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ARC RESISTANT ELECTRIC INITIATOR

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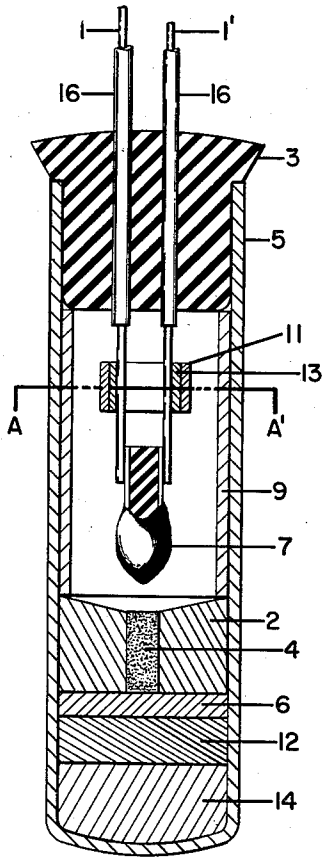


Fig. I.

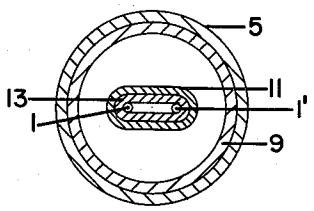


Fig. II.

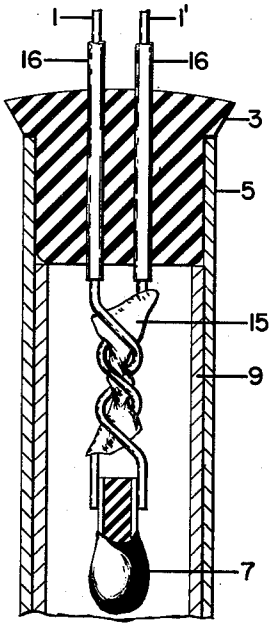


Fig. IV.

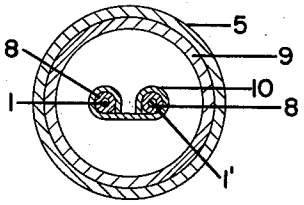


Fig. III.

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ARC RESISTANT ELECTRIC INITIATOR

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This invention relates to electric initiators and more particularly to delay electric initiators which are highly resistant to misfires due to internal arcing.

The usual ventless delay electric explosion initiator includes a tubular metal shell into which is charged an explosive material, a delay element including a delay train, a firing circuit including a bridge wire, and an ignition composition in contact with at least the bridge wire portion of the firing circuit. Upon application of electric current to the firing circuit the bridge wire is heated to the point where the ignition composition fires igniting the delay train. The delay train in turn at the end of its preset burning interval either directly initiates the explosive charge in the base of the initiator, or ignites a secondary charge which in turn initiates the explosive charge in the base of the initiator.

The use of delay initiators is well known in the blasting art. The most extensive use is to facilitate the detonation of explosive charges in rotation, or in the so-called "round" firing. The general advantages of delay detonation are: (1) The necessity of workmen returning to the blasting area to connect successive rounds is eliminated. (2) The number of misfires due to broken connecting wires caused by neighboring blasts is minimized as the delay detonators, being simultaneously ignited and self-contained, are not generally affected by other successive blasts of the round.

It has been discovered that various malfunctions of delay electric initiators, which are seemingly unrelated, are caused by a large amount of heat, generated by an electrical arc which occurs within the initiator when an excessive electrical current is supplied. The gases from the ignition composition within the initiator are heated rapidly and a high internal pressure is soon built up. The heat and high pressure condition within the initiator causes either an outward rupture of the initiator wall or a violent dislodging of the initiator seal, and the enclosed hot gases are rapidly released. The effect of this action on the blasting operation is unpredictable and varied. The sudden release of the gases may create conditions under which the burning delay element may be extinguished or the speed of burning of the delay element is retarded. The delay element will then fail to initiate the explosive charge of the initiator at the present time interval. The release of the hot gases and flame can ignite the surrounding explosive which may slowly burn with the possibility of detonation developing. If the delay element is extinguished and the surrounding explosive charge is ignited, several minutes may elapse before heat from the burning explosive either causes detonation or ignites the explosive charge of the initiator which initiates the remainder of the burning explosive. Heat generated by the burning explosive may decompose the explosive charge of the initiator, and, in such case, the surrounding explosive may, unpredictably, either burn completely or detonate at any point before it is completely consumed by burning. If the burning element is extinguished by the sudden release of the entrapped gases, and the explosive charge is not ignited by the hot gases, the shot may fail completely. Thus, the occurrence of a violent electrical arc within the delay electric initiator may result in various malfunctions such as: a premature detonation, a misfire, or a delayed detonation commonly known as a "hangfire."

The various malfunctions caused by arcing occur more frequently when any of the various parallel circuit arrangements such as normal parallel, reverse parallel, and closed loop parallel are used with a continuous source of electrical energy of high potential such as a power line. When electric initiators are connected in parallel, the voltage across the bridge wire terminals frequently is high enough to sustain an electrical arc after the bridge wire melts, and, when a power line of high current capacity is used, the arc may generate enough heat within the initiator prior to initiation to cause malfunction. Parallel circuit arrangements of delay initiators are often used in the blasting art and the convenience and advantages of a power line as a source of electrical energy are well known. Thus, the majority of arcing difficulties encountered in blasting operations occur when a commonly used circuit arrangement is combined with a commonly used source of electrical energy.

The present invention relates to delay electric explosion initiators and particularly to means for preventing misfires and malfunctions of delay electric blasting initiators resulting from the high and rapid heat build-up within the initiator caused by internal arcing occurring between the bridge wire connections or between the bridge wire connections and the inner shell wall of the initiator.

An object of this invention is to provide a new and improved type of delay electric explosion initiator which will properly operate over a wide range of current values including severe overload conditions.

It is a further object of this invention to provide a ventless delay electric explosion initiator which will tolerate high electrical currents without misfiring when connected in parallel and fired from a power line source of electrical current.

It is a further object of this invention to provide a delay electric initiator which can be successfully used under widely varying conditions of current, voltage, initiator arrangement, and number of initiators used in a shot, making close supervision of details of the above mentioned conditions of less importance when connecting and firing the initiators.

An electric delay initiator specifically designed to operate only under high current conditions would be precluded from general use in the blasting art because of the danger of misfires due to an insufficient supply of current available from blasting machines, condensers, small generators and batteries. Therefore, it is the purpose of this invention to provide a versatile delay electric initiator which is resistant to malfunction caused by internal arcing and is operable over a wide range of current and voltage conditions.

In general, delay electric initiators in accordance with this invention comprise a tubular metal shell closed on one end and containing one or more detonating charges housed in the closed end. A delay element is positioned immediately above said detonating charges and in ignitable position thereto. An electric ignition element is positioned above said delay element and has electrical wires leading therefrom and is adapted to be connected to a source of electrical current. A sealing plug is inserted in the open end of the metal shell to close said open end. A shunting assembly is located between the match and the sealing plug, so as to electrically separate the leg wires by a heat-destructible, non-conducting insulation.

Having generally described the initiator of the invention, the novel structure thereof will be more particularly illustrated with reference to the accompanying drawings in which FIGURE I is a sectional view in elevation of an initiator containing a shunt assembly of the present invention. FIGURE II is a cross section of the initiator shown in FIGURE I, taken on plane A and A'. FIGURE III is a cross-sectional view of an initiator showing

an alternate form of the shunt assembly of the present invention. FIGURE IV is a partial sectional view in elevation showing an alternative means for associating the leg wires of an initiator with each other by means of a shunt assembly of this invention. Similar parts are shown by similar numbers throughout the several views.

In FIGURE I, leg wires 1 and 1', having insulated portions 16 and 16', pass through a plug 3 of resilient material which is held in a compressed position in the mouth of initiator shell 5. The wires are bared from a point just below the bottom of plug 3 and extend downward terminating in an ignition means shown as electric match 7. A bridge wire (not shown) connects wires 1 and 1' within electric match 7. An insulator tube 9 extends from the bottom of plug 3 to the top of the delay element 2. Delay element 2 contains a delay train 4 and is positioned in firing relation to the electric match 7. A base charge 14 is positioned in the closed end of the initiator shell 5. Immediately above the base charge is a primer charge 12. Immediately above the primer charge and in firing relation to delay train 4 is a flash charge 6. The firing elements are so arranged that the firing successionally progresses from the ignition of the electric match to the initiation of the base charge. The shunt assembly is comprised of metallic ferrule 11 placed around a heat-distructible non-conducting ferrule 13. The shunt assembly is securely positioned around the bared portions of wires 1 and 1' at a point between plug 3 and electric match 7. Exposure to the elevated temperature prevailing within the initiator when electrical arcing occurs, decomposes the heat-destructible non-conducting ferrule 13. The decomposition of said non-conducting ferrule allows the metallic ferrule 11 to contact the bare portions of leg wires 1 and 1', thereby creating a path of low resistance for the flow of electric current which aborts a violent arc within the initiator.

FIGURE II is a cross-sectional view of the initiator shown in FIGURE I, taken on plane A and A'. This figure demonstrates the arrangement of the bared leg wires 1 and 1' in relation to the shunt assembly. Non-conducting heat-destructible ferrule 13 encases bared wires 1 and 1', and is in turn encased by metallic ferrule 11.

FIGURE III illustrates a modification of the shunt assembly as shown in FIGURES I and II, wherein a coating of non-conducting heat-destructible material 8 is placed around leg wires 1 and 1' and a metal clip member 10 positioned around said coated leg wires.

FIGURE IV shows an alternate form of the invention wherein bared leg wires 1 and 1' are so arranged in relation to each other that breakdown of the heat-destructible, non-conducting material 15 inserted therebetween causes the leg wires to be directly shorted, thereby preventing the formation of a high heat forming arc within the initiator. The heat-destructible, non-conducting material 15 shown in FIGURE IV may if desired be applied as a coating on both or either of leg wires 1 and 1'.

In order to insure that the shunt assembly will not shunt the firing current applied to the initiator, the shunt assembly should have a dielectric strength of at least 200 volts, and it is preferred that the shunt assembly have a dielectric strength of about 600 volts.

The breakdown of the heat-destructible, non-conducting portion of the shunt assembly should preferably occur 10 to 200 milliseconds after ignition of the electric match. The lag should be long enough to permit match ignition but short enough to avoid excessive heating by the arc. The breakdown may be initiated by heat produced by the arc.

The electrical resistance of the shunt assembly after firing of the ignition element should be low enough to quench the arc. The preferred order of magnitude of the resistance after the initiator is fired is in the order of $\frac{1}{10}$ ohm.

The current carrying capacity of the shunt assembly is preferably as great as the leg wires in order that full protection will be provided by the shunt under all situations.

The metallic portion of the ferrule and clip-type shunt assemblies, as shown in FIGURES I, II and III, may be fabricated of any suitable conductor which will withstand the internal heat generated within the initiator. Aluminum has been found to be most satisfactory. The non-conducting, heat-destructible portion of the shunting assemblies of this device may be fabricated of any suitable insulating material, providing that such material has breakdown characteristics consistent with the requirements aforementioned. The following insulating materials for example, have been found to give satisfactory results in the practice of this invention: thin sheets of polyethylene, thin sheets of cellophane, coatings of polyurethane resins and coatings of silicone resins.

The following table is a compilation of test results comparing various forms of the described invention and prior art initiators. The examples shown are for purposes of illustration and should not be interpreted as limitations of the invention.

The prior art initiators tested were generally similar to that shown in FIGURE I with the exception of elements 11 and 13.

The initiators of Example I were the same in all respects as the prior art initiators except that an aluminum ferrule insulated with "R–671" silicone resin produced by Dow Corning Corporation was pinched around the bared leg wires between the sealing plug and the electric match. The ferrules were pressed on the leg wires with a flat press pin using a force of between 100 and 150 pounds.

The initiators of Example 2 were similar to the prior art initiators except that the leg wires were insulated with "Solder Film," a tradename of the Kennecott Wire and Cable Co., for polyurethane resin coating, and the portions of the leg wires between the sealing plug and the electric match were twisted together, the twisted portions being insulated from each other by the thin layers of polyurethane resin.

The initiators of Example 3 were similar to the prior art initiators except that a section of polyethylene film, ¼" x ½", having a thickness of 0.003" was positioned between the bared leg wires with the long dimension parallel to the length of the wires and the portion of the wires between the plug and the match was twisted together about the insulation.

Each initiator was individually tested by applying a current of 10 amperes from a 220-volt, 60-cycle A.C. power line for a time period of 5 seconds. In each test, a rheostat was connected in series with the test cap to adjust the current initially to the calculated value.

	Prior Art Initiators	Example 1	Example 2	Example 3
Number tested	50	39	10	11
Initiators detonated percent	84	100	100	100
Initiators failed, percent	16	0	0	0
Sealing Plugs blown out of shell, percent	100	0	0	0

While the foregoing descriptive matter and examples have been relatively specific for the purpose of illustrating the novelty of the present invention, numerous modifications and alternative operations will be apparent and, therefore, are considered within the scope of this invention.

What is claimed is:

1. A delay electric initiator comprising a shell, an electric ignition element disposed within said shell, a pair of electrical conductors leading to said ignition element, said conductors being potentially engaged into a single low resistance electrical circuit but maintained out of such engagement by insulation having a dielectric strength of at least 200 volts, said insulation being located near said

ignition means in position to be exposed to and destroyed by heat generated by internal arcing occurring within said initiator.

2. A delay electric initiator comprising a shell, having one open end, a plug mounted in said open end, an ignition means disposed within said shell, below said plug a pair of conductive leg wires passing through said plug and leading to said ignition means, a layer of insulation which has a dielectric strength of at least 200 volts and is destructible by the heat from electrical arcing within the initiator, said insulation electrically separating said leg wires, at a point intermediate said plug and said ignition means, said insulation located near ignition means in a position to be exposed to and destroyed by heat generated by internal arcing occurring withing said initiator.

3. A delay electric explosion initiator comprising in combination, a shell, a pair of spaced leg wires terminating within said shell in an ignition means, a continuous conductive shunt electrically mounted between said spaced leg wires, and held apart from them by a layer of heat destructible insulation having a dielectric strength of at least 200 volts, said insulation located near said ignition means and in position to be exposed and destroyed by heat generated by internal arcing occurring within said initiator.

4. A delay electric explosion initiator as described in claim 3 wherein said insulating means is a coating of resin.

5. A delay electric explosion initiator as described in claim 3 wherein said insulating means is a layer of polyethylene.

6. A delay electric explosion initiator comprising in combination, a shell, a pair of leg wires terminating within said shell in an ignition means, at least one of said leg wires being twisted around the other, the twisted portions of said wire being located within the confines of said shell, said wires being separated by a thin layer of insulation having a dielectric strength of at least 200 volts, said insulation being heat-destructible by heat from electrical arcing within the initiator, when exposed to said heat for a period of from about 10 to about 200 milliseconds.

7. A delay electric explosion initiator as described in claim 6 wherein said insulating means is a coating of resin.

8. A delay electric explosion initiator as described in claim 6 wherein said insulating means is a layer of polyethylene.

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