May 19, 1959 P. J. BRYAN 2,887,054

BLASTING INITIATOR

Filed Jan. 13, 1956

FIG. 1

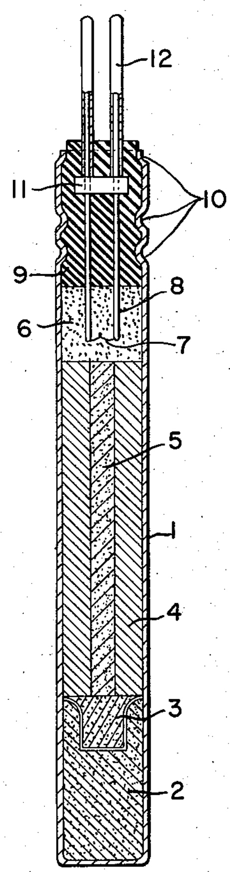


FIG. 2.

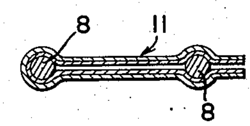


FIG. 3.

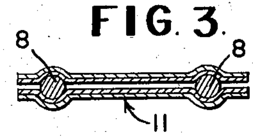
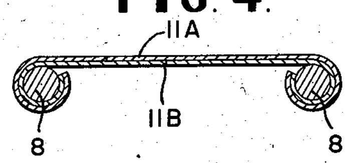


FIG. 4.



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2,887,054

BLASTING INITIATOR

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6 Claims. (Cl. 102—28)

This invention relates to delay electric blasting initiators having increased resistance to failure as the result of arcing during initiation.

Delay electric blasting initiators are used in quarrying, mining and construction operations to provide precision rotation firing of a plurality of explosive charges. Precision rotation firing affords improved fragmentation, reduced concussion and vibration, and greater efficiency per unit quantity of explosive. The delays between the various charges must be accurate in order to achieve the maximum effectiveness, and failures must be avoided.

The delay electric blasting initiators consist essentially of a detonating main charge, an ignition charge ignitable by a hot wire, and a delay element interposed between the main charge and the ignition charge. The charges and the delay element are retained in proper position within an elongated metal shell integrally closed at one end and sealed with a plug which also retains the electrical ignition means at the other end. The delay element usually consists of a thick-walled metal tube containing a column of a composition or mixture capable of self-sustained decomposition at a known and reproducible rate.

The early delay elements consisted of columns of deflagrating explosive compositions, notably black powder, and such delay elements are in use today. The deflagrating explosives are characterized by the production of considerable volumes of gas upon decomposition, so that provision must be made for venting these gases in order to avoid premature rupture of the shell or greatly accelerated burning rates of the composition due to the increasing pressures. Such venting is normally provided by perforating the shell in the area of the ignition charge and sealing the perforation with some readily rupturable material. The vented delay electric initiators are subject to desensitization of the ignition composition if they are immersed in water and subjected to a shock from an adjacent or nearby detonation before the delay element has been ignited. Further, a danger of igniting the explosive charge by the escaping gases before the desired delay has been obtained does exist.

For the foregoing reasons, considerable effort has been made to produce ventless delay electric initiators in which a delay composition producing little or no gas is used. While no compositions having the desired burning characteristics and completely free of gas production are known, a number of mixtures of an oxidizing agent and a metal fuel are known which burn at reproducible rates and which produce only small amounts of gaseous products. At the present time, most of the delay electric initiators used, particularly in the presence of water, are of the ventless type.

In many operations where machinery is powered by electricity, the operators prefer to use directly the same source of electrical energy to carry out their blasting operations, thus avoiding the need of additional equipment. The electrical energy available at these sites may

be either alternating current, up to 550 volts, or direct current, up to 250 volts. In other operations, the blasters wish to use portable sources of electrical energy such as batteries and blasting machines. Experience has shown that personnel using blasting initiators are unwilling to select initiators on the basis of the electrical characteristics of the power source they will use, and, therefore, the initiators must be designed to function at both low and high voltages.

At high voltages, i.e., 220 volts or more A.C. or 200 volts D.C., the bridge wire will be volatilized and an arc will form between the leg wires projecting below the plug, i.e., the bridge posts. This arc will continue until the leg wires have been burned back into the plug, and, in some cases, will continue for a distance into the plug. In the case of instantaneous initiators, the arc is of no consequence, because the detonation of the main charge occurs and the initiator is disintegrated. In the case of delay initiators, however, the consequences of such arcing can be very serious. The arc will frequently rupture the shell wall adjacent to the bridge posts, thus permitting the entrance of fluids into the shell. In the ventless type of delay initiator, the delay composition is usually loosely packed, and may be blown out by the sudden venting of the shell. Sudden release of pressure also will extinguish carriers that are packed to a high density. In the case of the vented or unvented shell, ignition of the delay charge may not occur before rupture. In either type, the delay period is adversely affected by the undesired venting of the shell.

Accordingly, an object of the present invention is to provide a delay initiator not subject to failure due to arcing. A further object is to provide such initiator wherein the means for eliminating arcing failure is low in cost and simple to install. Further objects will become apparent as this invention is more fully described.

I have found that the foregoing objects are attained when I provide a shunt across the leg wires so located that no damage to the delay portion of the initiator will result from the heat generated at the shunt, the shunt being so designed as to provide considerable resistance at low voltages and only negligible resistance at high voltages. I have found that the preferred location for the shunt is within the sealing plug. By placing the shunt within the sealing plug, the possibility of accidental dislocation or damage to the shunt is minimized. Further, break-through of the shell wall because of arcing at the shunt is less likely because of the insulating effect of the sealing plug. Finally, even if a rupture of the shell wall is produced, the working portions of the delay initiator continue to remain enclosed. As the shunt having high resistance at low voltages and low resistance at high voltages, I prefer to use a two layer strip, one layer consisting of metal and the adjacent layer consisting of a fusible resistive film, the thickness and width of film being such as to provide a resistance of from 25–250 ohms. By positioning the thus designed shunt with the resistive film layer in contact with the leg wires of the initiator, the desired shunting action is achieved. When a low voltage is applied, as, for example, in firing the initiator by means of a blasting machine or battery, the resistance of at least 25 ohms at the shunt insures that the current diverted from the bridge wire will not affect ignition—a shunt having a resistance of 25 ohms requires an increase of only 0.02 ampere in the firing current, a negligible value. When a high voltage is applied, for example 220 or 440 volts A.C., the fusible resistive film will be burned or melted away almost instantly, so that the natural pressure of the sealing plug material will force the metal layer in contact with the leg wires, providing a short-circuit having negligible resistance. During the period required for the resistive film to be fused, the bridge wire will be energized to initiate the ignition composition. After the fusing of the resistive film, essentially all of the electrical energy will be shunted across the leg wires within the sealing plug, thus preventing arcing at the bridge posts.

In order to more fully illustrate my invention, reference is now made to the accompanying drawings, in which—

Figure 1 represents an assembled delay electric initiator in accordance with this invention;

Figures 2 and 3 represent alternative shunt applications; and

Figure 4 represents a greatly enlarged view of the shunt of this invention.

Referring now to the figures in detail, **1** is a tubular metal shell, for example of aluminum or gilding metal, **2** is a base charge, for example of PETN or RDX, **3** is a primer charge, for example lead azide or a fulminate, **4** is a delay element tube, for example, of lead, **5** is an essentially gasless delay composition such as a barium peroxide-selenium mixture or a boron-red lead mixture, **6** is an ignition composition such as boron-red lead or a loose mixture of bismuth, selenium and potassium chlorate, **7** is a resistance bridge wire, **8** are the leg wires, **9** is a sealing plug, for example of natural or a synthetic rubber, **10** are peripheral crimps in the shell wall, **11** is the shunt of the present invention having a metal layer **11A**, and a fusible resistive film layer **11B**, and **12** is insulation about the leg wires **8**.

As shown in Figures 2, 3, and 4, the shunt may be applied in a number of ways. In Figure 2, the shunt was folded about the wires to form a double span in which the resistive film layer is on the inside. In Figure 3, a double span is provided by using two shunts parallel to each other. In Figure 4, a single span is illustrated. I have found that the arrangement illustrated in Figure 2 is preferable when the sealing plug is formed about the leg wires while that illustrated in Figure 3 is preferable when performed plug halves are assembled to form the sealing plug. The arrangement illustrated in Figure 4, while operative, is disadvantageous because dislocation of the shunt during assembly is more likely and the shunt must be greater in width in order to provide the current-carrying capacity required.

With the construction described, a delay electric initiator is provided which is not altered in performance by application of high voltage energy because of arcing. To illustrate the improvement obtained with the present invention and the critical features thereof, reference is now made to the following tables.

In Table I, delay initiators identical in every respect except for the presence of the shunt of the present invention are compared. The tests were made by connecting 10 initiators in parallel and applying 440 volts A.C. to the circuit.

Table I

Shunt Present	Number of Initiators Tested	Number Detonated	Number Failed	No. having shells ruptured by arcing
Yes [1]	30	30	0	0
No	20	10	10	17

[1] Double-span shunt ⅛ in. wide consisting of 0.004 in. resistive film of a conductive rubber vulcanized on 0.002 in. shim brass—average resistance, 30–100 ohms, as measured on sample ignition assemblies.

The improvement provided by the presence of shunt is obvious. The seven non-shunted initiators which detonated despite ruptured shells would not necessarily have been satisfactory if subjected to water pressure or with respect to delay time; thus, only 3 out of 20 non-shunted initiators gave completely satisfactory performance as compared to 30 out of 30 of the shunted initiators.

Table II illustrates the use of different metals for the metal layer of the shunt. The tests were conducted as described for Table I.

Table II

Metal Layer	Number of Initiators Tested	Number Detonated	Number having shell rupture by arcing
Brass	160	160	0
Nichrome	10	10	0
Steel	20	20	0

Tests also were made using copper and aluminum with satisfactory results. Shim brass was selected for most experiments because of its availability and ease of handling.

Table III illustrates the criticality of providing sufficient cross-sectional area in the metal layer to carry the current. The tests were made as described for Table I, using a double-span shunt of a resistive film of conductive vinyl resin cemented on shim brass.

Table III

Cross-sectional area of metal in shunt (Total)	Number of Initiators Tested	Number Detonated	Number Failed	Shells Ruptured By Arcing
320 circular mils	110	95	15	45
640 circular mils	60	60	0	0
960 circular mils	160	160		0

Table IV illustrates the use of different resistive films in the shunt. The conductive rubber film, a standard commercial product consisting of carbon particles in a rubber matrix and having a resistance of 3 ohms-sq. cm., was vulcanized to shim brass. The conductive vinyl resin film, also a standard commercial product consisting of carbon particles in a vinyl resin matrix and having a resistance of 1 ohm-sq. cm., was cemented to shim brass with a rubber cement. The tests were performed as described for Table I.

Table IV

Type of Resistive Film	Number of Initiators Tested	Number Detonated	Number of Shells Ruptured By Arcing
Conductive rubber	30	30	0
Conductive vinyl resin	160	160	0

Table V illustrates the effect of the resistance of the resistive film on the performance of the shunt of this invention. The shunts were prepared by vulcanizing conductive rubber film of different thickness onto shim brass, and a double-span shunt was used in each case. The resistance was determined by measurement of several sample ignition assemblies in which the bridge wire was omitted. The tests were made as described for Table I.

Table V

Resistance of Shunt	Number of Initiators Tested	Number Detonated	Number of Shells Ruptured by Arcing
30–80 ohms	60	60	0
100 ohms	20	20	0
60–200 ohms	40	40	0
1,000 ohms	30	28	7

Summarizing the findings illustrated in the tables, the shunt of the present invention consists of (1) a metal layer in which the cross-sectional area is adequate to carry the current long enough to prevent arcing at the bridge posts, (2) a fusible resistive film layer of such dimension that the resistance of the shunt is less than 1000 ohms. The choice of metal or of fusible resistive film is not critical when the above requirements are met. As previously indicated, the resistance of the shunt must be at least 25 ohms to insure an adequate bridge wire current from low energy sources. Preferably, the resistance of the shunt will be between about 25 ohms and about 250 ohms.

Inasmuch as brass is representative of metals generally, the total cross-sectional area of the metal should be at least 500 circular mils (250 mils for each span when a double-span is used). The maximum cross-sectional area is limited only by the space available in the initiator.

The fusible resistive film is preferably laminated or cemented to the metal layer for ease of assembly. As previously indicated, it is the resistance of the shunt assembly and not of the film itself which is critical. Thus the selection of the film thickness will depend upon the width of the shunt and the amount of cement, if any, between the film and the metal layer.

The invention has been fully described in the foregoing, and many variations and modifications will be apparent to those skilled in the art. Accordingly, I intend to be limited only by the following claims.

I claim:

1. In an electric delay blasting initiator of the type wherein the leg wires of the electric ignition system pass through a sealing plug of con-conductive material closing the open end of the metal shell, the improvement comprising a two-layer shunt entirely within said sealing plug and spanning said leg wires, said shunt having a metal layer and a layer of a resistive fusible film and being so positioned that only the layer of resistive film is in contact with a bared portion of each leg wire.

2. A delay electric initiator as claimed in claim 1 wherein said shunt encircles said leg wires.

3. A delay electric initiator as claimed in claim 1 wherein the resistance of the intact shunt is between 25 and 250 ohms.

4. A delay electric initiator as claimed in claim 1 wherein the resistive film layer consists of conductive rubber.

5. A delay electric initiator as claimed in claim 1 wherein the resistive film layer consists of a conductive vinyl resin.

6. A delay electric initiator as claimed in claim 1 wherein the metal layer has a cross-sectional area of at least 500 circular mils.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,887,054

May 19, 1959

Paul J. Bryan

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 30, Table III, under the heading "Number Failed", opposite "960 circular mils" insert -- 0 --; column 5, line 28, for "conductive" read -- non-conductive --.

Signed and sealed this 8th day of December 1959.

(SEAL)
Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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