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DELAY ELECTRIC EXPLOSION INITIATOR

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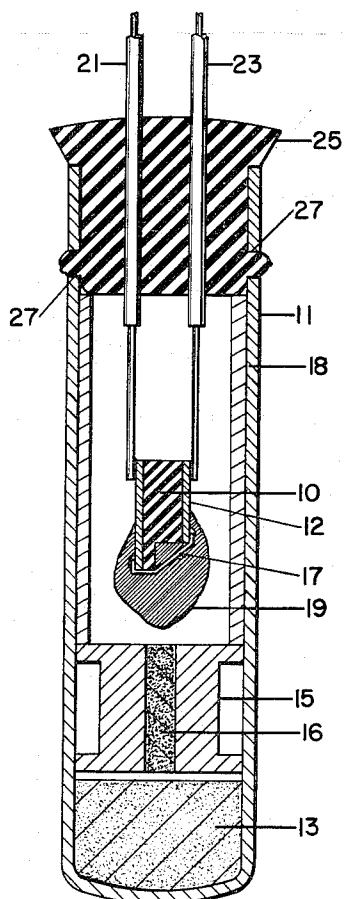


Fig. I.

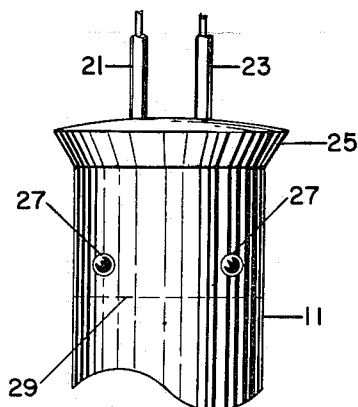


Fig. II

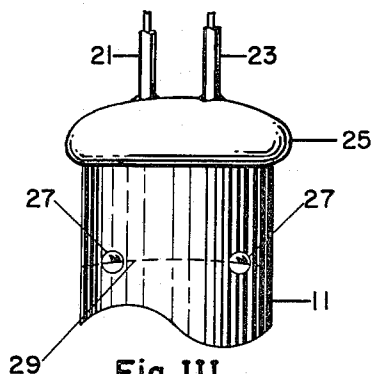


Fig. III.

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DELAY ELECTRIC EXPLOSION INITIATOR

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The usual ventless delay electric explosion initiator includes a metal shell having one open end, one closed end, and a plug of resilient material firmly fitting in the open end. Two leg wires pass through the plug. The ends of the leg wires within the shell portion are connected by a circuit that includes a short length of very fine bridge wire having a high electrical resistance. Upon application of sufficient electric current supplied through the leg wires the bridge wire is heated. In some delay electric explosion initiators the heated bridge wire ignites a heat sensitive powdered charge adjacent to the bridge wire, while in others the hot bridge wire ignites a match-head composition. In either case this ignition action is intermediate and in turn ignites the delay composition in a delay element fabricated to burn for a preset time interval and at the end of the interval to initiate a detonating charge located in the closed end 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 initiators, being simultaneously ignited and self-contained, are not generally affected by other successive blasts of the round.

It has been discovered that a malfunction of the usual ventless delay electric initiators can be caused by the occurrence of an electrical arc within the initiator which occurs when excessive electrical current is applied. The air and gases within the initiator are rapidly heated 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 shell or a violent dislodging of the initiator seal and the enclosed gases are rapidly released. The rapid release of the gases can snuff the burning delay fuse train and cause the shot to fail.

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 delay electric explosion initiator which will have a reduced susceptibility to malfunction if violent internal arcing occurs.

Since the introduction of electric initiators into the art, blasting operators have often been urged to utilize the strongest electric current available to supply an initiator arrangement in order to minimize the chance of dangerous misfires caused by current starvation. Utilization of the strongest current available has in some regions become almost a mining custom. The present trend in blasting practice is the utilization, whenever possible, of a power line source of electrical current to supply ar-

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rangements of electric initiators. When a power line source of current is used the initiators are often subjected to severe current overload conditions, and the number of malfunctions caused by internal arcing of the electric initiators greatly increases.

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, positioned above said delay element, has electrical wires leading therefrom and is adapted to be connected to a source of electrical current. A resilient or rubber-like sealing plug is compressed within the open end of the tubular metal shell. The tubular metal shell has one or more gas ports through the periphery of shell area which encloses the sealing plug. The gas ports are so positioned in the shell wall that they are sealed by the compressed sealing plug.

As explained before, upon application of large amounts of electrical energy to the initiator, the electrical energy causes an arcing within the initiator which results in a pressure build-up within the initiator in the manner previously described. The initiator of this invention minimizes the number of misfires due to arcing by a pressure release action. As the pressure within the initiator is built up behind the initiator plug, it causes the plug to move outward. As the plug moves outward the lower portion of the plug raises allowing the high internal pressure to bleed out through one or more ports in the shell wall. In this manner sudden pressure changes are avoided.

The invention will be better understood from the detailed description which follows and the accompanying drawings in which corresponding numbers represent corresponding parts throughout the various views. FIGURE I shows a longitudinal cross-sectional view of a delay electric initiator in accordance with an embodiment of this invention. FIGURES II and III are partial elevations of an initiator of this invention before and during operation.

Referring to FIGURE I: The initiator comprises a tubular metal shell 11, closed on one end and containing a detonating charge 13, in said closed end. A delay element comprised of delay tube 15 which contains a delay composition 16, preferably of the type which burns substantially without the evolution of gas is positioned immediately above said charge 13. An electric ignition element is comprised of conductive tabs 12 separated by insulation 10, the lower portion of conductive tabs 12 are electrically connected by a bridge wire 17 and the lower portion of tabs 12 including the bridge wire 17 are encased in match head 19. The electric ignition element is positioned immediately above the delay element and in ignitable position therewith. Match head 19 is positioned within match insulating tube 18 which is fabricated of a non-conductive material and extends from the bottom portion of the sealing plug 25 to the top of delay tube 15. Insulated leg wires 21 and 23 lead from said electric ignition element through the length of sealing plug 25 and are adapted to connect

with a source of electrical current. Sealing plug 25 is of a resilient or rubber-like material and is compressed within the open end of shell 11. Shell 11 has gas ports 27 therethrough located on a periphery of shell area being covered and sealed by the lower portion of the compressed sealing plug 25.

Referring now to FIGURES II and III, these figures show in greater detail the position of the sealing plug before and during a high pressure build-up within the detonator. FIGURE II demonstrates the sealing plug 25 in a normal position inserted in the open end of initiator shell 11 and tightly covering ports 27. Dashed line 29 represents the bottom of plug 25. FIGURE III demonstrates the initiator of FIGURE II undergoing a high internal pressure condition caused by the expanding hot gases within the initiator shell 11. The sealing plug 25 is shown in a thrust upward position caused by high internal pressure. The bottom of plug 25 represented by dashed line 29 has risen above the lower portion of ports 27 allowing a gentle and retarded escape of hot gases from initiator shell 11, and a corresponding reduction of pressure therein.

Delay electric explosion initiators, as commercially produced, customarily have gilding metal shells about 0.280" in outside diameter and about 0.260" in inside diameter. In one type of initiator in which the present invention has been employed the initiator shells were closed by rubber sealing plugs having a diameter of $\frac{5}{16}$ " and a length of $\frac{5}{16}$ ". After being compressed and inserted into the open end of the shells, these plugs had a length of approximately $\frac{7}{16}$ ". Suitable initiators of the invention have been made by providing such shells with one gas port $\frac{3}{32}$ " in diameter, the center of the gas port being located $\frac{1}{8}$ " from the bottom edge of the compressed sealing plug. However, said initiators may be made having shells of different materials as, for example, other metals or plastic substances and it will be evident that shells having other dimensional characteristics may be fabricated. In general, it may be said that for best results the total port area through the side of the shell should be between about 0.0004 and about 0.050 square inch. A total port area lower than this range does not usually provide adequate passage for escape of hot gases and larger total port areas may provide so much area that deleterious effects, such as materially weakening of the shell wall or effects equivalent to those produced by plug blow-outs may be observed. The shape of the ports employed, as well as their number, does not appear to be critical so long as an adequate area is provided. In a preferred form of the invention the ports are circular in shape. Such shape provides no sharp corners which may produce a condition which allows the metal to be easily torn. Ports in the shape of circles, triangles, rectangles and squares have been successfully used. Numbers of ports from 1 to 4 have been found suitable. It is preferred that when multiple ports are employed they should be spaced equidistant apart on the periphery of the initiator wall.

It is important that the ports providing the effects of the invention be covered and sealed by the rubber plug before initiation of the initiator. Otherwise, the shell will be unsealed and the advantages of the ventless initiator will not be obtained. On the other hand, the port should not be located so far above the bottom of the rubber plug that the plug is well started toward blowing out before the port is uncovered. In general, it was

found that the bottom of ports should be located not less than about $\frac{1}{16}$ " and not more than about $\frac{1}{4}$ " from the bottom of the plug. For example, using the $\frac{3}{32}$ " port, a satisfactory cap is produced by positioning the bottom of the port about $\frac{5}{64}$ " from the bottom of the plug as it is compressed in the shell.

What is claimed is:

1. A delay electric explosion initiator comprising a tubular shell having a side wall and an open end, a plug of resilient material positioned therein adjacent said side wall in a laterally compressed condition to seal said open end, said side wall having at least one gas port therethrough positioned so as to be sealed by a portion of said laterally compressed plug, located adjacent the side wall and opposite the portion of said plug nearest the open end of said shell, the said plug extending into said shell adjacent said shell wall to a point at least about $\frac{1}{16}$ inch beyond said gas port, the total gas port area in said side wall being between 0.0004 and 0.050 square inch.

2. A delay electric explosion initiator comprising a tubular shell having a side wall and an open end, a plug of resilient material positioned therein in a laterally compressed condition to seal said open end, said shell side wall having an approximately circular gas port $\frac{3}{32}$ inch in diameter therethrough, said laterally compressed plug extending into said shell along said side wall to seal said port and extend about $\frac{1}{8}$ inch beyond the center of said port.

3. A delay electric explosion initiator comprising a tubular shell having a side wall and an open end, a plug of resilient material inserted therein to seal said open end, said shell side wall having at least one approximately circular gas port therein, the total gas port area in said side wall being between about 0.0004 and about 0.050 inch in diameter, said plug extending into said shell along said side wall to seal said port and extend from about $\frac{1}{16}$ to about $\frac{1}{4}$ inch beyond said port.

4. A delay electric explosion initiator comprising a tubular shell having a side wall and an open end, said shell side wall having a gas port therethrough, said gas port spaced from said open end, and a plug of resilient material positioned in said shell of sufficient size to seal said open end and said gas port.

5. A delay electric explosion initiator comprising a tubular shell having a side wall and an open end, said shell having an inside diameter of about 0.26 inch, a plug of resilient material positioned therein in a laterally compressed condition to seal said open end and extending inward into said shell open end adjacent the said shell side wall for a distance of about $\frac{7}{16}$ inch, said shell side wall having at least one gas port therethrough positioned so as to be sealed by a portion of said laterally compressed plug located adjacent the said side wall and opposite the portion of said plug nearest the open end of said shell, the total gas port area in said side wall being between 0.0004 and 0.050 square inch.

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