Aug. 8, 1961 J. A. SCOTT 2,995,086

FUSEHEADS

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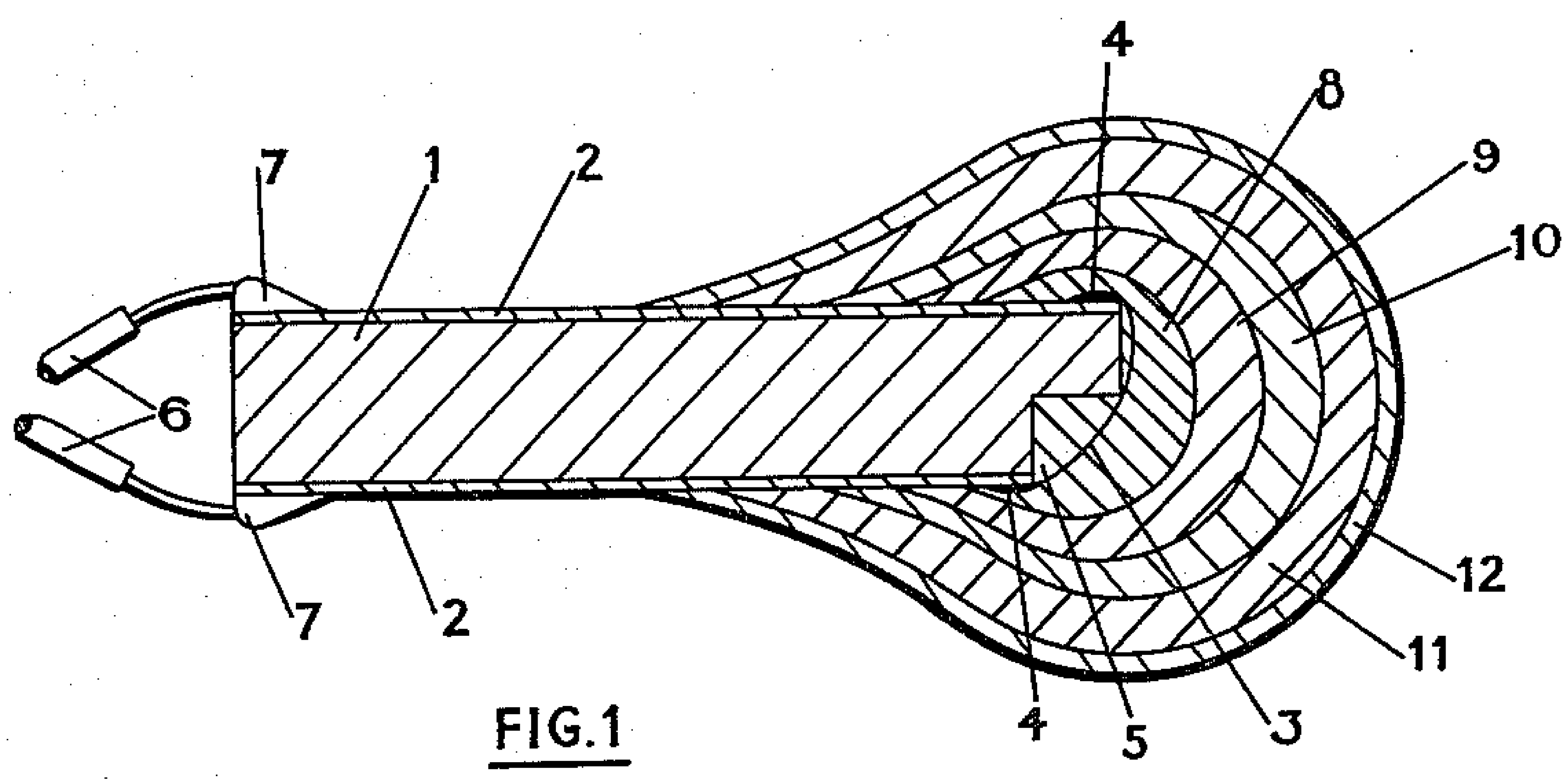

FIG.1

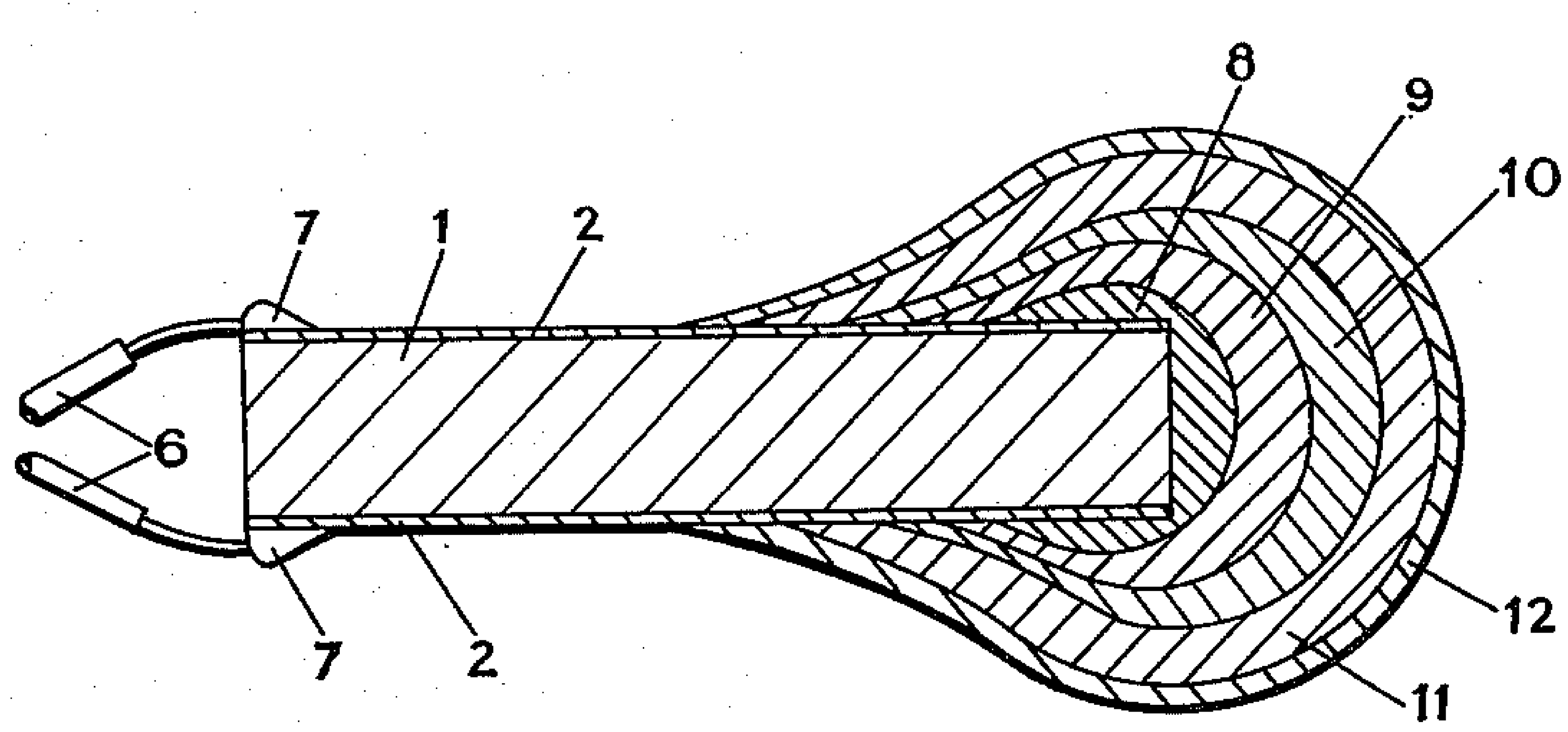

FIG.2

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FUSEHEADS

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This invention relates to new and improved fuseheads for instantaneous or delay electric detonators especially though not exclusively to those for ventless electric delay detonators.

Instantaneous electric detonators are invariably of ventless construction but in order that a delay detonator should be capable of a ventless construction it is necessary that the amount of gas resulting from the ignition of the electric fusehead and the delay fuse composition should be insufficient to create an internal pressure sufficient to burst open the closure at the mouth of the casing. There are ordinarily used for the purpose delay fuse compositions and fusehead beads whose products of reaction are substantially entirely non-volatile and which are frequently referred to as "gasless" although they all yield a small amount of gas.

The fuseheads to which this invention applies are of two kinds; viz. so-called "low tension fuseheads," which comprise two pole pieces of electrically conducting material separated by an electrically non-conducting medium, said pole pieces being connected together at one end by an electric resistance wire bridge which is embedded in a match-head bead of which the core consists of a composition highly sensitive to ignition by heating, hereafter referred to as a "priming composition," an intermediate composition ignitable from the core but not necessarily ignitable from the bare wire, having a powerful flame, hereafter referred to as a "deflagrating composition," and an outermost protective film; and so-called "high tension fuseheads," which are similarly constructed except that they have no resistance wire bridge, the composition surrounding the pole pieces itself being in this case one that is electrically somewhat conducting and capable of ignition upon the passage of a current through it when a suitable voltage is applied across the pole pieces. An outer skin of nitrocellulose or the like protective composition is customarily present. Both these kinds of fuseheads will be referred to throughout this specification and in the claims, collectively as "fuseheads of the kind described."

According to my invention, a fusehead of the kind described comprises in progressive ignition relationship a core consisting of a kernel of a priming composition whose products of reaction are substantially all non-volatile and which accordingly burns with very little or no evolution of gas, and a layer of a deflagrating composition which in turn is surrounded by a protective layer and, except in the case of an instantaneous fusehead, one or a succession of layers of slower burning composition whose products of reaction are also substantially all non-volatile and thus burning with very little evolution of gas, said layer or layers of slower burning composition, when included, being interposed between the priming composition and the deflagrating composition.

The thickness, number and physical and chemical structure of the kernel and any surrounding layers of compositions which burn with very little evolution of gas (hereafter referred to as "gasless compositions") will determine the time delay between initiation and detonation of the primary initiating explosive charge of a detonator incorporating a fusehead according to the invention. Thus, the greater the said time delay is required to be, the thicker will be the layer or layers of gasless delay compositions for any particular composition. The normal method of applying layers of gasless, deflagrating or indeed any other compositions to fuseheads of the kind described is that of dipping the fuseheads in a liquid containing the required ingredients for the layer concerned, a binding agent, for example, nitrocellulose, and a solvent, for example, amyl acetate, and thereafter drying off the solvent whereby a layer of composition is deposited on the fusehead.

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The invention enables the detonators in a delay series to be made shorter than when the conventional tubes filled with the delay fuse composition are interposed between an ordinary fusehead and the charge of the primary initiating composition, and if desired for all the detonators in a delay series to be made of the same length.

There is a limit to the thickness of such a layer which can be deposited in one dipping and a fusehead may therefore have to be subjected to two or more dips (each followed by drying-off of solvent) in respect of each layer of composition. Moreover two or more successive layers of gasless composition of different physical or chemical structure may be applied, and in this way a series of gasless delay detonators having a range of delay times from approximately 10 to several hundred milliseconds may be produced, but it will be appreciated that a detonator with a delay time of the order of 10 milliseconds is to all intents and purposes an instantaneous one.

In practice, delay detonators are frequently used in blasting work where it is desired to detonate a number of high explosive charges in a pre-determined order and with pre-determined time delays between successive detonations. In such an event it is desirable that the detonator employed for the detonation of the first high explosive charge should be substantially instantaneous. It is well-known that the electrical firing characteristics of all the detonators in such an arrangement should be similar since otherwise one or more detonators may fail to detonate. Consequently it would be undesirable to use an instantaneous detonator of the conventional kind (i.e. one evolving gas upon initiation) and preferably when using gasless delay detonators incorporating a fusehead according to this invention, to use in association with said detonators an instantaneous detonator which incorporates a fusehead according to this invention and such that the said instantaneous detonator is in effect, as already described, a gasless delay detonator with a very short delay time.

It is also well-known that in practice the firing current required for a number of fuseheads in series is a function of that number, in order to make sure that all fuseheads are initiated. I have found that the rate of increase in firing current with increase in number of fuseheads in series is lower for fuseheads according to the invention than for conventional fuseheads.

Preferably gasless delay fuseheads according to the invention have successive layers (applied by successive dips) of (*a*) a gasless priming composition, (*b*) one or more gasless delay compositions, (*c*) a deflagrating composition, (*d*) a barrier composition and finally (*e*) an outer skin. For low tension fuseheads, the priming composition may be a mixture of red lead and finely ground silicon, and for high tension fuseheads a priming composition consisting of a mixture of lead dioxide and finely ground silicon has been found satisfactory. Mixtures of red lead and coarse silicon have been found suitable as gasless delay compositions for time delays up to 70 milliseconds or thereabouts, and mixtures of zinc oxide, copper oxide and boron have been found suitable as gasless delay compositions for longer delay times. Mixtures of lead monoxide and silicon and mixtures of red lead, silicon and silica have also been successfully used as delay compositions, and, depending on the number of applications, delay compositions made up from the latter mixtures may conveniently be made to give a range of delay times which are intermediate between the upper and lower ranges which have been obtained from compositions containing the first two mentioned mixtures.

Delay compositions consisting of a mixture of bismuth and selenium powders, and delay compositions consisting of a mixture of antimony pentoxide and manganese powders have also been found satisfactory, and these have the advantage that, when applied in delay electric fuseheads incorporated in ventless electric delay detonators, such fuseheads may be initiated in certain inflammable atmospheres met with in practice, for example in coal mines where firedamp is present, without the hot particles of the products of reaction which are scattered when detonators incorporating such fuseheads are fired igniting the gases forming the inflammable atmosphere, the amount of incendive priming composition normally used in the kernel of a fusehead being so small that it is unable to ignite the said gases.

I have also discovered that a variation in delay times may be achieved by varying the amount of binding agent such as nitrocellulose in the delay composition, and that in particular a reduction in nitrocellulose content causes an increase in delay times.

Mixtures of charcoal and potassium chlorate have been successfully used as deflagrating compositions.

The outer skin, whose function it is to prevent the fusehead from bursting after initiation and before ignition of the deflagrating composition (in the event of very small quantities of gas being evolved in the substantially gasless compositions) may conveniently consist of nitrocellulose or ethyl cellulose and will in practice be merged with the barrier layer which normally also consists of nitrocellulose or ethyl cellulose, though the outer skin is, in the course of the manufacture of the fusehead, separately applied from the barrier layer, the nitrocellulose (or ethyl cellulose as the case may be) of the former layer having been dissolved in different solvents from those of the latter layer, as will be described later.

Several forms of the invention will now be illustrated with reference to the drawings and the following examples:

FIGURE 1 is a cross section through a low tension and FIGURE 2 a similar cross section through a high tension fusehead, both according to the invention. Referring to FIG. 1, **1** is a piece of pressboard sandwiched between two brass foil pole pieces **2**; a length of resistance wire **3** is soldered at its ends to the brass foil pole pieces **2** at **4**, to form a bridge, a portion of the pressboard **1** being recessed at **5**, in order to accommodate the requisite length of resistance wire. One tinplated copper leading wire **6** is soldered to each brass foil pole piece at **7**. The resistance wire **3** is completely surrounded by a bead of priming composition **8** which in turn is surrounded by a layer of a first delay composition **9**, a layer of a second delay composition **10**, a layer of a deflagrating composition **11** and finally an outer skin **12**, consisting of nitrocellulose or the like.

When an electric potential is applied across the leading wires **6**, the resistance wire **3** is heated sufficiently to ignite the priming composition **8** which in turn initiates the delay compositions **9** and **10**. These delay compositions burn at a controlled rate and eventually ignite the layer of deflagrating composition **11**, whereupon the fusehead bursts. The fuseheads according to the invention are intended for use in conventional detonators and, when so used, upon bursting as aforesaid initiate the explosive composition of the detonators with which they are associated.

The high tension fusehead shown in FIG. 2 is constructed in design to operate in exactly the same way as the low tension fusehead shown in FIG. 1, except for the omission of the resistance wire **3** (and therefore also of course, the recessed portion **5**). The part numbers listed in the description of FIG. 1 therefore also apply to FIG. 2. As was mentioned earlier in the specification, the priming composition **8** is inself electrically conducting, and in operation a suitable voltage is applied to the leading wires **6**, to produce a current through the priming composition **8** of sufficient magnitude to ignite it. Thereafter the sequence of events is the same as for the low tension fusehead, described above. High tension fuseheads are less commonly used than low tension fuseheads, but high tension fuseheads according to the invention may be used in conventional detonators.

The following examples illustrate different methods of manufacturing fuseheads according to the invention, and typical test results. All parts are parts by weight.

Example 1

Low tension fuseheads, having a resistance wire of 0.0013" diameter, were dipped in the fast burning mixture comprising 70 parts of red lead and 30 parts of finely ground silicon (i.e. substantially between 5 and 10 microns) which had been made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2½ parts of nitrocellulose. After drying, the fuseheads were further dipped in the slow burning mixture comprising 70 parts of red lead and 30 parts of coarse silicon (i.e. substantially between 10 and 20 microns) made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2½ parts of nitrocellulose. After drying they were further dipped in a mixture comprising 1 part of charcoal and 5 parts of potassium chlorate made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 7½ parts of nitrocellulose. With drying between each dip, the fuseheads were then consecutively dipped once in collodion (a solution of nitrocellulose in a mixture of ether and methylated spirits), and thereafter four times in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 15 parts of nitrocellulose. When fired by a pulse of electrical energy of 50 millisecond duration and a current of 1.5 amps, the times in milliseconds between application of the current and the bursting of the fusehead, for a group of fuseheads, were as follows:

35, 36, 35, 36, 32, 35, 33, 34, 36, 35, 35, 33, 40, 32, 37 30 36, 32, 34, 34.

Example 2

Fuseheads were made as described in Example 1, but two applications of slow burning red lead/silicon compositions were made instead of one. When fired by a 50 millisecond pulse of electrical energy at 1.5 amps, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads were as follows:

70, 69, 67, 58, 67, 63, 70, 66, 72, 75, 65, 69, 63, 64, 62, 64, 66, 69, 64, 65.

Example 3

Fuseheads were made as described in Example 1, but without any slow burning red lead/silicon composition applied. When fired by a 50 millisecond pulse of electrical energy at a current of 1.5 amps, the times in milliseconds between the application of the current and the bursting of the fusehead, for a group of fuseheads, were as follows:

13, 14, 14, 12, 12, 12, 12, 13, 12.

Example 4

Fuseheads were made as described in Example 1, but, instead of being dipped once in the slow burning red lead/silicon composition, they were dipped three times in a composition comprising 60 parts of zinc oxide, 15 parts copper oxide and 25 parts boron, made to a suitable consistency in a solution comprising 90 parts amyl acetate, 10 parts amyl alcohol and 2½ parts nitrocellulose. When fired by a pulse of electrical energy of 50 milliseconds duration at a current of 1.5 amps, the times in milliseconds between the application of the current and the bursting of the fusehead, for a group of fuseheads were as follows:

278, 200, 191, 290, 226, 215.

Example 5

Fuseheads were made as described in Example 1, but after dipping in the slow burning red lead/silicon composition and drying, and before dipping in the charcoal/potassium chlorate composition, they were dipped twice (with drying between dips) in a mixture comprising 70 parts of zinc oxide and 30 parts of boron, made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2½ parts of nitrocellulose. When fired by a pulse of electrical energy of 50 milliseconds duration at a current of 1.5 amps, the times in milliseconds between the application of the current and the bursting of the fuseheads, for a group of fuseheads, were as follows:

221, 244, 329, 226, 343, 229, 239, 199, 301.

Example 6

Fuseheads were made as described in Example 1, but instead of dipping in the slow burning red lead/silicon composition, they were dipped twice (with drying between dips) in a slow burning mixture comprising 64 parts of bismuth powder (passing a 300 B.S. mesh) and 36 parts of finely ground selenium powder (commonly known to the trade as "selenium blackpowder") made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2 parts of nitrocellulose. When fired by a pulse of electrical energy of 50 milliseconds duration and a current of 1.5 amps, the times in milliseconds between application of the current and the bursting of the fusehead, for a group of fuseheads, were as follows:

19, 26, 28, 33, 32, 35, 35, 30, 34, 31, 30, 28, 31, 27, 23, 31, 31, 28, 28, 33.

49 fuseheads, manufactured as aforesaid, were each assembled in a copper detonator containing a base charge of 0.25 g. tetryl and a priming charge of 0.35 g. of an aluminium-lead styphnate-lead azide composition (in the proportions 3:30:70 by weight). The detonators were fired in a 9% methane air mixture, and none of them ignited this inflammable atmosphere.

Example 7

Fuseheads were made as described in Example 6, but four applications of slow-burning bismuth/selenium composition were made instead of two. When fired by a 50 millisecond pulse of electrical energy at 1.5 amps, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads were as follows:

47, 63, 58, 57, 65, 60, 56, 63, 71, 54, 64, 67, 40, 56, 41, 68, 64, 70, 46, 61.

Example 8

Fuseheads were made as described in Example 6, except that the quantities of bismuth powder and selenium powder were 80 and 20 parts respectively, and that three applications of the slow burning mixture were made instead of two. When fired in the manner aforesaid, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads, were as follows:

58, 57, 66, 66, 51, 59, 55, 76, 53, 73, 78, 51, 91.

99 fuseheads, manufactured as aforesaid, were assembled in a copper detonator containing a base charge of 0.25 g. tetryl and a priming charge of 0.35 g. of an aluminium-lead styphnate-lead azide composition (in the proportions 3:30:70 by weight). The detonators were fired in a 9% methane-air mixture, and none of them ignited this inflammable atmosphere.

Example 9

Fuseheads were made as described in Example 6, except that, instead of being dipped twice in the slow-burning bismuth/selenium composition, they were dipped twice (with drying between dips) in a slow burning mixture comprising 60 parts of antimony penoxide and 40 parts of manganese (both passing a 300 B.S. mesh), made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2 parts of nitrocellulose. When fired as aforesaid, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads, were as follows:

123, 189, 145, 105, 128, 130.

25 fuseheads, manufactured as aforesaid, were each assembled in a copper detonator containing a base charge of 0.25 g. tetryl and a priming charge of 0.35 g. of an aluminium-lead styphnate-lead azide composition (in the proportions 3:30:70 by weight). The detonators were fired in a 9% methane-air mixture, and none of them ignited this inflammable atmosphere.

Example 10

Fuseheads were made as described in Example 6, except that, instead of being dipped twice in the slow-burning bismuth/selenium composition, they were dipped once in a slow-burning mixture comprising 65 parts of lead monoxide and 35 parts of silicon, made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2 parts of nitrocellulose. When fired as aforesaid, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads, were as follows:

45, 47, 57, 52, 48, 55, 45, 56.

Example 11

Fuseheads were made as described in Example 10, except that two applications of the slow-burning lead-monoxide/silicon composition were made instead of one. When fired as aforesaid, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads, were as follows:

77, 109, 113, 115, 86, 115, 131, 146, 121, 118.

Example 12

Fuseheads were made as described in Example 6, except that instead of dipping twice in the slow burning bismuth/selenium composition, they were dipped three times in a slow burning mixture comprising 70 parts of red lead, 30 parts of coarse silicon (i.e. substantially between 10 and 20 microns) and 10 parts of finely ground silica, made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2 parts of nitrocellulose. When fired as aforesaid, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads were as follows:

119, 72, 112, 105, 106, 80, 100, 106, 102, 105, 104.

Example 13

Fuseheads were made as described in Example 2, except that the silicon in the delay mixture was of such a particle size as to give a medium burning speed; the delay mixture was made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2½ parts of nitrocellulose. When fired as aforesaid, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads were as follows:

28, 27, 27, 27, 27, 29, 28, 25, 25, 21.

Example 14

Fuseheads were made as described in Example 13, except that the delay mixture was made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 1 part of nitrocellulose. When fired as aforesaid, the times in milliseconds between the application of the current and the bursting of the fusehead for a group of fuseheads were as follows:

47, 45, 37, 48, 47, 40, 36, 45, 49, 49.

Example 15

High tension fuseheads were dipped in a fast burning mixture comprising 60 parts of lead dioxide and 40 parts of finely ground silicon, made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2½ parts of nitrocellulose. After drying, they were further dipped in a slow-burning mixture comprising 70 parts of red lead and 30 parts of coarse silicon made to a suitable consistency in a solution comprising 90 parts of amyl acetate, 10 parts of amyl alcohol and 2½ parts of nitrocellulose. After drying, they were further dipped in a deflagrating charcoal/potassium chlorate mixture and this and the subsequent dips were exactly as in Example 1. When fired at 50 volts, the times in milliseconds between the application of the voltage and the bursting of the fusehead for a group of fuseheads were as follows:

91.0, 79.1, 81.7, 51.1, 89.3, 72.8, 56.4.

What I claim is:

1. In a fusehead comprising electrical igniting means and a kernel surrounded by a plurality of layers of igniting compositions in progressive ignition relationships; the improvement in which said kernel is a gasless priming composition and said layers are at least one layer of a slower burning gasless delay composition adjacent and around said kernel, a layer of deflagrating composition adjacent and around said delay composition and a protective layer adjacent and around said deflagrating composition, whereby there is a predetermined time delay between firing said electric igniting means and ignition of the deflagrating layer.

2. A low tension type of fusehead as claimed in claim 1, wherein the kernel of priming composition consists essentially of a mixture of red lead and silicon with a particle size of less than approximately 10 microns.

3. A fusehead as claimed in claim 1 including a binder in said kernel and said layer of deflagratory composition and said layer of slower burning composition.

4. A fusehead comprising low tension electrical igniting means, a kernel of gasless priming composition consisting essentially of a mixture of red lead and silicon with a particle size of less than about 10 microns in proportions of 70 parts red lead to 30 parts silicon, gasless delay composition surrounding said kernel and in ignition relationship therewith, a layer of deflagrating compostion surrounding said gasless delay composition and in ignition relationship therewith, and a protective layer around said deflagrating composition.

5. A fusehead apparatus as set forth in claim 4 in which the gasless delay composition includes at least one layer of a mixture consisting essentially of about 70 parts by weight red lead and about 30 parts by weight silicon, the silicon having a particle size between about 10 and 20 microns.

6. A fusehead as set forth in claim 4 in which the gasless delay composition includes at least one layer of a mixture consisting essentially of about 60 parts by weight zinc oxide, about 15 parts by weight copper oxide and about 25 parts by weight boron.

7. A fusehead as set forth in claim 4 in which the gasless delay composition includes at least one layer of a mixture consisting essentially of about 70 parts by weight of zinc oxide and about 30 parts by weight of boron.

8. A fusehead as set forth in claim 4 in which the gasless delay composition includes at least one layer of a mixture consisting essentially of about 64 parts by weight bismuth powder of particle size such that it passes a 300 B.S. mesh and about 36 parts by weight finely ground selenium powder.

9. A fusehead as set forth in claim 4 in which the gasless delay composition includes at least one layer of a mixture consisting essentially of about 60 parts by weight antimony pentoxide and 40 parts by weight manganese, the mixture being of such particle size that it passes a 300 B.S. mesh.

10. A fusehead as set forth in claim 4 in which the gasless delay composition includes at least one layer of a mixture consisting essentially of 65 parts by weight lead monoxide and 35 parts by weight silicon.

11. A fusehead as set forth in claim 4 in which the gasless delay composition includes at least one layer of a mixture consisting essentially of about 70 parts red lead, about 30 parts coarse silicon of particle size between about 10 and 20 microns and about 10 parts finely ground silica of particle size substantially less than about 10 microns.

12. A fusehead comprising high tension electrical igniting means having spaced electrodes, a kernel of gasless priming composition in contact with said igniting means, and consisting essentially of a mixture of about 60 parts by weight lead dioxide and about 40 parts by weight finely ground silicon, a gasless delay composition surrounding said kernel and in ignition relationship therewith and including at least one layer consisting essentially of a mixture of red lead and silicon having a particle size between about 10 and 20 microns, a layer of deflagrating composition surrounding said gasless delay composition and in ignition relationship therewith and a protective layer surrounding said layer of deflagrating composition.

13. The fusehead as set forth in claim 1 having two layers of gasless delay composition, the outermost layer having a slower burning speed than the inner layer.

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