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ELECTRIC INITIATOR

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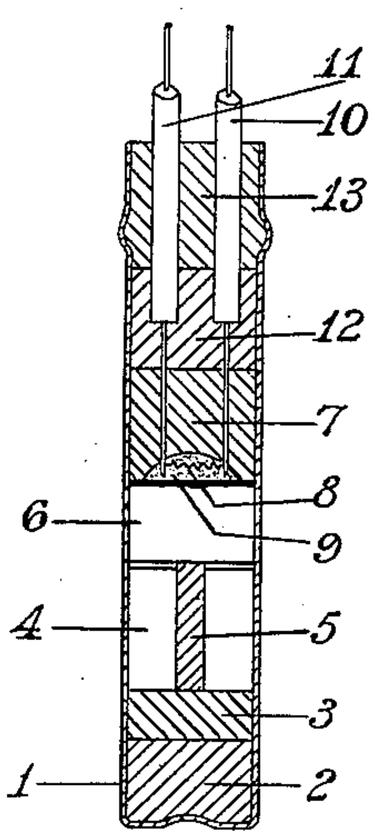


Fig. 1

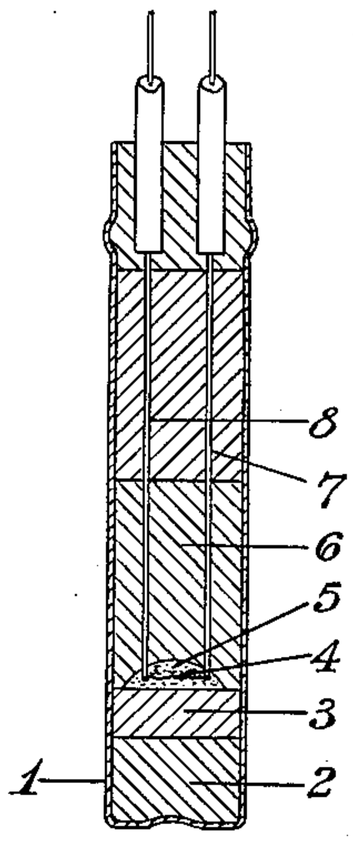


Fig. 2

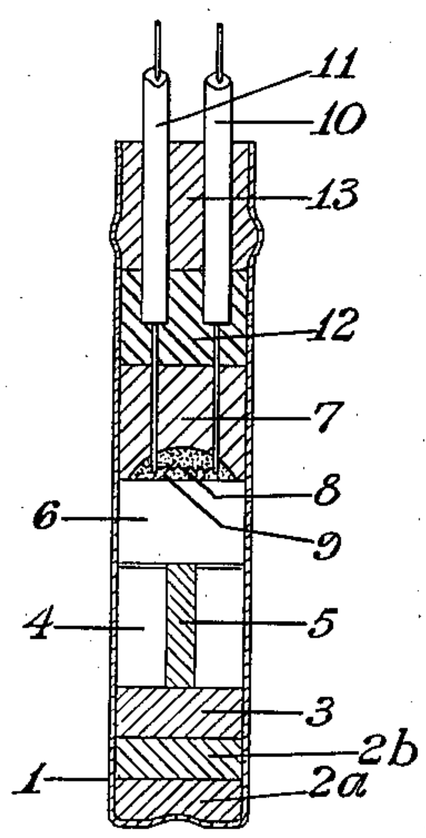


Fig. 3

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## ELECTRIC INITIATOR

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The present invention relates to a new and improved electric initiator, and more particularly to a new type of electric squib.

Electric squibs are useful in igniting deflagrating explosive compositions, black powder for example, where the nature of the explosive is such that it is desirable to bring about initiation by means of a flame, as distinguished from dynamites and other high explosives which are initiated by the sudden detonation of an explosive material of the type contained in blasting caps. The use of electric current for firing the squibs displays obvious advantages over the older fuse methods.

The electric squibs known to the art generally consist of an ignition charge, enclosed in a shell or tube of metal or other suitable material, and an electrical firing element. The latter is desirably formed by passing two leading wires through a mass of insulating material, which closes the end of the shell, and joining the ends of these wires within the shell. This connection of the ends of the leading wires is effected by means of a highly-resistant wire of such diameter that it is heated to incandescence when the electric current is passed through it. This fine connecting, or bridge, wire is surrounded by, embedded in, or cemented to the ignition charge so that passage of the current through the wire causes the charge to deflagrate. When the squib is thus fired, the flame plays upon the material to be ignited.

A special form of squib is the delay electric squib which is constructed in substantially the same way as the ordinary electric squib, with the difference that, in the delay squib, the firing element is separated from the ignition charge within the shell by a tube or carrier charged with a column of material having a uniform rate of combustion, which column serves as a time or delay element.

In the squibs known to the art, it is common to have the lower end of the shell either open or perforated in some way, to permit the escape of the flame on ignition. Sometimes a stopper is provided for this venthole, to be removed just prior to use. With or without such stopper, however, such squibs have been found to be very susceptible to the effects of moisture to which they may be exposed in storage or at any time prior to use, and thus may have been rendered entirely worthless, or at least less efficient, for the purpose for which they were intended. The situation is particularly serious in the case of delay squibs, in view of the fact that the admission of moisture through a vent may cause the delay column to be damped out, or to burn non-uniformly, thus rendering a whole round of shots unsatisfactory due to deviation from the calculated delay periods of one or more of the squibs in the group.

Many attempts have been made to remedy this imperfection. With this object in view, the ventless type of squib originated. In this type, the shell is closed; that is, no vent is provided for the flame. In order that the squib may function properly, the flame must be allowed to escape. If there is no vent in the shell, some other means of outlet must be furnished. In the art this has been attempted in several ways, none of which furnishes a squib without imperfection. In one type of ventless squib, the shell is provided with weakened portions of the wall in the region containing the charge to insure the rupture of the shell at such points on ignition. This has been effected in several ways. For example, weakening scores, furrows, or scratches have been made in the shell walls, or the shell itself has been drawn thin enough to permit such rupture, or crimps have been provided in the upper region to insure bursting in the lower region of the shell.

Other inventors, instead of weakening the shell to aid its rupture, have increased the disruptive power of the charge employed, to the extent that it will rupture the shell by the pressure which it produces in burning. As examples of closed shell squibs may be cited the products of Rolland (U. S. Patent 1,856,431) and of Lewis and Woodbury (U. S. Patent 1,964,826).

Although the inventors of the art have developed electric squibs impervious to moisture penetration, they have not produced an altogether satisfactory squib, for, in overcoming the moisture penetration difficulty, they have introduced other disadvantages. Weakening the shell by scoring requires additional operations which rob the art of simplicity and efficiency. Yet, if the shell is weakened by drawing it thin enough to rupture without violence, difficulties arise in the manufacture of delay squibs, inasmuch as the longer the period of delay required, the greater is the length of the shell required for a given delay composition. Unfortunately, it is practically impossible to draw shells long enough for the squibs of the higher delay periods, and thin enough to be ruptured without violence by a simple ignition charge, when the metal used is of the nature best adapted to shell manufacture.

On the other hand, if the charge is adapted to insure bursting of the unweakened shell by pressure, the squib presents, when handled, a hazard

approaching that of a blasting cap. This property renders the squib less desirable for handling in production and in the field. For example, in spite of the exercise of a high degree of caution in coal mining, it is possible that a squib may misfire and remain in the coal. Under such conditions, the closed shell squibs of the prior art present an undesirable hazard.

The object of the present invention is a new and improved electric squib. A further object is an improved squib of this nature which offers particular advantages when controlled delay intervals are desirable. Additional objects will be apparent from the general description of the invention which follows.

The invention described herein is concerned with a completely moisture-proof electric squib of the closed shell or ventless type, which is nevertheless as safe to handle as the vented types, and in addition produces sufficient heat to ignite not only moist powder but even powder pellets that have been soaked in water. This squib is constructed without scratching or otherwise weakening the shell. Any metal may be used for the shell which is suitable for the manufacture of initiators generally. These advances over the squibs of the art are accomplished by selecting a base charge which will melt a vent in the base of the shell to let the flame escape, instead of a base charge designed to burst the shell by generating pressure therein.

In order to disclose the nature of our invention more clearly, reference is made to the accompanying drawing, wherein Figure 1 is a sectional elevation of a delay electric blasting squib, Figure 2 is a similar view of an "instantaneous" blasting squib, while Figure 3 is a similar view of another form of delay electric blasting squib in accordance with our invention. Corresponding numbers are used to refer to corresponding parts in the various views.

The present invention is embodied in the ventless delay electric squib of the type shown in Figure 1, which consists essentially of a ventless metal shell 1, a base charge 2, an ignition charge 3, a delay composition 5 in an element 4, and an electric ignition means 6, 7, 8, 9, and 10. The base charge 2 is located in the shell, as shown. In order to soften the shell as described, the base charge is composed of a material capable of generating intense heat. For this purpose, a composition is used which contains a metal having a high heat of combustion, preferably in a finely divided state, and a strong oxidizing agent. We prefer to use for this purpose a mixture of finely divided metallic magnesium and barium peroxide.

The ignition charge 3 is shown in firing relation to the base charge. This ignition charge must be capable of generating heat sufficient to ignite the base charge, and must, itself, be susceptible to ignition by the delay composition 5. These qualities necessitate an ignition mixture differing widely from those common to the art. For this purpose, we prefer to use an ignition charge containing a mixture of barium peroxide, selenium, and nitrostarch. In firing relation with the ignition charge and above said charge is placed the delay element, comprising the metal carrier 4, which contains the delay composition 5, preferably of the type which burns substantially without the evolution of gas. The delay element is, in turn, in firing relation with the electrical ignition means above it through a chamber 6 to permit the expansion and cooling of the gases.

The electrical ignition means comprises the concave plug 7, in the concavity of which is fixed the bridge wire 8, around which is packed the charge of powder 9. The leading wires 10 and 11 complete the firing circuit, forming contacts with the opposite ends of the bridge wire and passing upward through the waterproofing layer 12 and the sulfur seal 13.

The essence of the invention may be embodied with equal facility in the ventless electric squib of the type shown in Figure 2, which differs from that of Figure 1 in the omission of the delay element, with the result that the ignition charge 3 is in direct firing relation with the electrical ignition means 4 to 8.

It is to be understood that the above description with reference to the drawing is used to represent preferred embodiments of the invention by way of illustration only, and is not to be regarded as a limitation upon the scope of our invention.

The following examples serve further to illustrate and explain the invention by disclosing the exact proportions of the components of the preferred mixtures which may constitute the several charges, and in addition disclose equivalent charge compositions, all of which serve to furnish detail sufficient to enable the artisan to practice this invention.

### *Example 1*

The ventless delay electric squib is of the type shown in Figure 1, as described heretofore, in which the various charges are of the following compositions and amounts:

*Base charge.*—9 grains of a mixture containing 87.5% barium peroxide and 12.5% metallic magnesium.

*Ignition charge.*—3 grains of a grained mixture containing 78% barium peroxide, 19% selenium, and 3% nitrostarch.

*Delay powder.*—85% barium peroxide, 15% selenium.

*Concave plug powder.*—51% mercury fulminate, 23% potassium chlorate, 9% nitrostarch, and 17% charcoal.

Although the above charges are most desirable, we may vary the proportions and amounts at will. However, we prefer to stay within the following limits:

*Base charge.*—5 to 20 grains of a mixture of 80 to 90% barium peroxide, and 10 to 20% magnesium.

*Ignition charge.*—1 to 10 grains of a mixture of 60 to 80% barium peroxide, 10 to 30% selenium, and 1 to 10% nitrostarch.

*Delay powder.*—Mixture of 70 to 90% barium peroxide and 10 to 30% selenium.

### *Example 2*

The ventless electric squib, of the type shown in Figure 2, is substantially the same as that of Figure 1, described in the foregoing, but differs in that no delay element is employed, so that the ignition charge is in direct firing relation with the electric ignition means. This squib is charged as follows:

*Base charge.*—10 grains of a grained mixture containing 75% cupric oxide and 25% metallic magnesium.

*Ignition charge.*—3.5 grains of a mixture containing 92% barium peroxide and 8% nitrostarch.

*Concave plug powder.*—38.5% mercury fulminate, 38.5% potassium chlorate, 15.3% nitrostarch, and 7.7% charcoal.

*Example 3*

The ventless delay electric squib is of the type shown in Figure 3, substantially the same as that of Figure 1, but differing in that two base charges, 2*a* and 2*b*, are employed, giving a squib which generates a heat so intense that the shell is vented even under ice water. The charges of this squib are of the following compositions and amounts:

*Lower base charge* (2*a*).—4 grains of a grained mixture containing 88% barium peroxide and 12% metallic aluminum.

*Upper base charge* (2*b*).—4 grains of a grained mixture containing 93% barium peroxide and 7% metallic aluminum.

*Ignition charge.*—2.5 grains of a grained mixture containing 78% barium peroxide, 19% selenium, and 3% nitrocotton.

*Delay powder.*—85% barium peroxide, 15% selenium, and an insignificant amount of an inert material.

*Concave plug powder.*—51% mercury fulminate, 23% potassium chlorate, 9% nitrostarch, and 17% charcoal.

Although we prefer to employ the charges used in the examples, it is to be understood that we are not to be limited to the ingredients, amounts, or proportions disclosed therein. Indeed, these factors may all be varied depending upon the strength of the squib desired, and equivalents may be employed where convenient. For instance, we have discovered that suitable base charges may be made from mixtures of either metallic magnesium, metallic aluminum, or alloys of both these metals, with cupric oxide, barium peroxide, cuprous oxide, lead dioxide, calcium peroxide, minium, or suitable mixtures of two or more of the aforesaid. In general, suitable reagents for use in these mixtures containing magnesium or aluminum comprise the oxides of all the metals from zinc through mercury in the electromotive series, namely, zinc, chromium, cadmium, iron, cobalt, nickel, tin, lead, copper, arsenic, bismuth, antimony, or mercury. Other suitable reagents are the permanganates, perchlorates, perborates, persulfites, peroxides, chlorates, bromates, and iodates.

Although our base charge is preferably composed of a metal and an oxidizing agent as described above, any substance will be suitable which will react with such a metal to bring about incandescence. Magnesium and aluminum, for example, react in such a manner with the cyanides, phosphates, carbonates, sulfates, and similar compounds.

Suitable ignition agents are mixtures of barium peroxide and selenium with either black powder, ground smokeless powder, or Turnbull's Blue; or black powder, pyro, and nitrostarch may be used alone as ignition agents. Any suitable oxidizing agent may be used to replace the barium peroxide. Another ignition agent comprises zirconium and an oxidizing agent, preferably barium peroxide.

As mentioned heretofore, an important advantage of our invention over the art lies in the intense and prolonged heating produced by the squibs of our invention. The importance of this feature may be illustrated by the following example.

*Example 4*

Pellets of black powder were soaked under water for varying lengths of time. They were then removed and ignition was attempted with various types of squibs. In this way, a standard squib of the art was compared with our squib of Example 1 and Figure 1. In this pellet test, the standard squib of the art failed to produce consistent ignitions of powder pellets which had been submerged for a period of one minute. On the other hand, our improved squib gave consistent ignition of the powder pellets even after they had been submerged for a period of 10 minutes.

In addition to this excellent performance of the improved squibs, when fired deliberately, they have proved extremely safe to handle in production and in the field, even failing to fire under rough handling such as slamming against concrete or iron surfaces. This feature is illustrated further by the fact that the squibs of Examples 1, 2, and 3 consistently failed to fire when a ten pound weight was dropped upon them from a height of 3 feet so as to strike them in the region of their ignition and base charges. Safety in manufacture is enhanced by the fact that the materials for these charges do not even display a violent burning quality. For instance, one-half pound of the ignition material of Example 1 was closed in a cardboard box and ignited by a fuse. In the process of combustion, the cover of the box was not even blown off and very little smoke was evolved.

In summary, the outstanding advantages of the ventless electric and ventless delay electric squibs of the present invention are resistance to moisture, safety, simplicity of manufacture, and capacity to generate intense heat.

In the foregoing embodiments of our invention, it is apparent that many variations in detail may be made without departing from the spirit or the scope thereof. Thus it is possible to change the composition of the shell, the closure means, the firing means, the delay column, or any such structural detail in any of the examples given, without circumventing the scope of this invention. Other changes in detail and other mechanical, electrical, or chemical equivalents of the means shown will be apparent to those skilled in the art. We therefore intend to be limited only in accordance with the following patent claims.

1. A non-violent, ventless electric blasting squib comprising a ventless, rigid shell, a base charge capable of generating sufficient heat to fuse a vent in said shell, a juxtaposed charge capable of igniting said base charge, and means for electrically firing said juxtaposed charge, both of said charges being incapable, upon combustion, of generating sufficient gas pressure within said shell either to burst said shell or to forcibly eject said base charge in an ignited condition through a fused vent in said shell.

2. A non-violent, ventless delay electric blasting squib comprising a ventless, rigid metal shell, a base charge capable of generating sufficient heat to fuse a vent in said shell, a juxtaposed charge capable of igniting said base charge, a delay element capable of igniting said juxtaposed charge, and means for igniting said delay element, both of said charges and the delay element being incapable, upon combustion, of developing sufficient gas pressure within said shell either to burst said shell or to forcibly eject said base charge in an ignited condition through a fused vent in said shell.

3. The delay electric squib of claim 2 in which the base charge comprises at least one metal having a high heat of combustion and in finely divided form, and an oxidizing agent.

4. The delay electric squib of claim 2 in which the base charge comprises at least one metal having a high heat of combustion and in finely divided form, and a substance capable of reacting with said metal with incandescence.

5. The delay electric squib of claim 2 in which the base charge comprises metallic magnesium and barium peroxide.

6. The delay electric squib of claim 2 in which the juxtaposed ignition charge comprises an oxidizing agent, a fuel which generates substantially no gas on combustion, and a readily-ignitible fuel.

7. The delay electric squib of claim 2 in which the juxtaposed ignition charge comprises barium peroxide, selenium, and nitrostarch.

8. The delay electric squib of claim 2 in which the juxtaposed ignition charge comprises an oxidizing agent and a readily-ignitible fuel.

9. The delay electric squib of claim 2 in which the juxtaposed ignition charge comprises barium peroxide and comminuted smokeless powder.

10. A non-violent, ventless delay electric blasting squib including a ventless, rigid metallic shell, a base charge comprising barium peroxide and finely divided magnesium, a juxtaposed charge capable of igniting said base charge and comprising barium peroxide, selenium, and nitrostarch, a delay element capable of igniting said juxtaposed charge and comprising barium peroxide and selenium, and means for electrically igniting said delay element, the charges within said shell being incapable, upon combustion, of generating sufficient gas pressure within said shell either to burst said shell or to forcibly eject said base charge in a molten condition through a fused vent in said shell.

11. The delay electric squib of claim 10 in which the base charge comprises 80 to 90% barium peroxide and 10 to 20% metallic magnesium in finely divided form.

12. The delay electric squib of claim 10 in which the superposed ignition charge comprises 1 to 10 grains of a composition composed of 60 to 80% barium peroxide, 10 to 30% selenium, and 1 to 10% nitrostarch.

13. The delay electric squib of claim 10 in which the charge contained in the delay element comprises 80 to 90% barium peroxide and 10 to 30% selenium.

14. A non-violent, ventless electric blasting squib comprising a ventless, rigid shell, a base charge capable of generating sufficient heat to fuse a vent in said shell, a juxtaposed charge capable of igniting said base charge, and means for electrically firing said juxtaposed charge, both of said charges being incapable, upon combustion, of generating sufficient gas pressure within said shell to burst said shell.

15. A non-violent, ventless delay electric blasting squib comprising a ventless, rigid metal shell, a base charge capable of generating sufficient heat to fuse a vent in said shell, a juxtaposed charge capable of igniting said base charge, a delay element capable of igniting said juxtaposed charge, and means for igniting said delay element, both of said charges and the delay element being incapable, upon combustion, of developing sufficient gas pressure within said shell to burst said shell.

16. A non-violent, ventless delay electric blasting squib including a ventless, rigid metallic shell, a base charge comprising barium peroxide and finely divided magnesium, a juxtaposed charge capable of igniting said base charge and comprising barium peroxide, selenium, and nitrostarch, a delay element capable of igniting said juxtaposed charge and comprising barium peroxide and selenium, and means for electrically igniting said delay element, the charges within said shell being incapable, upon combustion, of generating sufficient gas pressure within said shell to burst said shell.

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