

[54] **DELAY COMPOSITION AND DEVICE**

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[51] Int. Cl.**C06c 11/00**

[58] Field of Search**149/37, 2; 102/37.7, 37.4, 102/24, 27, 70**

[56] **References Cited**

UNITED STATES PATENTS

3,297,503	1/1967	Hoffmann et al.	149/37 X
3,329,539	7/1967	Menke.....	149/37

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[57] **ABSTRACT**

The disclosed embodiment of the present invention is a pyrotechnic mixture of a fuel and an oxidizing agent having a predetermined burning rate, thereby forming a delay composition. The fuel consists of zirconium and the oxidizing agent consists of molybdenum trioxide, both of which are in a finely divided form and in intimate admixture, and are present in proportions of about 1/3 to about 2 moles of molybdenum trioxide per mole of zirconium. This composition provides a time delay when employed in a train of pyrotechnic materials. One embodiment of such a train of materials includes a column of the delay composition positioned between corresponding ends of two deflagrating cords.

11 Claims, 3 Drawing Figures

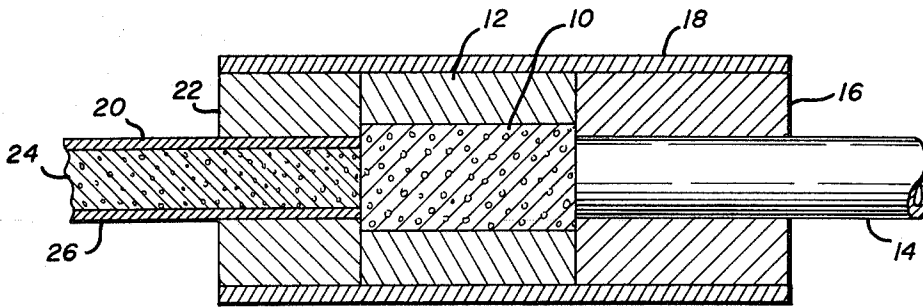


Fig. 1

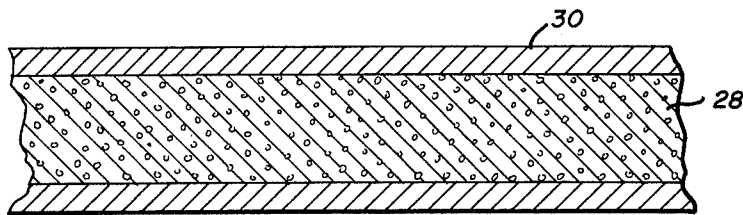


Fig. 2

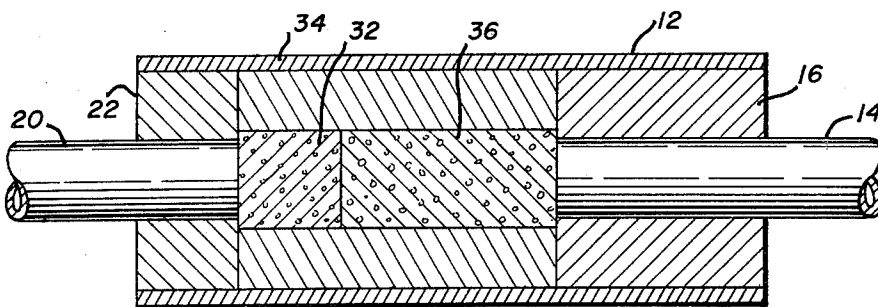


Fig. 3

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DELAY COMPOSITION AND DEVICE

This invention relates generally to a pyrotechnic delay and more particularly to a pyrotechnic composition which is adapted to be employed in a train of pyrotechnic materials as a time delay.

It is desirable in many applications involving pyrotechnics to provide a time delay between two pyrotechnic or deflagrating devices. Pyrotechnic delay devices are normally employed in sequencing systems wherein it is desired to perform a particular function a predetermined time after the occurrence of an event or the performance of another function. For example, a pyrotechnic delay device may be employed in a rocket to ignite a second stage a predetermined time following the burning of a first stage. Such delay devices may also be employed to close an electrical contact or open a valve at a given time after the occurrence of a certain event. In most applications of such time delays, a high degree of reliability and accuracy is required.

Two types of time delay compositions are presently known in the art. The gasless type of time delays, examples of which are commonly called tungsten, manganese, and zirconium-nickel delay compositions normally have burning rates in the order of 0.033 inch per second to 2 inches per second. Burning of the gasless delay compositions produces a relatively small amount of gas, but yields a relatively large amount of residue. A large proportion of the residue which remains agglomerates and only a relatively small proportion remains in a finely divided state. The agglomerated residue cannot be vented from the delay device, thereby causing, by its presence, a change in the burning rate. That is, as the delay composition deflagrates an agglomerated residue is being produced immediately adjacent the reaction zone which interferes with the deflagration process. As a result, the burning rate of such gasless delay compositions is altered by the presence of any agglomerated residue which is produced during the deflagration process.

The second type of delay composition consists of a gassy pyrotechnic; an example of which is potassium perchlorate and aluminum. The gassy delay compositions produce relatively little residue, but yields a relatively large amount of gas. The gassy pyrotechnics have a much higher burning rate than the gasless delay compositions. Because of the large yield of gassy products from the deflagration of such delay compositions, a relatively complicated design is required to permit proper venting of the gases. The gases which are produced from deflagration of such delay compositions interfere with the deflagration process and tend to accelerate the deflagration.

Both of the above described delay compositions suffer from the distinct disadvantage of being extremely sensitive to changes in pressure which occur during the deflagrating process. As a result, such delay compositions become less reliable at higher altitudes, since a larger pressure drop will result from the time of the initial deflagration to the point in time at which the deflagration is vented to ambient pressure. It is not uncommon in such prior known devices for the deflagration to be extinguished immediately after the initial deflagration occurs when such devices are exposed to relatively low ambient pressures. As a result, such devices are not suitable for high altitude, low pressure operating conditions.

In order to overcome the disadvantage in prior known delay devices, special designs have been devised which required more parts and relatively complicated parts and fabrication techniques. The usual pressure change which results from ignition to advanced combustion of delay compositions is in the range of from 1,000 psi to one atmosphere pressure. Without special designs, the combustion of such prior known delays could extinguish as a result of such a pressure drop. Furthermore, the ignition and burning could not be controlled. One such design of delay devices includes the provision of at least one cavity between the ignition source and one end of the delay composition. Such a cavity is separated from the delay composition by a plate having a relatively small opening or orifice therein. The orifice supports pressure drop for a predetermined time period, such that the change in pressure is relatively gradual. If a deflagrating cord is employed as the ignition source, the cavity and plate are provided between one end thereof and one end of the delay composition. The deflagrating cord produces a flash of hot or burning gases through the cavity and orifice to ignite the delay composition. It can be readily appreciated that if such a cavity is not required, the design of the delay device can be greatly simplified.

If the relatively gasless delay compositions which are known in the art are not vented to ambient pressure, the products of combustion (gases) will interfere with the burning process and effectively alter the desired burning rate. If the gassy delay compositions which are known in the art are not vented to ambient pressure, the device which confines such compositions must be provided with a space of free volume which will accept the combustion products. If gases are confined, the burning rate is increased, since any small change in volume which may be caused, for example, by changes in density, manufacturing tolerances, straining of the delay housing by high pressures, etc., will cause a random, nonreproducible change in the burning rate. Designers of gassy delay compositions do not customarily configure delay housings to confine the products of combustion because of these difficulties. Consequently, it can be appreciated that the known gassy delay compositions are not suitable for high altitude applications.

If it is desirable to change the burning rate of such prior known devices, it has been the practice to incorporate within such compositions certain types of additives or to employ off-stoichiometric mixture ratios of the basic components of the composition. For example, additives such as lead styphanate are employed to cause a faster burning rate of the delay composition, since such material is capable of maintaining deflagration in the absence of other materials. An off-stoichiometric mixture can be obtained by adding additional fuel to the composition. Use of such additives or the formulation of such compositions with off-stoichiometric mixture ratios in such prior known delay compositions renders them extremely sensitive to blending techniques and to the accuracy of the mixing ratios.

The undue sensitivity results from the fact that a relatively small amount of an additive will cause a relatively large change in the burning rate. Similarly, if additional fuel component is added to an otherwise stoichiometric mixture, a small addition thereof will provide a relative-

ly large change in the burning rate. If a plot is made of burning rate versus the ratio of fuel to oxidizer, the resulting curve will be relatively steep in the region of a stoichiometric ratio. Accordingly, it can be appreciated that such delay compositions are extremely sensitive to blending techniques and to the accuracy of the mixing ratios. As a result, extremely close blending tolerances and formulation tolerances must be maintained to insure a reasonable degree of accuracy in the burning rate of such compositions.

Accordingly, it is the object of the present invention to provide a delay composition which is insensitive to formulation deviations and/or mixing tolerances.

Another object of the present invention is to provide a delay composition which yields a relatively small amount of gas during the deflagrating process.

Still another object of the present invention is to provide a delay composition, the residue products of its combustion being in a finally divided state and capable of being vented during the deflagrating process.

Yet another object of the present invention is to provide a delay composition which is insensitive to a change in pressure from the point of ignition to a point of advanced combustion thereof.

A further object of the present invention is to provide a delay composition which can be ignited from an ignition source which is in direct contact therewith.

Another object of the present invention is to provide a delay composition which is readily ignitable and such ignition is not sensitive to changes in ambient pressure, such as result from a change in altitude.

Still another object of the present invention is to provide a delay composition which may be employed in a train of pyrotechnic materials and exhibits reproducible vented performance.

These and other objects, features and advantages of the present invention will be more fully realized and understood from the following detailed description when taken in conjunction with the accompanying drawing, wherein:

FIG. 1 is a view in section of an in-line delay unit which employs the delay composition of the present invention;

FIG. 2 is a sectional view of a delay cord which employs the delay composition of the present invention;

FIG. 3 is a second embodiment of an in-line delay unit employing the delay composition of the present invention.

The delay composition of the present invention is formed of zirconium as a fuel and molybdenum trioxide as an oxidizing agent, both of which are in a finally divided state and in intimate admixture. Approximately $\frac{1}{2}$ to 2 moles of molybdenum trioxide per mole of zirconium are employed. This delay composition is substantially insensitive to formulation deviations or tolerances because of the near unity mixture ratios. The burning rate of this delay composition may range from approximately 4-10 inches per second without the use of any additives. A mixture formed of 50 percent by weight of molybdenum trioxide and 50 percent by weight of zirconium exhibited a burning rate of 6.3 inches per second. The products of combustion of this delay composition do not interfere with the deflagration process and are easily vented.

The delay composition of the present invention may be employed in a variety of devices, several of which are illustrated in the figures of the drawing. The device illustrated in FIG. 1 is an in-line delay unit having a relatively short time delay.

A delay composition 10 which may consist of molybdenum trioxide and zirconium in the range of ratios given hereinabove, is pressed into an insert 12. The consolidation pressure, which is in the range of 20,000 psi to 80,000 psi, compacts the composition 10 within the insert 12 such that it becomes self-supporting therein. The end of a deflagrating cord 14 is positioned within another insert 16 such that it is flush with one surface thereof. The insert 16 with the cord 14 are pressed into one end of a sleeve 18. The insert 12 containing the pressed delay composition 10 therein is then pressed into the sleeve 18 such that the end of the cord 14 engages a surface of the pressed composition 10. Finally, the end of another deflagrating cord 20 is positioned within an insert 22 which is, in turn, pressed into the sleeve 19 into intimate contact with the other surface of the pressed delay composition 10. The cords 14 and 20 are identical and are formed of a pyrotechnic core 24 surrounded by and encased in a sheath 26. The pyrotechnic core of each deflagrating cord is in intimate contact with opposite surfaces of the delay composition 10, such that combustion can be transferred therebetween. It will be noted that there is no need for providing a cavity between the end of the deflagrating cord and the delay composition of the present invention.

The deflagrating cords 14 and 20, which are well known on the prior art, support a burning rate of approximately 20,000 inches per second. If a burning front is transmitted through the pyrotechnic core of the deflagrating cord 20, it will initiate the delay composition 10 upon reaching its surface. The velocity of the burning front will decrease to the burning rate of the delay composition 10, for example, 4-10 inches per second. When the burning front is passed through the composition 10 and reaches the end of the cord 14, it will be transferred to the pyrotechnic core thereof and transmitted therethrough at its corresponding burning rate. Accordingly, the composition 10 provides a time delay in the transmission time of the burning front through the device.

The pressure of the burning front will attain a level of approximately 1,000 psi which will be impressed on the delay composition 10. When the pyrotechnic core of the deflagrating cord 20 is completely burned, a vent will be provided through the center of the sheath 26 to ambient pressure. Accordingly, the pressure applied on the delay composition 10 will drop from approximately 1,000 psi to less than one atmosphere within a relatively short time period. However, since such a pressure drop will not affect the ignition and burning of the delay composition of the present invention, no special devices or designs need be employed.

The delay composition of the present invention may also be employed as the material in a delay cord, as illustrated in FIG. 2. As shown therein, a composition 28 which is a form of molybdenum trioxide and zirconium in the range of ratios given here and above, is encased by a metallic sheath 30. In actual practice, the outside diameter of the cord illustrated in FIG. 2 may be as

small as 0.04 inch. The sheath 30 may be formed of aluminum, antimonial lead, copper, silver, or the like material. The delay cord may be initiated at its one end by any type of an ignition charge and will produce an ignition output at its other end.

The delay composition of the present invention is compatible with both a deflagrating cord and standard delay compositions presently known in the art. The delay unit of FIG. 3 illustrates this compatibility of the delay composition of the present invention. As shown therein, a composition 32 formed of molybdenum trioxide and zirconium is supported within one end of an insert 34 and a standard delay composition 36 as supported in the other end thereof. The insert 34 is supported within the sleeve 12 such that one surface of the delay composition 32 is in intimate contact with one end of the deflagrating cord 20 and one surface of the delay composition 36 is in intimate contact with one end of the deflagrating cord 14. The presence of the delay composition 32 enhances the ability of the delay composition 36 to ignite, thereby forming a more reliable delay unit. The delay composition 32 consisting of molybdenum trioxide and zirconium in the range of ratios given here and above has good ballistic compatibility; that is, it is capable of readily igniting the delay composition 36.

The delay composition of the present invention has been found to be insensitive to changes in ambient pressure and, therefore, acceptable for high altitude applications. Because of the near unity mixture ratios, the delay composition of the present invention is substantially insensitive to formulation deviations or tolerances.

The principles of the invention explained in connection with the specific exemplifications thereof will suggest many other applications and modifications of the same. It is accordingly desired that, in construing the breadth of the appended claims they shall not be limited to the specific details shown and described in connection with the exemplifications thereof.

The invention claimed is:

1. A composition comprising molybdenum trioxide

and zirconium, said molybdenum trioxide and zirconium being present in proportions of about one-third mole to two moles of molybdenum trioxide per mole of zirconium.

2. A composition as defined in claim 1, wherein said molybdenum trioxide and zirconium are in a finally divided form and in intimate admixture.

3. A composition as defined in claim 1, wherein said molybdenum trioxide and zirconium are present in proportions of approximately 50 percent by weight of each.

4. A delay device comprising a housing, a delay composition mounted in said housing and formed of molybdenum trioxide and zirconium in proportions of about $\frac{1}{3}$ to 2 moles of molybdenum trioxide per mole of zirconium, and means for initiating combustion at one end of said delay composition.

5. A delay device as defined in claim 4, wherein said delay composition has a compactness achieved by being pressed into said housing with a pressure of approximately 20,000 to 80,000 psi.

6. A delay device as defined in claim 4, wherein said initiating means is in intimate contact with said delay composition.

7. A delay device as defined in claim 4, further including another delay composition mounted in said housing immediately adjacent said first mentioned delay composition.

8. A delay device as defined in claim 7, wherein said initiating means is in intimate contact with said first mentioned delay composition.

9. A Delay device as defined in claim 4, wherein said initiating means includes a first deflagrating cord.

10. A delay device as defined in claim 9, further including a second deflagrating cord, one end of which is mounted adjacent to the other end of said delay composition.

11. A delay cord comprising a sheath and a delay composition mounted in said sheath and formed of molybdenum trioxide and zirconium in proportions of about $\frac{1}{3}$ to 2 moles of molybdenum trioxide per mole of zirconium.

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