoing objects may be achieved when I provide as an electric initiator a thin-walled metal tube in which is positioned axially a rigid cylinder in the bore of which is confined a small quantity of lead azide, said tube being sealed by an ignition assembly.

In accordance with the present invention, an initiating charge comprising 0.03 to 0.6 grain of lead azide disposed within the central bore of a heavy-walled rigid cylinder whose outer to inner diameter ratio is 2 or more is inserted axially in an open-ended tube and an ignition assembly is sealed within one end of the tube.

In order to describe more fully the present invention, reference is made to the accompanying drawings, in which:

Figures 1 to 3 are sectional elevations of the initiator of the present invention, showing various modifications of the ignition assembly.

Figure 4 is a sectional view of a fuse or cord assembly incorporating the initiator of the present invention, which assembly is suitable for use, for example, in the previously mentioned seismic prospecting method.

In all figures, identical parts are indicated by the same symbols.

In Figure 1, 1 is a thin-walled tube of metal, plastic, etc., 2 is a heavy-walled rigid cylinder, preferably of lead, having a central bore, 3 is a mass of lead azide contained within the bore of cylinder 2, 4 is a high-resistance bridgewire, 5 indicates the lead wires, 6 is a resilient sealing plug, for example of rubber, and 7 indicates circumferential crimps which maintain the sealing plug 6 and the cylinder 2 in proper position within the tube.

In Figure 2, 4 is a bridgewire surrounded by a coherent mass, or bead, 8, of an ignition composition, and in Figure 3, 8′ is a loose mass of an ignition composition which is in contact with the bridgewire 4′.

In Figure 4, the initiator as shown in Figure 2 is combined with a length of explosive connecting cord, a portion of which is indicated by 9. The cord is shown butted against cylinder 2 and held in place by a circumferential crimp 10.

In operation, the current is applied to the lead wires and passes through the high-resistance bridgewire producing heat which actuates the lead azide contained within the bore of the rigid cylinder. In this form of the ignition assembly, the so-called "exploding" bridgewire assembly, which is shown in Figure 1, the passage of high current through the bridgewire volatilizes it and hot particles of metal are thrown against and ignite the lead azide, which, in this case, acts as a combined ignition-initiation composition. Alternatively, an ignition composition, such as a boron-red lead mixture, may be positioned, in the form of a bead or a loose ignition charge, around the bridgewire, as shown in Figures 2 and 3. The passage of low firing currents through the bridgewire ignites the ignition composition which, in turn, initiates the lead azide. In a modification of the ignition assembly, the bridgewire is eliminated, and the current arcs across the gap between the ends of the lead wires and ignites the loose mass of ignition composition disposed as is shown in Figure 3. In all cases, the ini-

tiator assembly is nonviolent in functioning, which is clearly indicated by the failure of the initiator shell to rupture.

The initiator of the present invention may be combined readily, as shown in Figure 4, with a length of detonatable explosive cord, for example detonating fuse, or "Primacord," or the explosive connecting cord, to form a blasting initiator assembly or the like, the detonation of the lead azide within the cylinder causing initiation of the adjacent explosive cord.

The following examples serve to illustrate specific embodiments of the initiator of the present invention. However, they will be understood to be illustrative only and not as limiting the invention in any manner.

*Figure 1*

A number of initiators having the bead ignition system shown in Figure 2 were assembled, in which the weight of the lead azide within the cylinder and the length of the cylinder, which was made of lead, were varied as indicated in the following table. Lengths of the connecting cord were crimped in the initiators so that the cord was butted against the end of the heavy-walled cylinder, as shown in Figure 4. In the tests, the initator actuated the cord without violence.

TABLE I

| Distribution of $PbN_6$ (grains/ft.) | Length of Cylinder (in.) | Total Wt. of $PbN_6$ in Cylinder (grains) |
|---|---|---|
| 2.5 | 1/8 | 0.026 |
| 2.5 | 1/4 | 0.052 |
| 5 | 1/8 | 0.052 |
| 5 | 1/4 | 0.10 |
| 10 | 1/8 | 0.10 |
| 10 | 1/4 | 0.21 |
| [1] 10 | 1/2 | 0.42 |
| 20 | 1/8 | 0.21 |
| 20 | 1/4 | 0.42 |
| 25 | 1/8 | 0.25 |
| 30 | 1/8 | 0.31 |
| 30 | 1/4 | 0.62 |
| 60 | 1/8 | 0.53 |

[1] In testing this initiator, no connecting cord was used. The lead azide within the initiator detonated completely without rupture of the shell.

*Example 2*

A number of initiators having the "exploding" bridgewire ignition system were assembled. In assembling these initiators, the lead azide-containing lead cylinder was inserted in a metal capsule having a 0.005-inch-thick bottom, the end of the cylinder being flush against the bottom of the capsule. The capsule then was inserted in the open-ended tube, one end of which then was sealed by the ignition assembly. A length of "Primacord" was inserted and crimped in the other end of the shell, the end of the "Primacord" being butted against the bottom of the capsule. The lead azide-containing cylinder was varied as shown in the following table, and the "Primacord" was initiated in all cases without rupture of the initiator shell.

TABLE II

| Distribution of $PbN_6$ (grains/ft.) | Length of Cylinder (in.) | Total Wt. of $PbN_6$ in Cylinder (grains) |
|---|---|---|
| 30 | 1/4 | 0.62 |
| 30 | 1/8 | 0.31 |
| 20 | 1/4 | 0.42 |
| 20 | 1/8 | 0.21 |
| 10 | 1/4 | 0.21 |
| 10 | 1/8 | 0.10 |

*Example 3*

In another series of experiments, a number of initiators were assembled having a 3-grain charge of loose 62/35/3 bismuth/selenium/potassium chlorate ignition composition which was placed, as shown in Figure 3, above the cylinder, which was positioned within the metal capsule. After the ignition charge was placed in the tube, one end of the tube was sealed by a rubber plug assembly containing the lead wires. The bridgewire, which connected the lead wires, was in contact with the ignition charge. A length of "Primacord" was connected to each initiator as described in Example 2, and the initiators were then tested. The lead azide charges summarized in Table 3 were used, and in all cases the "Primacord" was initiated by the unit.

| Distribution of $PbN_6$ (grains/ft.) | Length of Cylinder (in.) | Total Wt. of $PbN_6$ in Cylinder (grains) |
|---|---|---|
| 30 | 1/4 | 0.62 |
| 30 | 1/8 | 0.31 |
| 20 | 1/4 | 0.42 |
| 20 | 1/8 | 0.21 |

*Example 4*

An arc-fired initiator was assembled by inserting a 1/8-inch-long lead cylinder into the center portion of a 15/16-inch-long aluminum tube, the cylinder containing 0.6 grain of lead azide. A 1.5-grain charge of loose lead azide was placed on top of the cylinder, and then the ignition assembly was sealed into the tube, the assembly comprising a pair of lead wires maintained in the sealing plug so that there was a 0.010-inch gap between the bared ends of the lead wires, which ends were surrounded by the charge of loose lead azide. Upon application of an electric current, the loose lead azide charge ignited and initiated the lead azide in the cylinder.

As shown in the foregoing examples, a quantity as low as 0.03 grain of lead azide in the initiator of the present invention is sufficient to initiate a high explosive. Heretofore, initiating charges comprising about 5 grains of a high explosive such as lead azide were used in initiators to insure consistent initiation, this quantity of high explosive causing the undesirable violence. The initiator of this invention is based upon the discovery that a column of lead azide within a rigid cylinder can be ignited by conventional ignition means even at a loading as low as about 2.5 grains per foot and then when the column is at least 1/8 inch in length, consistent initiation of detonating fuse or connecting cord can be obtained. Thus, as little as 0.03 grain of lead azide will produce consistent initiation of detonating fuse and connecting cord. However, quantities up to 0.6 grain of lead azide centrally disposed in a rigid cylinder can be used without loss of the nonshattering and substantially noiseless characteristics desired, provided the lead azide column does not exceed a loading of about 60 grains per foot. At higher column loadings, regardless of the length of the column, appreciable shattering effects and noise cannot be avoided. The length of the rigid cylinder containing the lead azide is critical only in the minimum requirement, i.e., at lengths less than 1/8 inch, inadequate priming action is obtained. However, no advantage results from using a cylinder of over 1/2 inch in length.

In summation, the lead azide will preferably be present in a quantity of from 0.03 to 0.6 grain at a loading of from 2.5 to 60 grains per foot and centrally positioned in a rigid cylinder 1/8 to 1/2 inch in length. Inherent in the foregoing is the fact that the lead azide column is of the same length as the rigid cylinder. The lead azide contained within the cylinder may be admixed with another high explosive such as PETN or nitromannite.

The cylinder is constructed of a rigid material which is nonreactive with the lead azide. Although lead has been exemplified and is preferred, other metals and their alloys, such as aluminum and steel, can be used. In addition, polymeric materials, or plastics, having the required rigidity are suitable.

The cylinder is positioned axially in an open-ended thin-walled tube of metal, plastic, etc. in igniting proximity to the ignition assembly. The dimensions of the tube are not critical, the outer diameter of the cylinder being adjusted in relation to the inner diameter of the tube and being so selected that the cylinder can be inserted into the tube and crimped in place without difficulty. When the initiator is to be combined with detonatable explosive cord, the diameter of the tube is selected accordingly. Tubes of about ⅔ inch in length were exemplified, but shorter tubes which are of a length sufficient to contain the cylinder and the ignition assembly and longer tubes, i.e. up to about 3 inches in length, are equally suitable. Of course, the tube wall must be of a thickness such that the ignition composition does not shatter it.

To protect the lead azide within the cylinder from water, a thin metal wall may be provided adjacent the cylinder, for example, by providing a capsule of thin metal which surrounds the sides and bottom of the cylinder as illustrated in Example 2. The thin bottom, which can be of a thickness in the order of 0.005 inch, does not interfere with the functioning of the initiator. As an alternative method of protecting the lead azide, a sealant can be applied to the end of the cylinder opposite the ignition assembly without interference with the functioning of the initiator.

A variety of electrical ignition assemblies can be sealed into the tube, for example by a resilient plug, such as a rubber plug, of conventional design, through which the customary lead wires are introduced into the initiator. These ignition assemblies include a bridgewire and bead arrangement, a bridgewire inserted in a mass of loose ignition composition, the previously described "exploding" bridgewire unit, and an arc-firing system in which the bridgewire is eliminated. The "exploding" bridgewire unit is especially advantageous because such a unit can be actuated only by application of very high firing currents. The specific ignition or burning composition used in the ignition assembly is not critical to the initiator of the present invention, any ignition composition being suitable for use. Such ignition compositions usually comprise a fuel-oxidant mixture, such as boron-red lead ($Pb_3O_4$), silicon-red lead, manganese-bismuth trioxide, lead sulfocyanate-potassium chlorate-calcium silicide, bismuth-selenium-potassium chlorate, diazodinitrophenol-potassium chlorate, and the like, or a single compound, such as lead styphnate, tetrazene, or a loose charge of lead azide.

The lack of violence of the initiators is apparent. No noise aside from a slight popping sound, was produced by any of the initiators. Visual inspection of the initiators showed that no tube rupture occurred, indicating the absence of shattering effects. This lack of violence presents an important safety feature. For example, when six of the initiators described in Example 2 were bunched together, actuation of the central initiator occurred without sympathetic actuation of the other five initiators.

The heat stability of the initiator of the present invention likewise was shown by a series of tests. In these tests, one group of the initiators prepared as described in Example 3 was subjected to heat-cycle storage under conditions more severe than those normally encountered in storage of initiators (95% relative humidity and —65° F. to 160° F.) for one month, and another group was maintained at 185° F. for six weeks. All the initiators so treated actuated lengths of the connecting cord. The tests made to illustrate the initiating ability of the present initiator show that the initiator is capable of actuating both the explosive connecting cord, which contains about 0.1 to 10 grain of PETN or RDX per foot, and conventional detonating fuse such as "Primacord," even when the cord or fuse is not positioned immediately adjacent the lead azide.

It will be obvious to those skilled in the art that many modifications in the design and use of the initiator of the present invention are possible without departure from the scope of the present invention. I intend, therefore, to be limited only by the following claims.

I claim:

1. An electric initiator of high-temperature stability which comprises a tube open at both ends, a thick-walled rigid cylinder ⅛ inch to about ½ inch in length with an outer-to-inner diameter ratio of at least about 2.0 and having a central bore containing from 0.03 to 0.6 grain of lead azide at a distribution of from 2.5 to 60 grains per foot and positioned axially in said tube, and an electrical ignition assembly sealed within one end of said tube in igniting relationship to said lead azide, said initiator being of low brisance and resulting in substantially no offensive noise upon initiation.

2. An initiator according to claim 1, wherein said ignition assembly comprises a pair of lead wires connected at their inner ends by a bridgewire.

3. An initiator according to claim 2, wherein said bridgewire is surrounded by a mass of an ignition composition.

4. An initiator according to claim 1, wherein said ignition assembly comprises a pair of lead wires, the inner ends of which are in contact with a loose mass of an ignition composition.

5. An electric initiator as in claim 1 in combination with a length of detonatable explosive cord in said tube adjacent said rigid cylinder at the end remote from the electrical ignition assembly.

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