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ELECTRIC BLASTING INITIATOR

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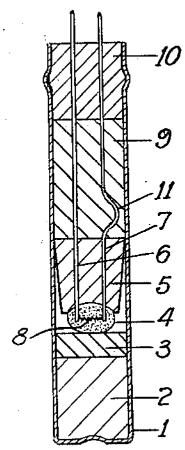

FIG.1

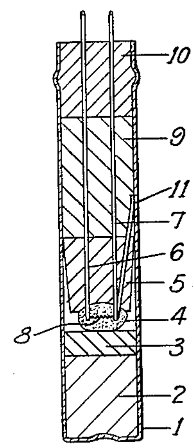

FIG.2

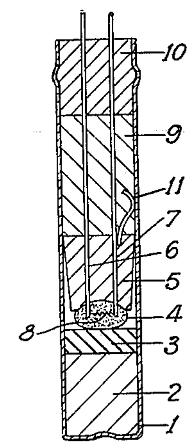

FIG.3

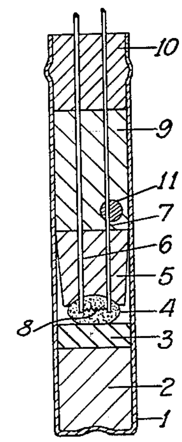

FIG.4

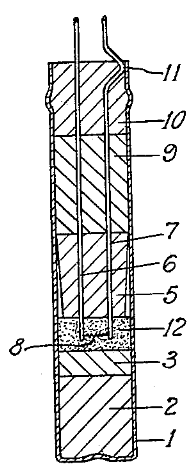

FIG.5

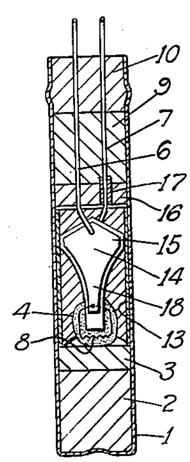

FIG.6

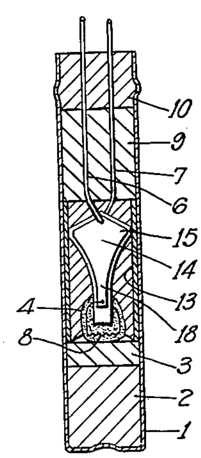

FIG.7

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ELECTRIC BLASTING INITIATOR

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Application October 30, 1935, Serial No. 47,385

25 Claims. (Cl. 102—10)

The present invention relates to electric blasting initiators generally, and more particularly to electric blasting caps without appreciable time lag and substantially free from susceptibility to static electricity.

Electric blasting caps consist essentially of a cylindrical metal shell containing a detonating base charge, an ignition composition, and an electrical firing means in contact with, or embedded in, the ignition composition. The firing means employed almost without exception in this country comprises a high resistance electric wire between the two leg wires of the firing circuit. When the current is applied to the firing circuit, the high resistance or bridge wire is heated to incandescence, thereby firing the ignition composition, which in turn initiates the detonating base charge.

Electric blasting caps are usually classified by those skilled in the art into three general types, depending on certain structural characteristics of the firing means. One of these is known as the "bridge plug type" and contains a plug of insulating material, usually in the shape of a truncated cone, which holds the leg wires of the firing circuit in fixed space relationship. The leg wires, extending somewhat beyond the substantially flat surface or base of the plug, are connected by a high resistance bridge wire which is embedded in an ignition composition.

A second type of electric blasting cap is known as the "concave plug type." In this type, the bridge wires are also held in fixed space relationship by a conical-shaped plug of insulating material. In this case, however, the smaller base of the concave plug is provided with a rather shallow concavity. The ends of the leg wires, and the bridge wire connecting the two, are disposed within this cavity, which serves mechanically to protect the bridge wire from rupture. The ignition composition employed for this type of blasting cap is generally applied in a plastic condition and dries to form a hard "cemented" composition in this depression.

The third type of electric blasting cap is known as the "match-head type", and consists generally of a flat strip of insulating material, the two faces of which are covered with metallic foil. A bridge wire passing around the end of the strip connects the two separated pieces of foil, which are soldered to the respective leg wires. The bridge wire is usually dipped in a plastic ignition composition which dries to form a tear-drop shaped pellet similar in appearance to an ordinary match-head.

All the above types of electric blasting caps may be conveniently further classified into relatively "fast" and relatively "slow" caps on the basis of the time required for the cap to detonate after the firing current has been applied. Such a classification is made to distinguish between electric blasting caps which are suitable for ordinary blasting operations, and those which are adaptable to certain rather special uses, as for example, in seismographic exploration for mineral or other deposits, where a fast cap is highly desirable. Heretofore, however, this distinction between "fast" and "slow" caps has been rather qualitative in nature, since all the available electric blasting caps possessed an inherent, measurable, and significant time lag or interval between the instant the firing current was applied and the instant the blasting caps detonated.

The time lag above referred to is the overall lag resulting from two separate factors, the first of which is the interval of time between the application of the firing current and the breaking or fusion of the high resistance bridge wire. This interval, which we may term the "bridge wire lag", is generally dependent upon the firing current used, since the bridge wire will fuse in a shorter time at a higher amperage than it will at lower amperage. For many practical purposes, however, the "bridge wire lag" is not significant, since in seismographic explorations and other types of work requiring a fast cap, the instant the bridge wire breaks or fuses is conveniently assumed to be the instant of detonation.

A far more serious factor affecting the overall time lag, and one which is of great significance in the special uses above referred to, is the interval of time between the breaking of the bridge wire and the actual detonation of the cap. This lag, which we shall hereinafter refer to as the "induction period", depends to a certain extent on the firing circuit used. Thus at high amperages, for example 20 amps., the "bridge wire lag" for a given ignition composition will be shorter, as above mentioned, and consequently the "induction period" will usually be longer than at lower amperages, for example 5 amps. At a given amperage, however, the "induction period" is a definite characteristic property of the ignition composition employed. Thus certain materials have an inherently long "induction period", whereas in others this period is not measurable.

Although a number of materials of the latter type are available, the use of these "fast" ignition agents has heretofore involved considerable danger from the point of view of static electricity, for it has been found that ignition compounds which have a negligible or immeasurable "induction period" are very susceptible to static electricity; that is to say, electrostatic charges of low voltage, which are well within the range of that which may be accumulated by a man of ordinary electrical capacity, are capable of igniting these "fast" ignition compounds and thereby initiating the blasting cap. While in general it appears that all ignition compositions can be fired by an electrostatic discharge, this susceptibility to static electricity increases very rapidly as the "induction period" approaches zero.

Heretofore, this close relationship between electrostatic susceptibility and speed of ignition of a given compound has not been recognized. On the contrary, the fact that materials such as copper acetylide, and the like, were not only "fast" but also susceptible to static electricity was regarded as a mere coincidence. Much time and effort was therefore expended in attempting to discover other "fast" ignition agents which did not possess this undesirable susceptibility. It is now abundantly clear, however, that the two properties may be expected to occur together. These rapid ignition compounds cannot, therefore, be employed safely in electric blasting caps unless the susceptibility of the finished blasting cap to static is substantially reduced or eliminated by means which are certain in effect and sufficiently rugged in construction to withstand mechanical handling in the field.

The object of the present invention is a new and improved electric blasting cap which is substantially free from susceptibility to electrostatic charges. A further object is an electric blasting cap without an appreciable "induction period", and substantially free from susceptibility to static electricity. A still further object is a blasting cap of the character described, the electrostatic susceptibility of which is substantially eliminated by means which are certain in effect and sufficiently rugged in construction to withstand mechanical handling in the field. Other objects will be apparent as the invention is hereinafter more fully described.

We have found that these objects may be accomplished by providing the firing circuit of an electric blasting initiator, having an electrostatic-susceptible ignition composition, with a means whereby the susceptibility of the initiator to static electricity is substantially eliminated or reduced. The invention further comprises an electric blasting cap, the firing circuit of which is provided with a means whereby static electricity is caused to pass harmlessly to the shell wall at a point outside the locus of the static-susceptible ignition composition. The invention is equally applicable to all types of electric blasting initiators whether of the bridge plug, the concave plug, or the match-head types.

The means above referred to may be formed by two general types of procedure. In the first place, the static electricity may be caused to pass to the shell wall by forming (A) an actual, physical, electrical-conducting contact between the shell wall and one of the leg wires at a point outside the locus of the ignition composition. In the second place, the static electricity may be caused to pass to the shell wall by forming (B) a spark gap or arc between the shell wall and one of the leg wires at a point outside the locus of the static-susceptible ignition composition, such that the resistance across the arc provided is substantially less than the resistance across the arc formed by the firing circuit and the shell wall at the locus of the ignition composition. The static electricity will then jump across the gap having the least resistance, and pass harmlessly to the shell wall, where it will be effectively grounded.

The first method above referred to for grounding the firing circuit of the blasting cap to the shell wall may be carried out in a great number of alternative ways. We may (1) deform one of the leg wires in such a manner that the wire deviates from the usual, substantially straight path and contacts the shell wall. Thus, for example, we may form a kink or loop in the wire, or we may solder one of the leg or leading wires to the shell wall, or we may bend a continuation of the leg wire so that it contacts the shell wall.

Another alternative consists in (2) affixing an electrically conducting appendage to one of the leg wires, and contacting the appendage to the shell wall. This appendage may be formed of a low resistance material such as a metal, as, for example, copper, silver, and the like. Or the appendage may be formed of a high resistance material such as graphite, tungsten, platinum, and the like. Thus, for example, we may affix a metal bead, or solder a metallic spur or wire to one of the leg wires and contact the same to the shell wall.

Another alternative method consists in (3) forming a deviation or depression in the shell wall so that the latter is in contact with one of the leg wires. Still another alternative consists in (4) placing an electrically conducting material between, and in contact with, the shell wall and one of the leg wires. Other methods will be apparent to those skilled in the art.

The second general method (B) above referred to, involving an arc or spark gap, may be carried out by any of the procedures mentioned in the preceding paragraphs. In this case, of course, it is not necessary to form any physical, electrically conducting connection between the means provided and the shell wall. It is only necessary that the resistance of the arc provided is substantially less than that of the arc between the shell wall and the firing circuit at the locus of the ignition composition.

In order to describe our invention more clearly, we shall refer to the attached drawing which illustrates several embodiments thereof. This is done solely by way of illustration, and is not to be regarded as a limitation upon the scope of our invention, since many variations within the purview of this invention will be readily apparent to anyone skilled in the art.

Referring to the drawing, Figures 1–7 inclusive represent vertical sections of various types of electric blasting caps in accordance with our invention. Figures 1–4 inclusive illustrate the application of our invention to the "concave plug type" of electric blasting caps; Figure 5 illustrates its application to a "bridge plug type"; and Figures 6–7 inclusive illustrate its application to the "match-head type".

Similar characters are used throughout the several views and in the following description to designate corresponding parts.

Referring generally to Figures 1–4 inclusive, a shell 1 of suitable electrically conducting material such as a metal, for example, copper, aluminum, or the like, is provided with a base charge 2, a priming composition 3, and an ignition composition 4, the latter being disposed at least partly within the cavity of the concave plug 5, as shown. The leg wires 6 and 7 are held in fixed space-relationship by the concave plug 5. The ends of the leg wires, and the high resistance or bridge wire 8 connecting the same, are disposed within the cavity of the concave plug 5. The cap is sealed by a waterproofing composition 9 and a sulfur seal 10.

In Figure 1, the base charge 2 comprises tetryl, the priming charge 3 comprises lead azide, and the ignition composition 4 is the silver salt of chlorinated azodicarbonamidinenitrostarch composition, disclosed and claimed in co-pending application, Serial No. 47,386 filed October 30, 1935. The leg wire 7 is bent to form the kink or elbow 11. As illustrated, the elbow 11 is not in contact with the shell wall 1, but is close to it, thereby forming an arc, the resistance of which is substantially less than that of the arc formed by the ends of the leg wires 6 or 7, and the shell wall at the locus of the ignition composition 4. Any charge of static electricity which may be applied across the leg or leading wires, or across one of the leg or leading wires and the shell wall, will, therefore, jump across the arc between 11 and the shell wall and thereby dissipate itself without affecting the ignition composition 4. An apparent alternative of the above is to contact the elbow 11 with the shell wall, or to form a loop in the wire instead of the elbow or crook shown.

It is apparent that the electrostatic charge may be applied between the shell wall and either one of the leg or leading wires 6 and 7, without causing the ignition composition to ignite. For, should the leg wire 6 be involved in the electrostatic circuit, the current will flow through the resistance or bridge wire 8 and thence proceed to the arc between 11 and the shell wall, without affecting the ignition composition 4, unless the voltage of the static charge is many times greater than that which a man of ordinary capacity can accumulate. It is apparent, therefore, that the means provided effectively guards against the possibility of detonation of the cap by static electricity. It is also apparent that, since the means provided is effectively sealed within the blasting cap, it cannot be subsequently impaired by handling in the field.

Referring now to Figure 2, the base charge 2 consists of tetryl; the priming charge 3 consists of lead azide; and the ignition composition 4 comprises basic lead picrate gelatinized with nitrostarch, as disclosed and claimed in co-pending application, Serial No. 47,382 filed October 30, 1935. The means for substantially reducing the susceptibility of the cap to static comprises the continuation 11 of the leg wire 7, which continuation is bent back sharply at the point of juncture of the leg wire 7 with the bridge wire 8 and contacts the shell wall as shown. In this case the static electricity will flow through either leg wire to the continuation 11 and thence the shell wall 1, thereby effectively grounding the static charge. It is not necessary, however, for the continuation 11 actually to contact the shell wall, since a short arc or spark gap is equally effective, as above mentioned.

In Figure 3, the shell 1 is provided with a base charge 2 of tetryl, a priming charge 3 of lead azide, and a "fast" ignition composition 4 comprising lead styphnate gelatinized with nitrostarch, as disclosed and claimed in co-pending application, Serial No. 47,382 filed October 30, 1935. The means for grounding the firing circuit comprises a short length of wire 11, as for example copper or stiff iron wire, which is soldered or otherwise affixed to the leg wire 7. As illustrated, the spur or length of wire 11 is in contact with the shell wall. As heretofore mentioned, this is not essential to the efficiency of the means provided. We prefer, however, to contact the spur 11 with the shell wall, since the circuit thereby formed between the shell and the leg wires is more readily tested by ordinary electrical testing equipment than a corresponding arc or spark gap. Before the cap is sent out into the field, it is therefore possible to check, as often as desired, the means which will prevent accidental firing of the detonator.

In Figure 4, a priming charge 3 of a composition comprising 90% mercury fulminate and 10% potassium chlorate is disposed over the tetryl base charge 2 and within the conical depression formed therein. The ignition composition 5 comprises the mercury salt of chlorinated azodicarbonamidine, disclosed and claimed in co-pending application, Serial No. 47,386 filed October 30, 1935. A metal bead 11, compressed about or soldered to, the leg wire 7, is close to the shell wall, thereby forming a low resistance arc across which the static electricity may jump without affecting the ignition composition 4. If desired, the metal bead may contact the shell wall.

Figure 5 represents a vertical section of a "bridge plug type" of electric blasting cap provided with a base charge 2 consisting of 80% mercury fulminate and 20% potassium chlorate. The bridge plug 5 supports the leg wires 6 and 7. The bridge wire is surrounded by, or embedded in, the loose charge 12 of lead styphnate, as disclosed and claimed in co-pending application, Serial No. 47,382 filed October 30, 1935. The cap is sealed as usual with a waterproofing composition 9 and a sulfur seal 10. The leg wire 7 is soldered to the rim of the shell, as illustrated, thereby permanently grounding the firing circuit with respect to static electricity.

Referring now generally to Figures 6 and 7, the "match-head type" of electric blasting cap illustrated comprises the shell 1 of suitable electrically conducting material such as a metal, as for example, copper, aluminum, or the like. In the bottom of the shell is a pressed base charge 2 comprising 40% trinitrotoluene and 60% picric acid (in Figure 6), or tetryl (Figure 7). Superposed on the base charge 2 is a priming charge 3 consisting of straight mercury fulminate (Figure 6) or lead azide (Figure 7). Disposed within the paper cylinder 13 is the match-head. The metal plate or foil 14 is provided with shoulders 15, which extend substantially to the paper shell 13. The ignition composition 4 comprises copper acetylide (Figure 6) or silver azide gelatinized with nitrostarch (Figure 7) as disclosed and claimed in co-pending applications, Serial No. 47,383 filed October 30, 1935, and Serial No. 47,384 filed October 30, 1935. The blasting cap is closed with a waterproof composition 9 and a sulfur seal 10.

In Figure 6 the firing circuit is grounded to the shell wall 1 by means of a plug of electrically conducting material 16, which engages the leg wire 7 and the shell wall 1 in electrically conducting relation. The plug is separated from the leg wire 6 by the insulation 17. If desired, the plug 16 may consist of a low melting metal such as an alloy, as, for example, Babbitt metal, which is poured into the cap about the insulation 17 on the leg wire 6. The plug may also consist of compressed graphite or other electrically conducting material if desired.

In Figure 7, the susceptibility of a match-head type of cap to static is substantially eliminated by providing a low resistance arc or spark gap outside the locus of the ignition composition. To this end, the metallic plate or foil 14, forming part of the match-head, is provided with the shoulders 15 which extend substantially completely to the paper tube 13, which is in contact with the shell wall 1. By this means the static charge may escape to the shell wall across the gap between 15 and the shell wall without affecting the ignition composition 4 of copper acetylide. It is, of course, essential that the ignition composition 4 should cover only the lower tab or handle 18 of the match-head, and should not be disposed close to the shoulder 15. In other words, the ignition composition 4 should not be disposed between the parts 15 and 1 of the arc or spark gap. In shape, the match-head shown differs somewhat from the ordinary match-head heretofore employed, in that the shoulders 15, are appreciably wider and the tab or handle 18 is somewhat longer. This change, though apparently slight mechanically, is of great significance from the point of view of static susceptibility, for it substantially prevents the shoulders 15 from being inadvertently covered with the ignition composition 4, which condition we have found will render the finished cap so sensitive to static that a static charge of low voltage, well within the range of that which can be accumulated by a man of average capacity, will invariably fire the ignition composition and detonate the cap. This dangerous condition has heretofore entirely escaped attention.

All of the electric blasting caps illustrated in the drawing and described in the foregoing paragraphs possess three very desirable properties. In the first place all of the detonators herein described have an overall time lag of less than 0.0009 seconds when fired at 12 amps. In many cases this total lag is very much less, for example, 0.0006 seconds, and even as low as 0.0003 seconds. In the second place the "induction periods" of the caps according to our invention are negligible or immeasurable when a firing current of 12 amps. is employed. In other words the bridge wire break is either caused by, or is simultaneous with, the detonation of the cap. And finally the finished electric blasting caps are substantially free from susceptibility to static electricity. The voltage required to detonate the blasting caps of our invention is far beyond that which a man of ordinary capacity can accumulate. It is apparent, therefore, that the detonators may be used under normal conditions without danger from electrostatic discharge.

The advantages in the use of our invention are numerous and important. It provides a permanent, simple, easily-manufactured, and effective means for substantially completely eliminating the hazards involved in the use of ignition compounds which are susceptible to static electricity. The invention therefore permits the safe use of many ignition compounds which were heretofore regarded as dangerous for commercial application. By the use of our invention, it is possible to produce an electric blasting cap without appreciable time lag and substantially free from susceptibility to static. Heretofore, such an electric blasting cap could not be made by any known means.

While our invention is particularly useful for "fast" electric blasting caps having an ignition composition comprising rapid ignition compositions such as lead styphnate, lead picrate, basic lead picrate, silver azide, or the mercury or silver salts of chlorinated azodicarbonamidine, and other "fast" ignition compounds such as copper acetylide and the like, it is applicable to electric blasting initiators generally, regardless of the ignition composition employed. Thus, it may be employed with electric squibs, electric detonators, or delay electric detonators. Again the invention is equally applicable to the concave plug type, the bridge plug type, and the match-head type of electric blasting initiator. Furthermore, it may be employed in any blasting initiator regardless of the base charge, priming charge, or ignition composition employed, since all electric initiators are to some extent susceptible to static electricity.

In the foregoing detailed description of our invention, it is apparent that many variations in detail may be made without departing from the spirit or scope thereof. Thus, it is possible to change the base charge, the priming charge, or the ignition charge, or to change the structural details in any of the examples given without circumventing the scope of this invention. Other changes in detail and other mechanical or electrical equivalents of the means shown will be apparent to those skilled in the art.

Since the present invention constitutes the first discovery of the relationship between static susceptibility and the speed of an ignition composition, and of a practical and effective means of eliminating the static hazards in electric initiating devices, the appended claims are to be construed broadly.

We claim:

1. An electric explosive initiator, the firing circuit of which is provided with a discharging means whereby the susceptibility of the initiator to static electricity is substantially reduced.

2. An electric blasting initiator, the firing circuit of which is provided with a means whereby static electricity is caused to pass harmlessly to the shell wall of said initiator.

3. An electric blasting initiator, one of the leg wires of which is provided with a means whereby the susceptibility of the initiator to static electricity is substantially reduced.

4. An electric initiator, one of the leg wires of which is provided with a means whereby static electricity is caused to pass harmlessly to the shell wall of said initiator.

5. An electric blasting initiator comprising a firing circuit and an ignition composition which is susceptible to static electricity, said firing circuit being provided with a means whereby the electrostatic-susceptibility of the initiator is substantially reduced.

6. An electric blasting initiator comprising a firing circuit and an ignition material which is susceptible to static, said firing circuit being provided with a means whereby static electricity is caused to pass harmlessly to the shell wall of said initiator at a point outside the locus of said static susceptible material.

7. An electric blasting cap, the firing circuit of which is provided with a means whereby the electrostatic-susceptibility of said blasting cap is substantially eliminated.

8. An electric blasting cap, one of the leg wires of which is provided with a discharging means whereby the electrostatic-susceptibility of said blasting cap is substantially reduced.

9. An electric blasting cap containing an ele

trostatic-susceptible ignition composition, the firing circuit of said blasting cap being provided with a means whereby said electrostatic susceptibility is substantially reduced.

10. An electric blasting cap containing an electrostatic-susceptible ignition composition, one of the leg wires of said blasting cap being provided with a means whereby said electrostatic-susceptibility is substantially reduced.

11. The electric blasting cap according to claim 10, in which said ignition composition has a negligible induction period.

12. An electric blasting cap containing an electrostatic-susceptible ignition composition having a negligible induction period, one of the leg wires of said blasting cap being provided with a means whereby static electricity is caused to pass harmlessly to the shell wall of said blasting cap, at a point outside the locus of said electrostatic-susceptible ignition composition.

13. An electric blasting cap, containing an electrostatic-susceptible ignition composition, having a negligible induction period, one of the leg wires of said blasting cap being provided with a means whereby static electricity is caused to pass harmlessly to the shell wall of said blasting cap through an electrically conducting connection between said leg wire and said shell wall at a point outside the locus of said electrostatic-susceptible ignition composition.

14. An electric blasting cap containing a static-susceptible ignition composition which has a negligible induction period, one of the leg wires of said blasting cap being provided with a means whereby static electricity is caused to pass harmlessly to the shell wall of said blasting cap across an arc between the shell wall and said leg wire at a point outside the locus of said electrostatic-susceptible ignition composition, the resistance of said arc being substantially less than the resistance of the arc formed by said shell wall and said firing circuit at the locus of said electrostatic-susceptible ignition composition.

15. The electric blasting cap according to claim 12, in which said electrically conducting connection between said leg wire and said shell wall is formed by the direct contact of said leg wire with said shell wall.

16. The electric blasting cap according to claim 12, in which said electrical conducting connection between said leg wire and said shell wall comprises an electrically conducting appendage affixed to said leg wire and engaging said shell wall in electrically conducting relation.

17. An electric blasting cap, one of the leg wires of which engages the shell wall of said blasting cap in electrically conducting relation.

18. An electric blasting cap comprising a static-susceptible ignition composition which has a negligible induction period, one of the leg wires of said blasting cap engaging the shell wall of said blasting cap in electrically conducting relation at a point outside the locus of said electrostatic-susceptible ignition composition.

19. An electric blasting cap without appreciable time lag, comprising an ignition composition having a negligible induction period, and a means engaging the firing circuit and shell wall in electrically conducting relation whereby the electro-static-susceptibility of said blasting cap is substantially reduced.

20. An electric blasting cap having an overall time lag of less than 9 x 10^{-4} seconds when fired at 12 amps., the firing circuit of said blasting cap being provided with discharging means for the substantial elimination of susceptibility to static electricity.

21. An electric blasting cap having an overall time lag of less than 6 x 10^{-4} seconds when fired at 12 amps., the firing circuit of said blasting cap being provided with discharging means for the substantial elimination of susceptibility to static electricity.

22. An electric blasting cap having an overall time lag of less than 3 x 10^{-4} seconds when fired at 12 amps., the firing circuit of said blasting cap being provided with discharging means for the substantial elimination of susceptibility to static electricity.

23. An electric blasting cap having an overall time lag of less than 0.0008 second when fired at 12 amps., comprising an ignition composition having a negligible induction period, one of the leg wires of said blasting cap being grounded to the shell wall whereby the electrostatic susceptibility of said cap is substantially reduced.

24. An electric blasting cap provided with an ignition composition which has substantially no induction period when fired in said cap at a firing current of 5–20 amperes, the firing circuit of said blasting cap being provided with discharging means for the substantial elimination of susceptibility to static electricity.

25. An electric blasting cap comprising an ignition composition and a bridge wire, the breaking of said bridge wire being substantially simultaneous with the firing of said ignition composition when a firing current of 5–20 amperes is applied to said bridge wire, the firing circuit of said blasting cap being provided with discharging means for the substantial elimination of susceptibility to static electricity.

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