Nov. 19, 1968 W. F. MICHAEL III 3,411,446

IGNITER CORD

Filed June 9, 1967

Fig. 1

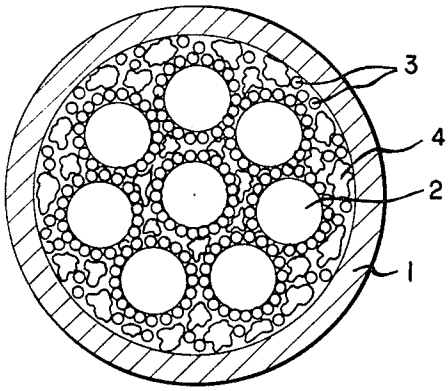
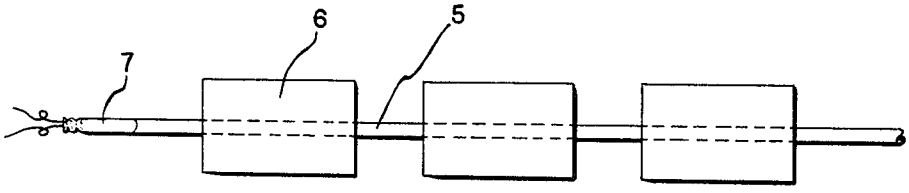


Fig. 2



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United States Patent Office 3,411,446 Patented Nov. 19, 1968

3,411,446

IGNITER CORD

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Filed June 9, 1967, Ser. No. 644,872
9 Claims. (Cl. 102—27)

ABSTRACT OF THE DISCLOSURE

This invention relates to a flame-sensitive igniter cord comprising a sheath of a ductile, malleable metal, e.g. lead, and substantially coaxial thereto and within the sheath a continuous column of a core composition of, by weight, from at least about 20% to less than about 50% lead azide explosive and the balance particulate metal wherein at least about half the particulate metal is magnesium. Particulate metal is present in a size range wherein large particles between about 100 to 250 microns and small particles between about 1 to 75 microns are admixed with lead azide. The explosive composition of the igniter cord has a core loading of at least 0.05 grain per foot and the total core composition has a distribution of about from 0.25 to 25 grains per foot of length of said sheath.

Background of the invention

For many years, propellant and rocket ignition engineers have recognized the necessity for a rapid, lightweight, and uniform ignition system to insure optimum performance of the propellant charge and motor systems. Although major contributions have been made toward this goal, e.g., by the provision of igniter cords such as described in U.S. Patents Nos. 2,974,596, 3,062,147 and 3,320,882, assigned to the present assignee, a need still exists for an igniter-propagating cord which is safe to handle and store, which will reliably bring about the desired rapid ignition of the propellant compositions with a minimum of brisance and violence to the components of the assembly in which it is to be used and is flame sensitive. An igniter cord is particularly needed which has low brisance and yet will ignite compositions which are of marginal ignitability, for example smoke pellets or bombs comprising red dye, potassium chlorate, sulfur, sodium bicarbonate and cellulose nitrate, directly without the necessity of an igniter mix on the surface of the central core.

Summary of the invention

In accordance with this invention such a flame-sensitive igniter cord is now provided which comprises a ductile, malleable metal sheath containing substantially coaxial thereto a continuous column of a core composition of, by weight, from at least 20% to less than about 50% lead azide explosive, the balance particulate metal with the proviso that at least about half the particulate metal is magnesium and particulate metal is present in a size range wherein large particles between about 100 to 250 microns and small particles between about 1 to 75 microns are admixed with lead azide, the explosive composition has a core loading of at least 0.05 grain per foot and the total core composition has a core loading of from 0.25 to 25 grains per foot of sheath length. The igniter cord preferably contains a mixture of two different particle size ranges of metals wherein 40% to 60% of the particulate metal is between 100 and 250 microns and the balance between 1 and 75, and preferably 15 to 60 microns. Generally, the size ratio of large to small particles is at least 2.5 to 1. Most preferably, when the igniter cord contains another particulate metal, e.g. aluminum, in addition to magnesium, the magnesium is of the larger particle size. Quite surprisingly, igniter cords containing relatively minor amounts of lead azide function effectively and reliably when at least half the particulate metal mixed with said azide is magnesium, alone or with another particulate metal, when the metal particles have two different particle size ranges. Although it is not desired to limit this invention by theory, the increased igniting ability of the ignition cords of the present invention can be, in part, attributed to formation of a plasma upon detonation of the lead azide and vaporization of the small and large metal particles that are thrown out onto the surface to be ignited through this plasma. This seems to provide an ignition front of greater heat and duration than that provided by ignition cords used heretobefore.

Brief description of the drawing

FIGURE 1 is a cross-sectional view of a particularly preferred igniter cord which employs metal particles, e.g., aluminum and magnesium, of different particle size distribution.

FIGURE 2 is a sectional view of an assembly which makes particularly good use of the ignition-propagating cord of this invention as an igniter for smoke pellets.

Description of preferred embodiments

The igniter cord of the present invention contains lead azide in certain amounts with magnesium having a certain particle size range alone or in admixture with other particulate metals. The lead azide is present in minor amounts of, by weight, at least about 20% to less than about 50%, and preferably 35% to 45%, of the core composition, the balance particulate metal of which at least about half is magnesium. Lead azide imparts flame sensitivity and low brisance to the igniter cord which are required properties for many applications.

The lead azide used for nonviolent low brisant action is preferably of high purity, e.g. that having a lead azide content of about 98.5% which is commercially known as RD–1333 or RD–1343 lead azide and is more particularly described on pages A557 to A563 of the Encyclopedia of Explosives and Related Items, volume 1, published by Picatinny Arsenal, Dover, N.J. This degree of purity is desirable since it makes possible closer control of the composition of the mixture and does not introduce extraneous diluents which might have a deleterious effect on the propagation characteristics of the cord. However, dextrinated lead azide may also be used.

The ignition cord of lead azide-particulate metal can also contain minor amounts, e.g. up to about 10%, and usually not more than 5%, based on the total weight content of the explosive composition of other crystalline particulate high explosives in admixture with lead azide. For example, representative cap-sensitive materials such as RDX, HMX, PETN and TNT can be mixed with lead azide. However, in order that the particular beneficial effects of the lead azide-magnesium mixture is not lost, usually not more than about 5% of a cap-sensitive high explosive (based on total weight of explosive) will be used with lead azide.

It is necessary to use the particulate metal magnesium, alone or in combination with other suitable particulate metals, to obtain the unexpected results of rapid ignition of a propellant composition or smoke bombs, with or without an igniter coating. It is necessary that at least about half of the particulate metal in the explosive composition is magnesium. Furthermore, the particulate metal, whether it be magnesium alone or magnesium with another particulate metal, such as aluminum, must have two different particle size ranges wherein the large particles are between about 100 to 250 microns and small particles are between about 1 to 75, and preferably 15 to 60 microns. Preferably, when a mixture of particulate metals

is used the magnesium is present in the larger particle size range. Usually, the size ratio of large particles of particulate metal is at least 2.5 to 1. Generally, about 40 to 60% of the particulate metal is between 100 and 250 microns and the balance between 1 and 75 microns.

The effective, reliable ignition effect of cords containing such a low percentage of lead azide and such a high percentage of particulate metal, primarily magnesium, is surprising because it has generally been accepted that the metal particles act as a heat sink and, consequently, absorb energy which could be used to ignite the grain. However, it has been discovered that flame-sensitive ignition cords need only contain from about 20% to less than about 50% lead azide provided that at least about half the particulate metal mixed with the lead azide is magnesium and the particulate metal has two different particle size ranges, the larger being between about 100 to 250 microns and the smaller between 1 to 75 microns. As the particulate metal, various metal powders including aluminum, boron, titanium, zirconium, tellurium, selenium, palladium, zinc, antimony and cadmium as well as mixtures thereof can be used in combination with the required magnesium, provided, of course, that at least about 50% of the particulate metal is magnesium. Two different particle size ranges of the particulate metal or metals in the size ranges mentioned above is necessary. Particularly effective igniter cords are obtained when 40 to 60% of the magnesium particles, based on the total metal content are from 100 to 250 microns in particle size and the balance of the metal which preferably is magnesium or aluminum, is from 1 to 75, preferably 15 to 60 microns in particle size. Although magnesium may be present in either the large or small particle size, especially good results are obtained when magnesium has the larger particle size ranges. Suitable metal shapes which may be utilized are, for example, ground particles, atomized pellets, band saw dust, flakes, metal shavings or rotary fillings. It has been found that aluminum powder of which the major fraction is 35 to 60 microns in particle size is particularly suitable for use with high purity lead azide and magnesium of 100 to 150 micron particle size. Other particulate, comminuted forms of aluminum, e.g., grained aluminum, atomized aluminum, and flake-like aluminum powder, can also be used. The particulate metal can be a mixture of two or more grades of comminuted magnesium metal. A particularly preferred igniter cord comprises 35 to 45% lead azide, 55 to 65% of a mixture of magnesium and aluminum in about equal parts by weight, the particles of magnesium being from about 150 to 250 microns and the aluminum particles being about 15 to 60 microns.

Actuation of the cord by electric or nonelectric initiator, e.g., a flame or spark, causes ultrarapid propagation, e.g. at about 1200–3000 meters/second, of the ignition stimulus down the length of the grain or charge adjacent to the cord so that substantially simultaneous, sustained deflagration of the entire internal surface of the propellant occurs. This simultaneous deflagration results in an immediate actuation of the propellant. The ignition-propagating cord of this invention gives excellent results with respect to its igniting ability and the velocity at which the ignition stimulus is transmitted. The desired velocity, i.e., 1200 or more meters per second, is obtained when the cord contains at least about 0.05 grain of lead azide per foot of length. By varying the composition and distribution of the mixture of high explosive and particulate metal, which is predominately magnesium, within the metal sheath not only the velocity of transmittal of the ignition but also its sustained igniting ability can be controlled. When the cord contains magnesium and from at least about 0.05 grain of lead azide per foot of length, the distribution of the mixture can be varied upward from about 0.25 grain of total composition per foot without deleterious effects upon either the velocity or igniting ability of the cord. The use of less than about 0.25 grain of mixture per foot is generally not feasible, since the energy of cords containing the mixture at such low distribution for most purposes does not consistently insure reliable ignition of the propellant grain or charge. For most applications, the core loading (distribution) of the mixture in the cord will not exceed about 25 grains per foot of sheath length, and preferably where nonviolent, nonbrisant ignition is particularly desired, the core loading will not exceed about 20 grains per foot and, generally, will not be less than about 1 grain per foot.

In order to describe the invention in still greater detail reference is now made to FIGURE 1. In this figure, **1** designates the metal sheath typically of lead, **2** indicates particles of lead azide, **3** indicates relatively small particles typically of aluminum, and **4** indicates relatively larger particles, e.g., of magnesium. The ratio between particle sizes of the metals is greater than about 2.5. All metal particles can be magnesium alone or mixed with other metal particles such as aluminum, boron, titanium, zirconium, tellurium, selenium, palladium, zinc, antimony or cadmium.

FIGURE 2 shows one preferred use of the ignition cord of this invention. The cord **5** is threaded through an axial aperture in smoke pellet **6**, several of such pellets being strung along the cord. A squib **7** is affixed to one end of the cord as a means of actuating the cord. The cord also may be used to ignite rocket propellants, gas generator propellants for auxiliary power units, artillery gun charges, mortar charges, cartridge activated devices, oil well perforating guns, cannons, etc. Such ignition is achieved readily without the need for an igniter coating or column in the main propellant charge as has been required heretofore.

The ignition propagation cords of this invention are prepared by filling a tubular sheath which preferably is of a relatively heavy-walled ductile metal, such as lead, a lead alloy or aluminum, with a certain quantity of a mixture of the lead azide and particulate metal comprising magnesium, preferably, but not necessarily, a grained mixture, and subsequently drawing, swaging, or rolling the tube until substantially the desired distribution of the mixture is obtained. Of course, the ductile metal selected should not be reactive with any component of the mixture under predicted conditions of storage and handling of the cord. Inasmuch as one of the most desirable properties of a propellant igniter is a minimum of residue, lead is highly desirable as the sheath material since the hot metal particles which are produced by action of the explosive particles are very small and vaporize to a great extent such that only a small amount of residue and "trash" remain. The small metal particles produced by actuation of the cord actually scour and clean the propellant surface and allow the cord to ignite wet, dirty, or otherwise inhibited propellant grains.

The weight and thickness of the ductile metal sheath used will vary. Naturally, at low loadings and with low proportions of high explosive compound, a thinner sheath will be used than at higher loadings. In general, the ratio of thickness of the sheathing in inches to core loading in grains per foot will be at least about 0.010. For example, the thickness of a lead sheath is usually about 0.020 inch at a core loading of 2 grains per foot thus insuring complete fragmenting of this sheath and reliable initiation of the propellant charge.

The following examples serve to illustrate specific embodiments of the detonating ignition cord of this invention.

Example 1

A mixture is formed comprising 60% of RD–1333, high purity lead azide and 40% aluminum having a particle size of about 20 to 53 microns (100% passes a 270 mesh screen). This blend is combined with a small amount of a 7% solution of pyronitrocellulose in butyl acetate (50 g. mixture/10 cc. solution) the mixture becoming substantially completely wetted by the solution. The paste so formed is then pushed through a 42 Tyler

mesh screen of bolting cloth and dried 8 hours at 120° F. The dried powder is cooled, then passed through a 28 mesh screen to break up lumps. 71.5 parts of this mixture is combined with 28.5 parts of 70–80 mesh (177 to 210 micron) magnesium metal. The mixture, which comprises 43 parts lead azide, 28.5 parts magnesium, and 28.5 parts aluminum, has a loading density of about 1.13 g./cc. is vibrated into a lead tube 13 inches long, 0.29 inch in inner diameter and 0.500 inch in outer diameter. The tubing is drawn out through a series of dies into a tube 0.096 inch in outer diameter, 0.040 inch inner diameter, the core loading being 7 grains per foot. The ignition-propagating cord detonated, when actuated by a squib, at 2100 meters/second and in each of six attempts successfully ignited smoke pellets comprising 36.9% red dye (Military Spec D–3718–A), 32.1% potassium chlorate, 12.4% sulfur, 16.6% sodium bicarbonate and 2% cellulose nitrate (12.2% nitrogen).

The cord is drawn to a core loading of 2.6 gr./foot. When tested this cord detonates at 1435 meters per second and ignites smoke pellets in each of twenty-five attempts.

At a core loading of 15 grains/foot cord prepared as above detonates at 2220 m./sec. and successfully ignites smoke pellets in each of three attempts.

Example 2

The procedure of Example 1 is repeated and sixty parts of RD–1333 lead azide and 40 parts of 20–53 micron magnesium are mixed and grained. Sixty parts of this grained mixture is then combined with 40 parts of 149 to 105 micron magnesium powder. The blended powder is loaded into a lead tube as in Example 1 and drawn down to form cord having an outer diameter of 0.064 inch and a core loading of 5.9 gr./foot; the core comprises 43 parts RD–1333 lead azide, 28.5 parts of 20–53 micron magnesium and 28.5 parts of 149 to 105 micron magnesium. The cord detonates at 1880 m./sec. and reliably ignites smoke pellets.

I claim:

1. A flame-sensitive igniter cord consisting essentially of a ductile, malleable, metal sheath containing substantially coaxial thereto a continuous column of a core composition of, by weight, from at least 20% to less than about 50% lead azide explosive, the balance particulate metal with the proviso that at least about half the particulate metal is magnesium and particulate metal is present in a size distribution wherein large particles between about 100 to 250 microns and small particles between about 1 to 75 microns are admixed with lead azide, the explosive composition has a core loading of at least 0.05 grain per foot and the total core composition has a distribution of from 0.25 to 25 grains per foot of length of said sheath.

2. A flame-sensitive igniter cord of claim **1** containing particulate metal aluminum.

3. A flame-sensitive igniter cord of claim **2** wherein magnesium is in the larger particle size.

4. A flame-sensitive igniter cord of claim **1** wherein about 40% to 60% of the particulate metal has a particle size of between 100 to 250 microns.

5. A flame-sensitive igniter cord of claim **4** wherein magnesium has a particle size of between about 100 to 250 microns.

6. A flame-sensitive igniter cord of claim **1** containing 35 to 45% lead azide.

7. A flame-sensitive igniter cord of claim **6** wherein the small particles of particulate metal are between about 15 to 60 microns.

8. A flame-sensitive igniter cord of claim **1** containing not more than about 10%, based on the total weight content of explosive, of particulate high explosive.

9. A flame-sensitive igniter cord consisting essentially of a lead sheath containing substantially coaxial thereto a continuous column of a core composition of, by weight, from 35 to 45% lead azide explosive, the balance particulate metal with the proviso that at least about half the particulate metal is magnesium having a particle size between about 100 to 250 microns and the balance aluminum having a particle size between about 15 to 60 microns, the larger particles constituting about 40 to 60% of the metal, the explosive composition has a core loading of at least 0.05 grain per foot and the total core composition has a distribution of from 1 to 20 grains per foot of said sheath.

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