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AMMONIUM NITRATE-ALUMINUM EXPLOSIVE

Filed March 17. 1961

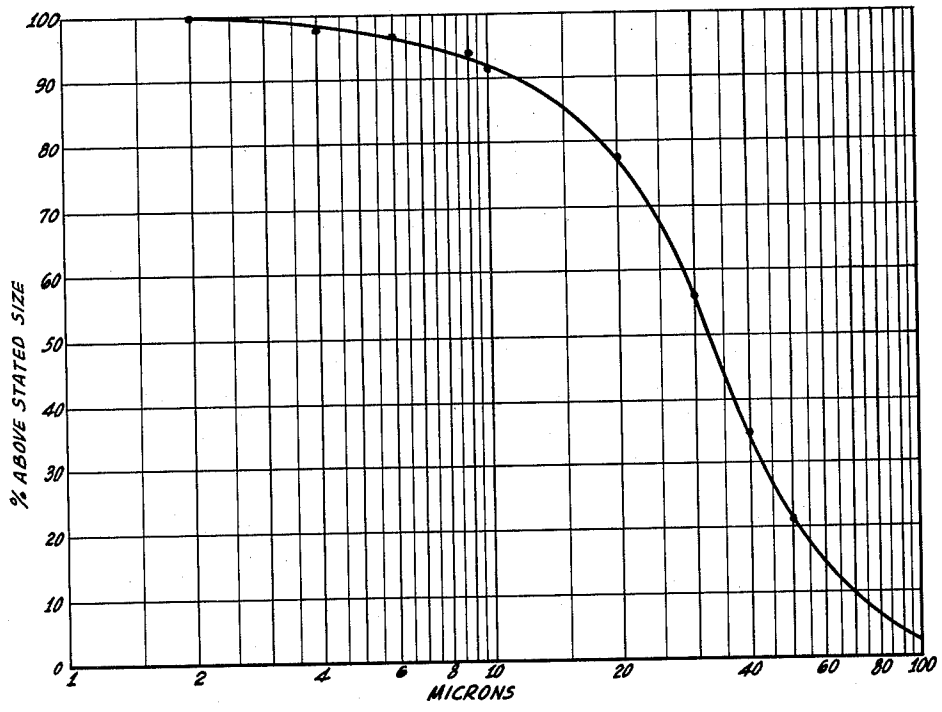


FIG. 1

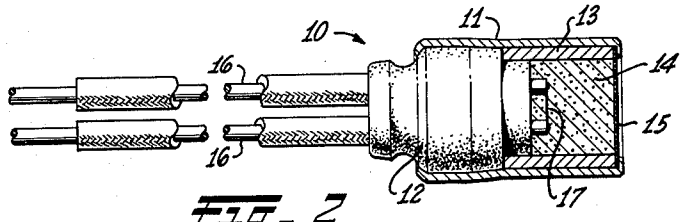


FIG. 2

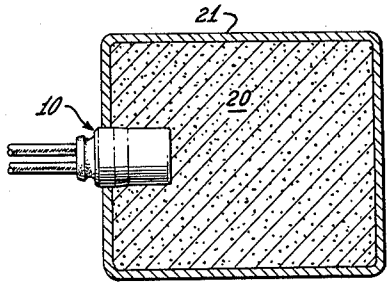


FIG. 3

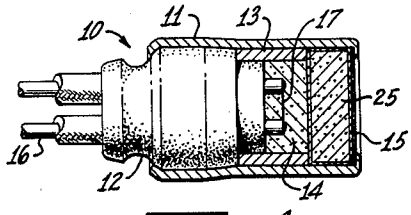


FIG. 4

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AMMONIUM NITRATE-ALUMINUM EXPLOSIVE

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This invention relates to explosives. More particularly it relates to an explosive in which ammonium nitrate is the principal or only oxidizer and aluminum (or other suitable metal) in finely divided form is the principal or only fuel or reducing agent, such explosive being suitable for use in a detonator or other explosive device wherein the explosive charge is initiated by an exploding bridgewire.

The exploding bridgewire system of detonation or initiation of explosive, propellant or like materials has arisen as an answer to the need, in military rockets and missiles and in space craft, for an initiator which does not employ a conventional primary explosive such as lead azide, lead styphnate or a fulminate. The conventional primary explosives serve the purpose of detonating a larger body of less sensitive explosive; of initiating a train of explosive, propellant and/or deflagrating material; or of performing an initiating function in some other like system. However, such primary explosives are overly sensitive and may lead to premature initiation with resultant destruction of the device.

The exploding bridgewire system has been developed to circumvent the need to employ a sensitive primary explosive. An explosive bridgewire (or EBW) system employs a wire of very small diameter through which a short pulse of very high current density is passed, which melts the wire and vaporizes it. The resulting plasma is itself a conductor. A large amount of heat is suddenly liberated and a shock wave is created, the combined effect of which is to initiate an adjacent explosive which may be considerably less sensitive than the conventional primary explosives. Electrical energy to create the necessary pulse of current is stored in a suitable circuit, such as a circuit having a bank of condensers which are charged and then discharged on demand.

Ammonium nitrate-aluminum explosive mixtures (the so-called "ammonals") have been used for this purpose. They are advantageous for this purpose because they are not as sensitive to impact nor to moderate heat as the primary explosives. However it has been difficult heretofore to prepare ammonium nitrate-aluminum mixtures which are sensitive to an EBW yet are adequately insensitive to certain rigorous tests such as impact tests and exposure to a rather high degree of heat which is short of the heat created by an exploding bridgewire. In service such systems (an EBW with an initiating explosive in the form of ammonium nitrate and aluminum) are subject to severe impact, and stray currents may heat the bridgewire to a rather high temperature without exploding it.

It has been difficult to prepare ammonium nitrate-aluminum mixtures which are, (1) initiated by an EBW, (2) resistant to impact and (3) insensitive to a hot wire. Thus, when it is sought to make the explosive sensitive to an exploding bridgewire by reducing the particle size of the aluminum the explosive is overly sensitive to impact and/or to a hot wire. Moreover, ammonium nitrate is hygroscopic and its tendency to absorb moisture causes the explosive to deteriorate and to become insensitive to an exploding bridgewire.

It is an object of the present invention to provide improvements in explosives.

It is another object of the invention to provide improvements in ammonium nitrate-aluminum explosives.

It is a particular object of the invention to provide ammonium nitrate-aluminum explosives which have a reduced tendency to deteriorate in storage as compared to such explosives heretofore available, which are sensitive to an EBW system and which are not overly sensitive in other respects, e.g., being resistant to impact and to a hot wire.

Another particular object of the invention is to provide an EBW device having an ammonium nitrate-aluminum mixture as an initiating explosive and which avoids at least some of the disadvantages of EBW devices heretofore used which have employed ammonium nitrate and aluminum as an initiating explosive.

It is a more general object of the invention to improve upon ammonium nitrate-metal explosives generally.

The above and other objects of the invention will be apparent from the ensuing description and appended claims.

In accordance with the present invention, ammonium nitrate and aluminum are mixed in suitable proportions, each in finely divided condition. The ammonium nitrate is preferably of high purity, e.g., not less than about 99.5% NH_4NO_3. Reagent grade ammonium nitrate is preferred. The aluminum is in flaked form and contains very little foreign material such as fatty or oily substances, although a thin coating of fatty material is permissible. It is important that the flakes of aluminum be substantially devoid of an oxide coating or that they have, at most, a very thin coating of oxide. A pyrotechnic grade of aluminum is preferred which is non-pyrophoric, which contains not more than about 1.5% of oily or greasy matter and which has a substantially oxide-free surface.

A suitable method of making flaked aluminum is to subject aluminum to a shearing action in the presence of an oily or greasy material such as a fatty acid (e.g., stearic acid or oleic acid) or a hydrocarbon oil. This forms an oily or greasy coating on the aluminum particles which prevents, or which greatly limits oxidation of the aluminum particles. If the oily or greasy coating is not excessive, it will not act to inhibit the effect of an EBW.

The proportions of ammonium nitrate and aluminum may vary considerably e.g., on the basis of 100 parts total, there may be 10 parts or less of to 25 parts or more of aluminum, the balance being ammonium nitrate. (All parts and percentages herein are by weight based on the finished mixture, unless otherwise stated.) Preferably about 15 to 20 parts of aluminum and 85 to 80 parts of ammonium nitrate are employed.

Both the ammonium nitrate and the aluminum should be finely divided, and if they are subjected to careful grinding and milling operations to reduce the particle size and to intimately blend the fine particles a product of greater energy output is obtained.

The ammonium nitrate, prior to the final grinding and milling operations, preferably has a particle distribution as follows (U.S. Standard Mesh):

10% minus 60 mesh plus 140 mesh
55% minus 140 mesh plus 230 mesh
35% minus 230 mesh

The flaked aluminum, prior to the final grinding and milling operations, preferably has a particle distribution according to the Coulter technique, approximately as follows:

99% greater than 1 micron
4% greater than 90 microns
50% greater than 32 microns and 50% less than 32 microns

The Coulter technique is described in an article by Robert H. Berg entitled "Electronic Size Analysis of Sub-sieve Particles by Flowing Through a Small Liquid Re-

sistor," published by American Society for Testing Materials, Special Technical Publication No. 234 (1958) as part of a Symposium on Particle Size Measurement, pages 245–255.

Referring to FIGURE 1 of the drawings, a curve is shown plotting particle sizes (in microns) of the aluminum as abscissae against percentages above the stated size as ordinates. The micron dimensions shown are derived by the Coulter technique and are the radii of spheres of equivalent volume.

The ammonium nitrate is then subjected to separate grinding and then the ammonium nitrate and flaked aluminum are placed in a V cone blender with rubber lined steel balls and subjected to blending.

These careful grinding and milling steps are optional and may be replaced by conventional mixing and blending but, as stated, the preferred procedure produces a mixture which has a higher energy output.

In addition to flaked aluminum, any other metal may be used which is sufficiently reactive with ammonium nitrate, which is in flaked form, which is of suitably small size and which has a surface free (or substantially free) of oxide coating. For example, flaked magnesium, zirconium and cerium may be used, also flaked alloys of these and other metals. Flaked magnesium is more sensitive to a hot wire than flaked aluminum, and certain metals may require a higher energy input to the bridgewire but some of the advantages of the invention are applicable to such other metals. However, aluminum is the preferred metal.

We have found that the mixtures of the present invention, more particularly ammonium nitrate and aluminum, are sensitive to an exploding bridgewire and are, therefore, suitable for use in an EBW system; that they have excellent storage qualities and do not tend, nearly as much as the ordinary ammonals, to deteriorate in storage; and that the preferred mixtures pass a number of safety tests including an impact test and hot wire tests, so that they are much safer to use with an EBW than ammonial mixtures used heretofore.

The following specific example will illustrate the practice and advantages of the invention:

Example 1.—A mixture was prepared of 20 parts by weight of aluminum and 80 parts by weight of ammonium nitrate. The ammonium nitrate was reagent grade containing not more than about 0.1% impurities and having a particle distribution (Standard mesh) as follows: 10% through 65 mesh and retained on 150 mesh; 55% through 150 mesh and retained on 250 mesh; and 35% passing 250 mesh. The aluminum was pyrotechnic grade, flaked aluminum containing not more than about 0.5% of oily or fatty material or of other impurities soluble in organic solvents. It had a particle distribution (Coulter method) as described above. The ammonium nitrate was subjected to grinding and was then added with the aluminum to a cone blender along with rubber lined steel balls and the mixture was subjected therein to milling and blending.

Referring now to FIGURE 2, wherein is shown a test initiator charged with a mixture of the invention, the device is generally indicated by the reference numeral **10** and it comprises a metal casing **11** within which is secured a header **12**. Also within the casing **11** is a metal sleeve **13** within which is a charge **14** of the explosive mixture of the invention. The lower end of the device is closed by a tape **15** which can be readily ruptured. Insulated wires **16** are shown which extend through the header **12** and the ends of which are bridged by a bridgewire **17** of very small diameter.

As is well known in the art a device of this character, wherein the wire **17** is of proper dimensions and composition, is provided with a source of electrical energy such as a circuit including a bank of charged condensers which are caused to discharge upon command and which create a high potential across the bridgewire **17** and a heavy flow of current therethrough. This melts and vaporizes the wire and releases a large amount of thermal energy and creates a shock wave which detonate the charge **14**.

Numerous test detonators of the type illustrated in FIGURE 1 have been loaded with the explosive mixture of Example 1 and detonated with but very few failures. These test initiators were detonated by a 2,000 volt, 1 microfarad source. Loading densities varied from about 0.60 to 0.72 gram per cc. Moreover, such detonators have passed safety tests such as the following:

A low voltage test employing a 35 volt D.C., 0.1 ohm source impedance, such voltage being applied to the bridgewire. No evidence of functioning of the device exists.

A 500 volt, 1 microfarad test.

The device also safely passes an impact test in which a free-falling 2 kilogram weight strikes a small quantity of the ammonium nitrate-aluminum mixture from a height of 180 centimeters. Also, in a thermal stability test, this material will withstand brief exposures to temperatures up to 325° F. without initiation or degradation.

EBW systems with the preferred ammonium nitrate-aluminum mixture of the invention in contact with the bridgewire are mild detonating systems having a detonation rate of 3400 meters per second. A 500 milligram charge produces 5 to 9 mil dents in a steel plate.

FIGURE 3 illustrates a commercial and military device in which the explosive mixture of the invention is used to initiate a larger charge of less sensitive explosive.

FIGURE 4 illustrates a commercial or military device in which the explosive mixture of the invention is used to ignite a gasless mixture such as a metal oxide and aluminum, which in turn functions to ignite a rocket motor (not shown).

Referring to FIGURE 3, the device is similar to that shown in FIGURE 2 and similar parts are similarly numbered. The casing **11** is itself encased in a body of explosive **20** which is contained in a housing **21**. The mixture **14** in the EBW device **10**, when initiated by the exploding bridgewire **17**, serves to detonate the explosive **20**. The explosive **20** may be any type of explosive such as TNT, which requires detonation to initiate it.

Referring to FIGURE 4, it will be seen that a portion of the ammonium nitrate-aluminum explosive of FIGURE 2 is replaced by a body of material **25** which may be, for example, a mixture of molybdenum trioxide and aluminum. This mixture is more remote from the bridgewire **17** and is ignited by the ammonium nitrate-aluminum mixture **14** when the latter is initiated by the exploding wire **17**. Ignition of the mixture **25** may serve to ignite a core of igniter material within a hollow cylinder of solid fuel in a rocket motor.

It will, therefore, be seen that the present invention provides a novel and very useful explosive mixture and certain novel and very useful explosive devices.

We claim:

1. An explosive mixture of ammonium nitrate and aluminum, the aluminum consisting substantially entirely of finely divided flake aluminum, said mixture being dry, the proportions of ammonium nitrate and aluminum being such that the said mixture is initiated and is completely consumed by an exploding bridgewire device when the bridge wire of such device is brought into contact with said mixture and said wire is caused to explode by the passage of current therethrough in a short time interval and at a high current density.

2. The explosive mixture of claim 1 wherein said ammonium nitrate and aluminum are present in the proportions of about 75 to 90 parts by weight of ammonium nitrate and about 25 to 10 parts by weight of aluminum.

3. The explosive mixture of claim 1 wherein said ammonium nitrate and aluminum are present in the proportions of about 80 to 85 parts by weight of ammonium nitrate and about 20 to 15 parts by weight of aluminum.

4. An exploding bridge wire device comprising a housing, a bridge wire therein of the exploding bridgewire type which, upon passage therethrough of electric current in

a short interval of time and at a high current density, will explode, and a charge of explosive in contact with said bridge wire to be initiated thereby, said charge or explosive consisting substantially entirely of a mixture of finely divided ammonium nitrate and aluminum, said mixture being dry and said aluminum consisting substantially entirely of flake aluminum, the proportions of ammonium nitrate and aluminum being such that said mixture is initiated and is completely consumed by operation of said device by the passage of current through and resulting explosion of said bridge wire.

5. The device of claim 4 wherein said ammonium nitrate and aluminum are present in the proportions of about 75 to 90 parts by weight of ammonium nitrate and about 25 to 10 parts by weight of aluminum.

6. The device of claim 4 wherein said ammonium nitrate and aluminum are present in the proportions of about 80 to 85 parts by weight of ammonium nitrate and about 20 to 15 parts by weight of aluminum.

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