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DELAY FUSE ELEMENTS FOR DELAY ELECTRIC DETONATORS AND DELAY ELECTRIC DETONATORS CONTAINING THEM

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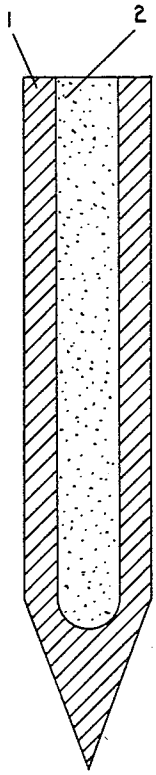


FIG. 1.

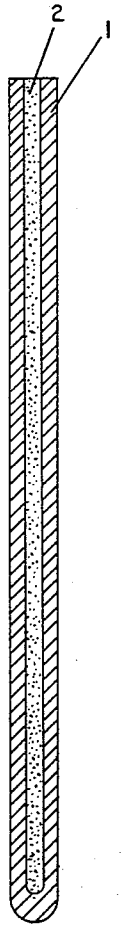


FIG. 3.

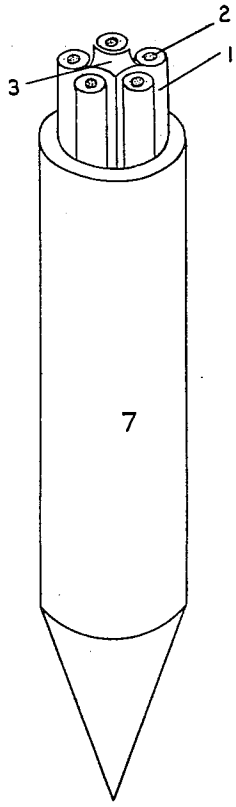


FIG. 5.

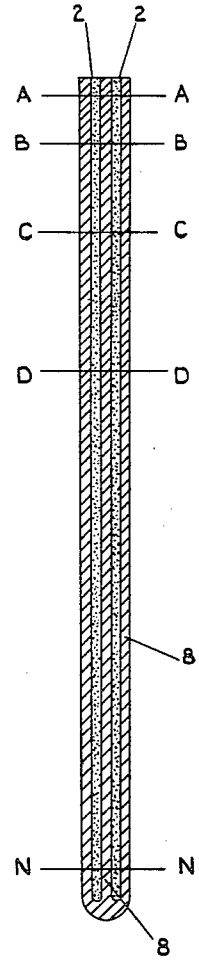


FIG. 8.

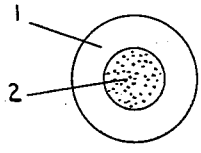


FIG. 2.

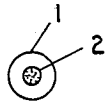


FIG. 4.

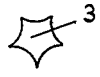


FIG. 6.



FIG. 7.

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DELAY FUSE ELEMENTS FOR DELAY ELECTRIC DETONATORS AND DELAY ELECTRIC DETONATORS CONTAINING THEM

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4 Claims. (Cl. 86—1)

The present invention relates to an improvement in delay fuse elements for use in the manufacture of delay electric detonators, and especially short period delay electric detonators, intended for use in gassy atmospheres, such as are liable to be encountered in coal mines, and to the method of production of delay fuse elements for such use.

Most of the delay electric detonators now produced are of ventless construction and contain delay fuse elements in which there is an axial cylindrical core of a delay fuse composition such as to generate little or no gas during its combustion. Delay electric detonators are marketed in sets, the individuals in each set being characterised by differing delay periods, so that on connecting up the detonators of the explosive charges in the boreholes in series a single firing operation brings about a succession of shots in rotation. They fall into two well recognised kinds which are referred to hereinafter as normal period delay electric detonators and short period delay electric detonators, the typical ranges of delay periods of these two kinds being respectively approximately ¼ or ½ second to 15 seconds and approximately 25 to 1000 milliseconds. To obtain certain blasting effects it is permissible to use either kind of delay electric detonator, but for some purposes it is possible to use only normal period delay detonators and for certain other purposes it is possible to use only short period delay electric detonators. Normal period delay electric detonators have been used for certain blasting operations in coal mines, and there are also certain operations in coal mines that it would be desirable to carry out with short period delay electric detonators.

No great difficulty has been encountered in manufacturing normal period delay electric detonators that will not ignite fiery or dusty atmospheres, but the production of short period delay electric detonators that will not ignite such atmospheres and which may accordingly be used safely in coal mines is a more difficult problem. In each case the metal of the detonator casing and the substance of the closure member must be of a non-incendive character e.g. copper or copper alloy, but not of aluminium. In the case of short period delay electric detonators the choice of compositions for the matchhead of the electric fusehead is more restricted than in the case of normal period delay electric detonators, and even when a suitable electric fusehead is employed there remains a severe difficulty owing to the fact that the delay fuse compositions that are required to give the short delay periods, which are typically of faster burning characteristics than those required for normal period delays, are also typically much more exothermic in their combustion, so that the slag left when they have burned through and the detonator casing has been disrupted by the explosive charge therein is liable to ignite fire-damp air mixtures.

The present invention provides a construction for delay fuse elements, and especially for short period delay fuse elements, for delay electric detonators, wherein the tendency of the slag of the delay fuse composition to ignite fire-damp air mixtures is suppressed or diminished, and the production of non-incendive delay electric detonators and especially of non-incendive short period delay electric detonators is accordingly facilitated.

In the manufacture of the delay fuse elements of delay electric detonators as hitherto carried out, the delay fuse composition is either compressed in increments into the axial cylindrical bore of a cylindrical tube of rigid metal, or a cylindrical ductile metal tube containing an axial cylindrical core of the composition of predetermined thickness is drawn down to a diameter such as to enable it to be fitted into the detonator casing after it has been cut to the required length corresponding to the delay period required. The diameter of the compressed core of the delay composition is ordinarily about 3.2 to 3.6 mm.

According to the present invention, however, the charge of the delay fuse composition running through the metal is sub-divided into a plurality of not less than three parallel columns which, instead of being axially disposed are disposed parallel to the axis through the metal of the delay fuse element separated from one another in positions intermediate between the axis and the cylindrical surface of the element, and further, are not of circular right section, whereby the cooling effect of the metal of the delay element on the slag of the composition resulting from its combustion is greatly enhanced.

The increased cooling effect occasioned by the reduction in the cross-sectional area and the non-circular right section of the columns of the delay compositions both increase the ratio of the metallic cooling surface to volume of the delay fuse composition in the delay element and render it possible to obtain short period delay fuse elements which, when assembled in the delay electric detonators, are non-incendive from, for example, red lead/silicon compositions and lead peroxide/silicon composition which in delay fuse elements of the customary construction are liable to eject particles from the disrupted delay electric detonator that will cause ignition of methane-air mixtures. The non-circular right sections of the columns may be for example elliptical or heart shaped. It might have been thought that a similar result could be obtained by merely reducing the diameter of the column of delay fuse composition without increasing the number of columns and without altering the shape of its usual circular section, but with the reduced diameter there is an increased liability for a single column to fail to ignite from the electric fusehead. On the other hand, the multiplication of the number of exposed surfaces of delay fuse composition distributed over the end surface of the delay element, substantially eliminates any chance of a failure of the electric detonator to fire as a result of the failure of any one column to ignite from the electric fusehead. Preferably the number of columns of the delay fuse composition in each element is four, five or six.

More particularly according to the present invention the improved delay fuse element for a delay electric detonator consists of a metal cylinder within which there are embedded in the metal in positions intermediate between the axis and the cylindrical surface a plurality of at least three parallel separate columns of the delay fuse composition whose right sections are non-circular and regularly spaced in the form of an interrupted ring concentric with the centre of the right section of the element. The metal is advantageously a ductile one, preferably lead.

Also according to the invention the method for the production of the improved delay fuse element comprises assembling together within a cylindrical ductile metal tube, all at least close to its inner surface and symmetrically disposed round its axis, a number of not less than three individual cylindrical tubes of the same metal having an axially disposed cylindrical core of the delay fuse

composition, and drawing down the assembly into the form of a cylinder of a diameter to fit within a detonator casing, so that the metal becomes substantially continuous and the cylindrical cores of delay fuse composition of originally circular right section becomes distorted as a result of the flow of the metal but remain separated from one another by the ductile metal in the form of an interrupted ring on at least one boundary of which there is a substantial thickness of the metal. After only an early stage in the drawing down of the tube that contains them, a ring of these individual cylindrical tubes will be in close contact with the inner wall of this outer tube, and it is preferred that the individual cylindrical tubes introduced should be each of an overall diameter such as would leave a substantial axial space after they are in contact with the inner wall of the containing tube, and that there should first also be inserted a core of the same metal preferably of fluted, stellated or polygonal section to occupy most of the free space around the axis, so as to facilitate the regular distribution of the cylindrical tubes containing the delay fuse composition around the inner surface of the ductile metal container tube and provide an additional cooling mass within the ring of tubes, before commencing to draw down the assembly. In less preferred forms of the invention the axial space is occupied by an additional metal tube containing a column of the delay fuse composition or is left unoccupied before commencing to draw down the assembly. The thickness of delay fuse composition core in each individual metal tube may then require to be smaller to achieve the necessary cooling effect than when there is inserted an axial metal core. In each case it will be understood that the metal flows during the drawing operation to occupy the free spaces, but when such a metal core is employed the benefit is obtained of the cooling effect of a more substantial thickness of metal around the axis than when the tubes lie close together. In the case where a ring of cylindrical metal tubes whose delay fuse composition cores are of circular right section are disposed around the unoccupied axis before the assembly is drawn down, the flow of metal into the free space results in the originally circular right sections becoming somewhat heart shaped with the apices inward, but when the axis is occupied by an additional metal rod the resulting right sections of the powder cores are approximately elliptical with their short axes lying radially.

The invention is further illustrated by the accompanying diagrammatic drawing, which represents various stages in the production of a delay fuse element in accordance with the invention.

FIGS. 1 to 4 are vertical section and plan views of a loaded lead tube;

FIG. 5 is a view of the fuse during assembly;

FIG. 6 is a cross section of rod 3;

FIGS. 7 and 8 are vertical section and plan views of the assembly after drawing.

FIG. 1 and FIG. 2 are respectively a vertical section and a plan view as seen from above of a thick walled cylindrical lead tube closed at one end which contains a hand tamped cylindrical charge of a pulverulent short short period delay fuse composition **2**, for example a 70:30 red lead-silicon mixture, a 50:50 lead peroxide-silicon mixture 50:50:10 lead peroxide-silicon-titanium dioxide mixture by weight.

The external diameter of the lead tube may conveniently be 20.7 mm. and the internal diameter 12.7 mm. FIGS. 3 and 4 are respectively a vertical section and a plan view as seen from above of the loaded tube shown in FIGS. 1 and 2 after it has been drawn out through a series of dies as a result of which its external and internal diameters have been reduced to 3.96 mm. and 2.03 mm. respectively, and the core composition **2** has been further compressed and consolidated as a result of the drawing operation. In FIG. 5 there are seen on a somewhat smaller scale five of the tubes **1** with their cores **2** of consolidated short period delay fuse composition as shown in FIG. 3 arranged regularly spaced around a rod **3** of lead whose cross-section, seen in FIG. 6, is that of a regular pentagon whereof the sides are inwardly curved, the diameter of whose inscribed circle is 3.81 mm. and surrounded by a lead tube **7** of external diameter 17.15 mm. and internal diameter 12.7 mm. closed at one end. The internal diameter of this lead tube **7** and the dimensions of the section of the rod **3** are such that the tubes **1** clustered around the latter can be inserted but are held apart from one another. FIG. 8 represents the assembly shown in FIG. 5 after it has been drawn down to 5.97 mm. diameter as a result of which the metal of the tube **7**, the tubes **1** and the rod **3** flow into close contact so as to form a matrix **8** and the originally cylindrical fuse cores **2** are not only reduced in area by the drawing operation, but are distorted from their originally circular cross section into the more or less elliptical or flattened section seen in the plan view of FIG. 7, the short and long axes being approximately 0.38 mm. and 1.27 mm. To provide lengths of delay fuse element corresponding to desired delay intervals end portions of the finished article of FIG. 8 are cut off as shown at AA and NN, the remainder being cut at desired lengths as shown by the lines at BB, CC and DD.

The resulting delay fuse elements are then inserted in known manner on top of a primary initiating charge consisting essentially of lead azide or mercury fulminate, if desired containing admixed with it a compound facilitating its ignition, for example lead styphnate in the case of lead azide, this primary initiating charge being superposed on the base charge of a secondary explosive in the copper alloy casing of a ventless electric detonator, from the electric fusehead of which the five delay fuse composition cores of the length of delay element are directly ignited.

Depending on the length of the draw-bench these two drawing operations may necessitate cutting the lead tubes during the drawing operation and consequently necessitate closing off at least one of the open ends of the relatively wide lead tubes. Even if such a cutting is unnecessary it is sometimes convenient to close the open end of the wide lead tube in order to permit dies to be arranged so that the direction of the pull can be reversed from time to time as the drawing operation proceeds.

As an example illustrating the non-incendive properties of ventless short period delay action detonators made in accordance with the invention, there were tested No. 6 commercial detonators each in a copper alloy detonator casing containing a base charge of 0.25 gram tetryl and a primary initiating charge of 0.35 gram of a mixture of lead azide, lead styphnate and aluminium, a 24 millimetre length of a delay element prepared as described above having 5 cores each of the aforementioned short and long diameters (say 0.76 mm. mean diameter) and containing a composition consisting of equal parts by weight of lead peroxide and silicon, whereof the delay time was 330 milliseconds, this being ignited by a low tension electric fusehead whereof the matchhead comprised a bead in direct contact with the resistance bridge-wire of a composition comprising lead mononitroresorcinate and potassium chlorate covered with an outer coating of a composition consisting essentially of cerium magnesium alloy, potassium chlorate, aluminium and charcoal. The sealing plug carrying the insulated leading wires to the electric fusehead of the detonator was of a polymerised chloroprene composition. On test openly suspended in a 9% by volume methane air mixture, no ignitions of the atmosphere resulted from the firing of 25 of these short period delay detonators. In contrast it was found that a ventless short delay electric detonator similarly made up with 26 millimetre long single cylindrical core delay fuse element of the same composition of core diameter 3.35 mm., given a delay period of 332 milliseconds, and whereof the electric fusehead bead coat-

ing consisted essentially of a mixture of cerium magnesium alloy and red lead, gave 10 ignitions out of 10 detonators tested in the same manner and when the length of the single core delay fuse element was reduced to 8 millimetres giving a delay period of 100 milliseconds there were still obtained 25 ignitions out of 25 ventless short delay detonators tested.

What we claim is:

1. A method for the production of nonincendive delay fuse elements, comprising the steps of; assembling at least three straight cylindrical ductile metal tubes containing axial cores of delay fuse composition within a cylindrical casing of said ductile metal in a generally parallel relationship, said tubes being disposed symmetrically about the longitudinal axis and close to the inner surface of said casing; inserting a core of said metal into the axial space of said assembly whereby said cylindrical tubes surround the same, said axial metal core being of a size sufficient to substantially fill said axial space and having an outer surface of a shape to maintain the tubes in symmetrical relationship about said axis; drawing the assembly to reduce its diameter to a predetermined value, to render substantially continuous the metal of said tubes, said axial core, and said casing, and to distort the cores of said tubes into a non-circular cross-section, said distorted cores remaining separated from one another by the metal tubes and the axial metal core, said core being in the form of an interrupted ring having a substantial thickness of the metal on at least one of its boundaries.

2. A method as in claim 1, wherein the metal core is fluted in cross-section.

3. A method as in claim 1, wherein the metal core is stellated in cross-section.

4. A method as in claim 1, wherein the metal core is polygonal in cross-section.

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