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MOLYBDENUM TRIOXIDE-ALUMINUM EXPLOSIVE AND EXPLODING BRIDGEWIRE DETONATOR THEREFOR

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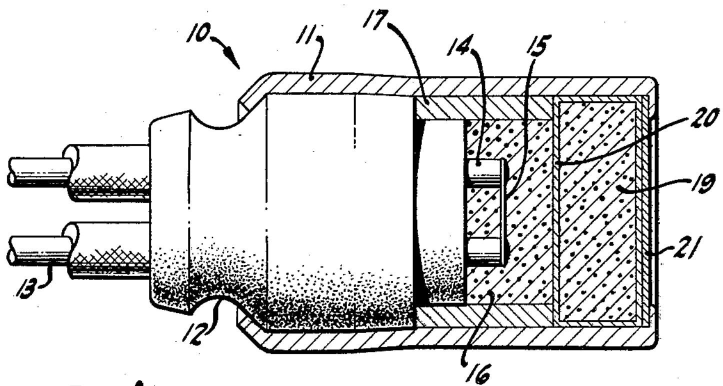

FIG-1

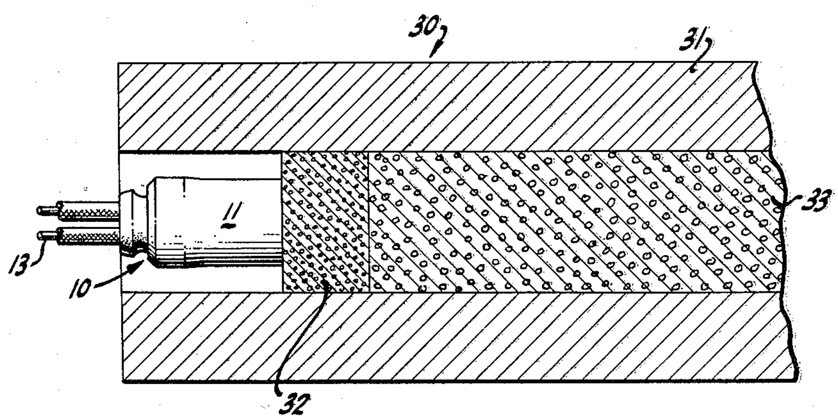

FIG-2

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MOLYBDENUM TRIOXIDE-ALUMINUM EXPLOSIVE AND EXPLODING BRIDGEWIRE DETONATOR THEREFOR

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This invention relates to explosive materials and the like. More particularly it relates to a mixture of an oxidizing agent and a fuel or reducing agent which can be initiated by an explosive, a pyrotechnic composition or an exploding bridgewire; which is adapted to serve as a component in a train of explosive materials; and which is adapted to serve as an igniter to ignite a large body of propellant material, as in a rocket motor.

The oxidizer-fuel mixtures of the present invention have particular application to exploding bridgewire devices (EBW devices).

EBW devices have been developed to an extensive degree since the advent of guided missiles and rockets, space craft, etc. to serve as initiators in lieu of primary explosive devices which use relatively sensitive materials such as azides, fulminates and lead styphnate. These latter materials, which are known as primary explosives, are used in suitable devices as initiators to detonate or ignite less sensitive explosives and the like, such as T.N.T., but their use in rockets and missiles is undesirable because of their sensitivity and likelihood of premature explosion, as from thermal excitation.

EBW devices have, therefore, been substituted for primary explosive devices. An EBW device comprises a wire of small diameter extending between two terminals and a source of electrical energy capable of delivering a short pulse of high energy to the wire such that the wire melts, evaporates and explodes. The release of kinetic and thermal energy caused by such explosion acts to detonate or ignite an explosive or pyrotechnic material in contact with the wire. A typical material employed for this purpose is a mixture of aluminum and ammonium nitrate, which is relatively insensitive, therefore relatively safe to use but which is initiated by an exploding bridgewire. Another typical material used heretofore is a mixture of potassium perchlorate and aluminum.

As is also known in the art, to bring about explosion of a bridgewire it is necessary to supply sufficient electrical energy at a high voltage with a very fast rise time in the voltage curve.

It frequently happens that the EBW device contains a train of two or more materials between the wire and the main body of explosive or propellant. For example, it may be required to employ a mixture of aluminum powder and ammonium nitrate in contact with the wire, and a body of more sensitive material which is initiated by the explosion of the aluminum-ammonium nitrate charge. The second element in the train of materials may be used to ignite a large body of propellant, as in a rocket motor, or it may be used to ignite a larger body of similar igniter material which in turn ignites a rocket motor.

For such purposes it is desirable to provide an oxidizer-reducer mixture (or igniter mixture) which is reliably initiated by the explosion of a typical EBW mixture such as an aluminum-ammonium nitrate charge. (The latter is initiated by an exploding bridgewire as explained above.) It is also desirable that the igniter mixture be relatively insensitive to impact, friction and heat such as it is likely to encounter during service, storage and handling.

Igniter materials have been provided heretofore, e.g., a mixture of a lead oxide such as lead dioxide and aluminum or a mixture of a lead oxide and boron. However, these mixtures are overly-sensitive to impact and friction and they are frequently impaired by high temperatures which are sometimes caused by stray currents through the bridgewire or from other sources.

It is an object of the present invention to provide improved materials of the general character and for the general purpose described.

It is another and more particular object of the invention to provide a mixture of an oxidizer and a reducer or fuel which can be used in an EBW device downstream from the bridgewire, which is relatively safe from ignition or degradation caused by elevated temperatures of the character described, and which is reliably initiated by a suitable EBW mixture when the latter is initiated by an exploding bridgewire, and which will serve to ignite a larger body of similar material and/or the main body of propellant in a rocket.

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

In accordance with the present invention, we provide a mixture of molybdenum trioxide and a suitable fuel or reducer. The preferred fuel or reducer is powered or otherwise finely divided aluminum but any other oxidizable fuel of suitable physical and chemical characteristics may be used, for example, boron, zirconium, magnesium, zinc and iron and mixtures or alloys of these and other materials, in finely divided form. Less susceptible fuels such as silicon and carbon (i.e., fuels which are very difficult to initiate) may be used if a more energetic initiator is used, or if they are mixed with a suitable proportion of a more susceptible fuel such as powdered aluminum or boron. Somewhat more exotic and sensitive fuels such as lithium, sodium and potassium may be used if they are kept in an inert atmosphere. Also metal hydrides such as lithium hydride may be used.

In the case of the preferred mixture (molybdenum trioxide and aluminum), the preferred proportions are approximately 74 parts by weight of molybdenum trioxide and 26 parts by weight of aluminum, which is approximately the stoichiometric ratio, there being a small excess of molybdenum trioxide. Similarly in the case of other mixtures wherein other fuels are used in place of, or in admixture with aluminum, approximate stoichiometric proportions are preferred. However, in all such cases a considerable variation is permissible. In general, the molar ratio of molybdenum trioxide to fuel may vary from as little as one-half the stoichiometric ratio or less to one and one-half times the stoichiometric ratio or more. Where the fuel, as in the case of iron, has more than one state of oxidation, it is assumed that the highest stable oxide is formed.

Mixtures of this character are suited for use in an EBW device wherein the initiating energy is supplied by the explosion of a bridgewire, wherein a less sensitive explosive such as a mixture of aluminum powder and ammonium nitrate is used adjacent the wire, and wherein the molybdenum trioxide-fuel mixture of the present invention is used adjacent the less sensitive explosive but remote from the wire. The reason is that the molybdenum trioxide-fuel mixtures of the present invention are more sensitive to a hot wire than may be frequently desired. However, the molybdenum trioxide-fuel mixture of the present invention can be used adjacent the bridgewire if safety requirements permit. Also, certain mixtures are less sensitive, hence may be used adjacent a wire. Even the more sensitive mixtures, such as the preferred 74%

MoO_3-26% Al mixture may be used adjacent the bridge of a modified exploding bridge device wherein the bridge, instead of being a continuous length of metallic conductor such as a wire of small diameter, is in the form of a dispersion of a conductor in a dielectric material. A suitable bridge of this type consists of aluminum dispersed in an inorganic cement and cast into the form of a rod. Such exploding bridge systems are non-conducting or substantially non-conducting except when high voltages are applied with a fast rise from a sufficient energy source. Accordingly, they are not as likely to be heated by stray currents and to initiate an adjacent explosive material. Therefore, it is within the scope of the present invention to employ the molybdenum trioxide-fuel mixtures herein described and claimed in direct contact with or juxtaposition to an exploding bridge of such modified character.

Among the numerous advantages of molybdenum trioxide-fuel mixtures of the present invention, may be mentioned the following: They are resistant to shock and friction. For example in an impact sensitivity test a 6 kilogram weight was dropped 50 centimeters onto a given quantity of explosive material contained in a cup. In one-third of these tests the molybdenum trioxide-aluminum mixture of the present invention produced sparks, but no explosion occurred. In 75% of identical tests carried out with a potassium perchlorate-aluminum mixture, explosion occurred.

Furthermore, the above molybdenum trioxide-aluminum mixture containing 74% of molybdenum trioxide and 26% aluminum has good temperature characteristics, e.g., it can be heated above 1100° F. without spontaneous ignition and to 900° F. for one hour without affecting its operability in an EBW device.

This mixture and many others within the scope of the invention are essentially gasless. That is to say, the products of combustion are solid rather than gaseous. Nevertheless a hot flame and hot particles are produced which are effective to ignite a rocket motor. This is advantageous because it avoids the production of excessive gas pressure with explosive violence such as might explode a rocket motor. Also the mixture of the invention can be ignited by a small charge, for example by a 0.05 gram charge of an aluminum-ammonium nitrate mixture, which itself is initiated by an EBW.

The mixture of the invention also has good properties with respect to heat output, maximum flame temperature and pressure-time relationship. Thus, the preferred molybdenum trioxide-aluminum mixture has a calorific value of 1,070 calories per gram, a flame temperature of 3,000° C. and a very fast rise of pressure with time when ignited in an EBW device.

As stated, the preferred mixture is relatively sensitive to a hot wire. Therefore, it is preferably not used in contact with the bridgewire of an EBW device. However, it can be used advantageously in contact with the bridge of a modified exploding bridge device as explained above, wherein the bridge is a rod of dielectric material having small particles if conductor dispersed therein. In an exploding bridge device of such character, the bridge is essentially a non-conductor at low voltages of the order of a few hundred volts. Therefore, it is not heated when subjected to stray voltages of that order. Accordingly, the more sensitive molybdenum trioxide-aluminum mixture (that is to say, more sensitive to a hot wire than aluminum-ammonium nitrate) can be used safely in direct contact with the bridge itself. Moreover, there is an advantage in using the molybdenum trioxide-aluminum mixture instead of an aluminum-ammonium nitrate mixture in such a device, in that the thermal and kinetic energy output of a dielectric bridge of the character described is not as great as the energy output of a wire. Therefore the fact that the molybdenum trioxide-aluminum mixture is more sensitive is an advantage because it is more dependably initiated by a dielectric bridge of the character described.

Certain structural embodiments of the invention will now be illustrated with reference to the accompanying drawings in which

FIGURE 1 is a view in longitudinal section of an EBW device in which the molybdenum trioxide-aluminum mixture of the present invention is employed remotely from the wire.

FIGURE 2 is a diagrammatic view showing how a device such as that shown in FIGURE 1 is employed in a rocket motor.

Referring to FIGURE 1 the EBW device there shown is generally designated by the reference numeral **10**. It comprises a metallic body **11** within which is secured a header **12**. Insulated wires **13** are connected to a suitable EBW power circuit (not shown) and at their inner ends the wires **13** are connected to terminals **14** which are connected by a bridge **15**. The bridge **15**, as stated above, is a wire of very small cross-section which, upon application of a sudden pulse of electrical energy, will melt, evaporate and explode, thereby releasing a pulse of thermal and kinetic energy. Adjacent the bridgewire **15** is a charge **16** of explosive material such as a mixture of aluminum and ammonium nitrate which is enclosed by a bushing **17**. This charge of explosive is in direct contact with and is initiated by the wire **15**. More remotely from the wire is a second body of explosive or pyrotechnic material **19** which is the molybdenum trioxide-aluminum mixture of the present invention and is contained in a cup **20** which is closed at one end and which is provided with a sealing cap **21** at its other end.

Initiation of the primary charge **16** will ignite the charge **19** which in turn can be used to ignite a rocket motor or for any other desired purpose.

As stated above, if the wire **15** is replaced by a dielectric bridge of low conductance, the charge **16** in direct contact with the birdge may be the molybdenum trioxide-aluminum mixture of the present invention. In that case the interior of the device to the right of the header **12** (as viewed in FIG. 1) will be filled with the molybdenum trioxide-aluminum mixture.

Referring now to FIG. 2, a rocket motor is there shown which is generally designated by the reference numeral **30**. It contains a body of solid propellant material **31**. An EBW device **10** of the type shown in FIG. 1 is shown in juxtaposition to a charge of igniter material **32** which in turn is in contact with a larger body of igniter material **33**. Typically, the igniter material **32** may be a small body of potassium perchlorate-aluminum mixture or a potassium nitrate-boron mixture of relatively small grain size. The main body of igniter material **33** may be of the same composition as the smaller body **32** but of larger grain size.

Upon application of a suitable voltage, with a sufficiently short rise time from a suitable energy source (e.g., 2000 volts, a rise time less than one microsecond and a 1.0 μf. power source) the EBW device **10** will initiate the body **33** which will initiate the body **32** and ignite the rocket propellant **31**.

It will, therefore, be apparent that a novel and advantageous explosive and/or igniter mixture has been provided and that novel and advantageous explosive and/or propellant devices have been provided which embody such mixture.

We claim:

1. A composition of matter consisting essentially of (1) molybdenum trioxide and (2) aluminum, said molybdenum trioxide and aluminum being in finely divided form and in intimate admixture, and being present in proportions of about one quarter to about three quarters of a mol of molybdenum trioxide per mol of aluminum.

2. An explosive device of the character described comprising a housing; a pair of terminals therein; a bridge of the exploding bridgewire type connecting said terminals; a first body of explosive in contact with said bridge and adapted to be initiated by a pulse of electrical energy

delivered to said bridge as a short pulse at a high voltage and with a short rise time whereby the bridge is vaporized and exploded and releases thermal and kinetic energy sufficient to initiate a charge of PETN; and a second body of explosive in sufficiently close proximity to said first body of explosive to be initiated by said first body but not in contact with said bridge, said second body of explosive consisting essentially of (1) molybdenum trioxide and (2) aluminum, said molybdenum trioxide and aluminum being in finely divided form and in intimate admixture and being present in proportions of about one quarter to three quarters of a mol of molybdenum trioxide per mol of aluminum.

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