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SAFETY DETONATOR

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My invention relates to improvements in detonators, such as are used for initiating charges of explosives. It is applicable to both electric and safety fuse types of both simple and compound detonators.

Its object is the production and use of new and improved types of detonators, characterized by excellent and reliable detonating efficiency, by low cost, and by being safer for manufacture and use than any detonators having sensitive explosives, such as fulminate, azide, diazodinitrophenol and the like, as ingredients of the main charge or charges, thereof.

A further object is the reliable, efficient and practical initiation of these safer types of detonators, whose main charge or charges are free of any explosive as sensitive to friction and impact as mercury fulminate, azide, etc.

Further objects and advantages will be evident from the following description of my invention.

Where referred to in this specification and appended claims, the term "primary detonator composition" means the material used as the entire explosive charge in so called "simple" or single-charge detonators; or that used as the primary or top explosive charge in so called "compound" detonators, in which are employed explosive base charges, usually of the non-primary detonating type.

Various kinds of what I term "safety" types of primary detonator compositions have been proposed for use in various types of detonators. These "safety" types of primary detonator compositions are characterized or defined as those that are free of any explosive ingredient which is as sensitive to friction and impact as are any of the group of explosives exemplified by mercury fulminate, lead azide, diazodinitrophenol, etc. Examples of these "safety" types of primary detonator compositions are: (1) solid nitration products of polyhydric alcohols of the general formula $C_nH_{n+2}(OH)_n$ (as nitrodulcite, nitromannite, etc.), alone or admixed with various proportions of other solid explosives, materially less sensitive than fulminate of mercury, lead azide and the like (examples of such other solid explosives being tetryl, nitrolactose, nitropentaerythrite, etc.); primary detonator compositions of this type having been disclosed in my copending applications Nos. 502,559, 502,560, and 575,929; (2) solid disaccharide nitric esters (as nitrolactose), alone or admixed with various proportions of other solid explosives, materially less sensitive than fulminate of mercury, lead azide and the

like, as disclosed in my copending application No. 575,930; etc.

In adapting these so-called "safety" types of primary detonator compositions for practical use in detonators, two chief requisites are involved, namely; (1) they must be adequately confined and (2) they must be adequately initiated by effective ignition. The first requisite or that of adequate confinement may easily be fulfilled by the use, for example, of a perforated inner capsule, pressed upon the said "safety" type of primary detonator composition in a shell, in a way well known in the manufacture of detonators and as shown in my copending application Serial No. 502,560, the shell being preferably of relatively high strength for best and most reliable results, as for example a gilding metal shell having a wall thickness of about ten thousandths of an inch. By the term "confining means", as used in the accompanying claims, I mean to include all the confining media of the primary charge, i. e., either the confining shell or both the shell and auxiliary confining element, as a capsule, if and when the latter is used in the detonator. One means of fulfilling the second requisite or that of effective ignition is by the employment of a preformed fuse-head, in accordance with the method disclosed in my copending application Serial No. 502,560, several electric types of which are available and well known. This method accordingly provides an adequate, readily available, electrical means for initiating detonators embodying "safety" types of primary detonator compositions; whereas, in contradistinction thereto, ordinary available types of safety fuse are not adequate for the initiation of detonators of this type, due to the insufficient heat or insufficient combination of heat and force provided therewith. It is accordingly very essential to the art of fabricating practical detonators, wherein the "safety" types of primary detonator compositions are employed, to provide an adequate means of initiation, whereby the ordinary safety fuse method of firing may be used where desirable. My present invention fulfills this need and, when embodied in detonators of the said type, renders them suitable with ordinary and readily available types of safety fuse as well as with electrically heated bridge wire.

Broadly, my invention consists of the employment of a charge of inflammable deflagrating material of such character and in such amount that it will convey effective ignition from either safety fuse or electrically heated bridge-wire initiation to a confined "safety" type of primary detonator

composition, without premature injury to the confining medium or media of the detonator.

My invention is largely based upon the important discovery that the proper functioning of a "safety" type of primary detonator composition in a detonator, is dependent upon a hitherto unrecognized but controllable factor. This novel factor resides in the prevention of the destruction, injury or disturbance of the confining media of a detonator, (embodying a confined primary charge of "safety" primary detonator composition) prior to the detonation of the said primary charge thereof. The extreme importance of this factor will be evident from the illustrative examples of unsuitable ignition media, shown below.

I have found, for example, that the flame durations and temperatures of certain types of ignition media are unsuitable, because they tend to soften, fuse and even burn through the confining media i. e., the shells and/or inner capsules of the detonators, before the "safety" type of primary detonator composition is able to advance from ignition to detonation, during which period it is very essential to have the confining media quite intact.

In such cases, the proper functioning of a detonator, embodying a "safety" type of primary detonator composition, is rendered very uncertain, due to the impaired confinement and to the very objectionable phenomenon of having the main explosives charge, (surrounding the detonator and which the detonator is to set off or detonate) becoming ignited, from the excessive heat of the said types of ignition media, before its detonation can be effected. Premature ignition of the surrounding explosive involves many important disadvantages as for example (1) the ejection of the detonator from the explosive by the force of the flame of either the ignition medium of the detonator or the flame of the ignited surrounding explosive or both, (2) the likelihood of dangerous "hang-fires", (3) the generation of toxic gases, (4) the reduction of blasting efficiency, (5) the likelihood of igniting inflammable gases and dusts in mines, etc. Exemplary types of ignition media, embodying the above difficulties, are compositions such as thermite; pyrotechnics whose fuels comprise excessive amounts of powdered magnesium, powdered aluminum or similar, very high heat producing material; and the like.

The following composition is an example of the objectionably hot type, the many disadvantages of which are described above: 58% barium nitrate, 29% magnesium powder and 13% lead hypophosphite. Ignition media, consisting of variously pressed charges of this mixture in amounts ranging from .075 gram to .25 gram when employed in detonators embodying, for example, gilding metal shells and inner capsules, base charges of tetryl, and primary charges of nitromannite, almost invariably burn through the side walls of the shells prior to the detonation of the detonators; resulting in unreliable functioning, as indicated by lead-plate tests, besides the pre-ignition of many types of surrounding explosives, in a majority of instances. For example, out of a group of fifteen attempts to detonate 60% nitroglycerine dynamite with detonators of this exemplary type, the dynamite was pre-ignited in 66⅔% of the trials and in 26⅔% of the trials the detonators were blown clear of the dynamite charges by the force of the flame of the ignition medium, ignited dynamite or both; the dynamite continuing to burn instead of detonating.

Further, in other exemplary cases, I have found ignition media, which are prone to detonate upon being ignited in the confines of a detonator, to yield variable and unreliable results, in conjunction with primary charges of "safety" types of primary detonator compositions. In such cases, the confinement is prematurely shattered, prior to the advancement of the primary charge of "safety" primary detonator composition from ignition to detonation; thereby interfering with its proper functioning. This effect may best be observed in compound type detonators, having base charges of non-primary types of explosives; the reduced efficiency of the primary charge resulting in the failure of the base charge to detonate, in spite of the fact that the same kind of detonators may be consistently completely detonated by means of types of ignition media, which avoid premature injury of the confining media, in accordance with my invention. Such materials, as for example, mercury fulminate, fulminate-chlorate, etc., which advance from ignition to detonation, at very rapid rates, even in small quantities, are therefore, unsuitable, unless desensitized in such a way as to make them progressive burning or deflagrating instead of detonating materials, in the quantities required for ignition media. An illustration of this is a composition consisting of 65% mercury fulminate, 25% litharge and 10% antimony sulphide, whose brisance is insufficient, in small quantities, to impart detonation to nitromannite cap charges confined under an inner capsule, but, nevertheless, detonate with sufficient force to so injure the confining media (shell and inner capsule) that the said nitromannite charges will not advance from ignition to detonation with sufficient efficiency to consistently initiate detonator base charges of tetryl and the like.

In contradistinction to ignition media, which prematurely injure the confining media, examples of which are described above, I have found non-detonating, progressive burning ignition media, whose flame temperatures and durations are such that they will effectively ignite "safety" types of primary detonator compositions, when confined in detonator assemblies, without melting shattering or otherwise prematurely injuring the confining media, to be entirely satisfactory and practical. Ignition media, of this satisfactory type, are embodied in various types of progressive burning or deflagrating compositions; various amounts of which are suitable, depending upon the heat and gas produced by and the speed of burning of the deflagrating material in the confines of the detonator assembly, together with the strength, heat resistance, and heat conductivity of the confining medium or media of the detonator assembly.

For instance, a deflagrating material exemplified by composition A, consisting of a mixture of 74% selenium dust and 26% barium peroxide, ignition charges of which evolve very little or no gaseous products of deflagration and insufficient developed heat to injure the detonator shells and/or inner capsules, is quite flexible as to the maximum amounts that may be satisfactorily used as ignition media in detonators embodying confined charges of "safety" types of primary detonator compositions; the limiting factor, in this case, being the amounts required to develop sufficient heat to effectively ignite the said primary charges. In the case of composition A, about .4 gram or larger amounts, when pressed from zero up to about 1300 lbs. per square inch,

are suitable as ignition media for detonators embodying nitromannite and the like, as the primary charges thereof, in accordance with my invention, in conjunction with confining media of materials about as or more heat resistant than gilding metal.

As for the opposite extreme, involving deflagrating compositions, exemplified by composition B—consisting of a mixture of 40% ground nitrocellulose smokeless powder, 20% potassium chlorate and 40% sulphocyanate, which are relatively fast burning and evolve considerable gaseous products of deflagration, the amounts used as the ignition media must be sufficiently small to prevent the bursting of the detonator shell prior to the effective ignition of the "safety" type of primary charge; the gases, in this case, being generated in too great a volume and at too rapid a rate for them to be vented past the crimped safety fuse sufficiently fast to avoid building up a pressure to the bursting point of the confining detonator shell. The amount of gas produced must therefore be limited by limiting the amounts of composition of the B type used as the ignition media. In the particular case of composition B, I have found amounts ranging from .04 gram to .08 gram, pressed from zero up to about 2600 lbs. per square inch, to be suitable as ignition media for detonators embodying nitromannite, nitrocellulose, nitrolactose, and the like as the primary charges thereof, in accordance with my invention, in conjunction with confining media of conventional thicknesses of materials about as strong or stronger than gilding metal.

Between these two extreme types, represented by compositions A and B, it will readily be seen that there are many other compositions having combinations of intermediate characteristics, which are suitable in intermediate amounts, for use in accordance with my invention. Composition C, for example, consisting of 25% tetryl, 10% magnesium powder, 40% barium nitrate and 25% lead hypophosphite, deflagrates and evolves gas at a sufficiently moderate rate with sufficient evolution of heat to effectively initiate primary detonator charges of nitromannite, to be satisfactory for use, in accordance with my invention, in quantities varying from about .15 gram to about .25 gram, pressed from zero up to about 2600 lbs. per square inch, under which conditions insufficient heat and/or pressure is evolved to injure shells and inner capsules of conventional thickness, of materials about as or more heat resistant and/or stronger than gilding metal.

It is to be understood that my invention is not limited to the above recited examples of suitable ignition media but that it includes within its purview all equivalents thereof, a large number of which can be formulated and adapted in accordance with my invention. Within this wide range there are certain ignition media that are better suited than others. For example, for detonators to be fired by safety fuse initiation, I prefer to employ ignition media that are relatively low in hygroscopicity, readily pressed into a form that will not easily be dislodged with ordinary handling, readily ignited by the spit of ordinary safety fuse—even in the pressed state, sufficiently small in magnitude to be economical, relatively insensitive to friction, etc.

Likewise, for example, for detonators to be fired by electrically heated bridge-wire initiation, I prefer to employ ignition media that are readily ignited by ordinary types of electrically heated

bridge-wires in the loose state, relatively low in sensitivity and hygroscopicity, etc.

Preferred types of inflammable compositions, for use as ignition media, in accordance with my invention, usually consist of an oxygen delivering substance and a fuel; with or without an inflammability sensitizer incorporated therewith, depending on the inflammability desired.

It is also desirable to incorporate such compositions in a wet state for sake of safety and for more intimate mixing of the ingredients. In selecting the oxygen delivering substance, I prefer the use of the less hygroscopic materials, such as the nitrates of barium or potassium; the chlorate, chromate, dichromate or permanganate of potassium; metallic oxides, as the peroxides of manganese, lead or barium; etc. In selecting the fuel, I prefer the use of one or more materials, whose combustion will take place, at a moderately fast rate, but without advancing to detonation, when incorporated with the selected oxygen delivering substance and whose heat of oxidation is sufficiently high for practical quantities, to effectively initiate a "safety" primary detonator composition, without being high enough to soften, melt or otherwise injure the confining medium, under the conditions of use. Typical fuel examples are tetryl; charcoal; naphthalene; selenium; trinitrotoluene; various picrates as ammonium picrate, etc.; various solid nitrocarbohydrates as nitrocotton, nitrostarch, nitrolactose, etc.; smokeless powder; and the like.

Various powdered metallic substances as silicon, magnesium, aluminum, ferro-silicon, and the like, may also be employed in varying quantities, but careful attention must be paid to the heat of combustion of the particular one selected, to make sure that the proportion used in the composition will develop insufficient heat, when employed as the ignition medium, to injure the particular confining media used in the detonator.

Powdered magnesium, for example, may be used only in proportions up to about 10%, in conjunction with another tempering fuel of the type of tetryl (see composition C given above), for use as ignition media in gilding metal shells of conventional thickness. Finally, if necessary to improve the inflammability of the ignition media, I may add various proportions of such materials as metallic sulphocyanates (as lead sulphocyanate), metallic hypophosphites (as lead hypophosphite), antimony sulphide, and the like, which serve as inflammability sensitizers.

In adapting suitable types of inflammable materials as ignition media, in accordance with my invention, it is not only very desirable to use minimum amounts for the sake of economy and to minimize the reduction in clearance above the detonator charges in the shells, but also quite advisable to avoid excessive amounts for the most reliable functioning of the detonators. In general, the heights of column of pressed ignition media are preferably no greater than about $\frac{1}{8}$ ". It is therefore preferable to select a relatively fast burning ignition medium, smaller amounts of which may be used, than to select a relatively slow burning ignition medium, much larger amounts of which are necessary to produce the heat required to effectively initiate the safety type of primary detonator charges.

An additional reason for this preference is that the longer duration of deflagration, prior to the initiation of the primary charges, involved with larger amounts of slower burning ignition

media, are more apt to heat conventional types of detonator shells to sufficiently high temperatures to pre-ignite the surrounding explosive charges—even though the shells are not actually penetrated or injured thereby.

In accordance with the above, I prefer inflammable compositions, of the general type, represented by composition B, described above. Composition B, I have found, consisting of an incorporated mixture of 20% potassium chlorate, 40% ground smokeless powder, and 40% lead sulphocyanate, is quite suitable for ignition media, in accordance with my invention, for both safety-fuse and electrically heated bridge-wire initiation; embodying many desirable properties. For example, it is not objectionably hygroscopic, it may be consistently ignited by the ends of ordinary types of safety-fuse—even in a pressed state that will resist being dislodged with reasonable amounts of handling, it may be consistently ignited by means of conventional types of electrically heated bridge-wires in contact therewith, and only small quantities (from about .04 gram to about .08 gram) are required.

It will be understood that I recognize the possibility of using especially heavy confining media and/or of special materials, having high heat resistances and/or low heat conductivities, to withstand the effects of the hotter types of ignition media; the employment of which is entirely within the scope of my invention. It will be also understood that I contemplate the ignition media, used in accordance with my invention, being in various suitable forms, as for example: as loose powders in contact with electrically heated bridge-wires; as superimposed pressed charges to take the spits of safety-fuse; as superimposed charges produced by introducing the inflammable composition into the detonators in a paste or liquid form and subsequently solidified, etc.

Further, it will be understood that my invention is applicable to detonators of any type, wherein "safety" types of primary detonator compositions, as defined above, are employed. Within this scope are included both simple and compound detonators, whose primary detonator compositions consist of one or more essential ingredients, such as solid nitration products of polyhydric alcohols of the general formula $C_nH_{n-2}(OH)_n$, as nitromannite, nitrodulcite, nitroerythrite, and the like, solid nitration products of disaccharides, as nitrolactose and the like, with or without various proportions of other solid explosives that are materially less sensitive than mercury fulminate, lead azide and the like, as tetryl, TNT, pentaerythritetranitrate, nitrostarch, picric acid and the like. Compound detonators embodying my invention may also include base charges consisting of one or more solid explosives that are compatible with the primary charges used therewith, such as tetryl, TNT, nitropentaerythrite, nitrolactose, nitrodulcite, nitromannite, nitrostarch, picric acid and like substances that are less sensitive to friction and impact than mercury fulminate, lead azide, diazodinitrophenol, and the like.

Various means of firing detonators, embodying my invention, are also contemplated as, for example, conventional and unusual types of safety-fuses, conventional and unusual types of electrical media as bridge-wires, spark gaps, conventional electrically ignited pre-formed fuse-heads or matches, etc.

Various materials may also be used for the

confining media, in accordance with my invention, such as aluminum, gilding metal, copper, nickel, iron, steel and the like; it being requisite to employ a material of sufficient strength and heat resistance to resist the heat and pressure of the ignition media. Whereas gilding metal is preferred, on account of its being non-sparking and conventional for detonators, as well as entirely suitable in conventional thicknesses for various types of ignition media as illustrated above, other materials of various thicknesses may be employed, if desired.

Having described my invention, what I claim is:

1. A detonator including a confined charge of a "safety" type of primary detonator composition, and an ignition medium for the said primary charge; the heat and pressure developed by said ignition medium being incapable of prematurely injuring the confinement of the said primary charge prior to the detonation thereof.

2. A detonator comprising, in combination, a metal shell having a suitable inside diameter for conventional types of safety-fuse or about .222 inch, a primary charge of a "safety" type of primary detonator composition confined therein, an inner capsule for auxiliary confinement of the said primary charge, and placed upon the confined primary charge, an ignition medium consisting of an inflammable, deflagrating material of such character and in such amount that the said ignition medium develops sufficient heat to effectively initiate the said primary explosive charge but insufficient heat to soften or melt the said confining shell or inner capsule and insufficient gas pressure to prematurely burst or injure the said confining shell or capsule prior to the detonation of the said primary explosive charge.

3. A detonator as in claim 2, characterized by the ignition medium thereof consisting of the following—from about .04 gram to about .08 gram, pressed up to about 2600 lbs. per square inch, of a mixture consisting of about 40% ground smokeless powder, about 20% potassium chlorate and about 40% lead sulphocyanate.

4. A detonator as in claim 2, characterized by the ignition medium thereof consisting of the following—about .4 gram, pressed up to about 1300 lbs. per square inch, of a mixture consisting of about 74% selenium dust and about 26% peroxide of barium.

5. A detonator as in claim 2, characterized by the ignition medium thereof consisting of the following—from about .15 gram to about .25 gram, pressed up to about 2600 lbs. per square inch, of a mixture consisting of about 40% barium nitrate, about 10% magnesium powder, about 25% tetryl and about 25% lead hypophosphite.

6. A compound detonator as in claim 21, whose base charge consists of tetryl and whose primary charge consists of nitromannite alone or admixed with other solid explosives less sensitive to friction and impact than mercury fulminate, lead azide and the like.

7. A detonator as in claim 2, whose primary charge consists of nitromannite alone or admixed with other solid explosives less sensitive to friction and impact than mercury fulminate, lead azide and the like.

8. A detonator as in claim 2, whose primary charge consists of nitrodulcite alone or admixed with other solid explosives less sensitive to friction and impact than mercury fulminate, lead azide and the like.

9. A compound detonator as in claim 21, whose base charge consists of nitromannite and whose primary charge consists of nitrolactose.

10. A compound detonator as in claim 21, whose base charge consists of tetryl and whose primary charge consists of a 50—50 mixture of nitromannite and nitrolactose.

11. A detonator as in claim 2, whose primary charge consists of an 85—15% mixture of nitromannite and tetryl.

12. The method of initiating a detonator, including a primary charge of a "safety" type of primary detonator composition comprising a solid nitration product of polyhydric alcohol of the general formula $C_nH_{n+2}(OH)_n$, and a confining medium for the said primary charge, which comprises superimposing an ignition medium on the said confined primary charge, bringing about the ignition of the ignition medium so as to effectively initiate the said primary charge; the composition and amount of the said ignition medium being so controlled in its development of heat and pressure as to prevent premature injury of the said confining medium prior to the detonation of the said primary charge.

13. A detonator comprising a shell, a primary "safety" charge in said shell, a confining element for said charge in said shell, and an igniting medium for said charge; the character and amount of the igniting medium being such with respect to the strength of the shell and confining means that said shell and confining means are completely resistant as to impairment of the confinement of the primary charge under the heat and pressure developed within the shell up to the time of detonation of the primary charge.

14. In a detonator comprising a "safety" type of primary detonator charge and a confining means for the said primary charge, an inflammable, deflagrating ignition medium that evolves less heat and gas pressure than that required to injure the said confining element within the time required for the said ignition medium to effect detonation of the said primary charge.

15. A detonator comprising in combination a shell, a primary charge of a "safety" type of primary detonator composition consisting of a solid explosive of the general formula $C_nH_{n+2}(NO_3)_n$ confined in said shell, and an ignition medium for the primary charge consisting of the following—from about .04 gram to about .08 gram, pressed from zero up to about 2600 pounds per square inch, of a mixture consisting of approximately 40% ground smokeless powder, approximately 20% potassium chlorate and approximately 40% lead sulphocyanate.

16. A detonator comprising in combination a metal shell having a suitable inside diameter for conventional types of safety fuse of about .222 inch, a primary charge of a "safety" type of primary detonator composition confined in said shell, and an ignition composition disposed outwardly of said primary charge consisting of a mixture of ground smokeless powder, potassium chlorate and lead sulphocyanate.

17. A detonator comprising a primary charge of a "safety" primary detonator composition con-

sisting of a solid explosive of the general formula $C_nH_{n+2}(NO_3)_n$, a confining means for the said primary charge, and an ignition medium consisting of an inflammable deflagrating material of such character and in such amount that the said ignition medium develops sufficient heat to effectively initiate the primary charge without developing sufficient heat and pressure to injure the said confining means prior to the detonation of the said primary detonator charge.

18. A detonator comprising a shell, a primary charge of the "safety" type confined therein, a confining capsule for the said primary charge within the shell and a hot flash composition of such material and such amount that the flash delivered thereby is sufficiently hot to effect detonation of the primary charge but not hot enough, and the pressure generated thereby insufficient to injure or dislodge the confining shell and capsule within the time required to effect detonation of the primary charge.

19. A detonator comprising in combination, a confined primary explosive charge that is free of any ingredient that is as sensitive to friction and impact as mercury fulminate, lead azide or diazodinitrophenol, and an inflammable deflagrating medium for the effective initiation of the said primary charge; the heat and pressure generated by said ignition medium being incapable of prematurely injuring the confinement of the said primary charge prior to the detonation of said primary charge.

20. A detonator comprising, in combination, a primary explosive charge that is free of any ingredient that is as sensitive to friction and impact as mercury fulminate diazodinitrophenol or lead azide, a confining means for the said primary charge, and an ignition medium for the effective initiation of the said primary charge consisting of a charge of inflammable deflagrating material super-imposed upon the said primary detonator charge, the said ignition medium being of such character and in such amount that the heat and pressure produced by its deflagration are incapable of prematurely melting or otherwise injuring the said confining means prior to the detonation of the said primary charge.

21. A compound detonator comprising a shell, a base charge therein of an explosive that is free of any ingredient that is as sensitive to friction and impact as mercury fulminate diazodinitrophenol or lead azide, a primary charge of a "safety" type of primary detonator composition confined in said shell outwardly of the base charge, a confining capsule within the shell and bearing upon said primary charge, and an ignition medium consisting of an inflammable deflagrating material of such character and in such amount that the said ignition medium develops sufficient heat to effectively initiate the said primary explosive charge but insufficient heat and pressure to prematurely soften, melt, burst or injure either the confining shell or capsule prior to the detonation of the said primary charge.

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