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S. ZEMAN ETAL
PYROTECHNIC COMPOSITIONS
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Fig. 1

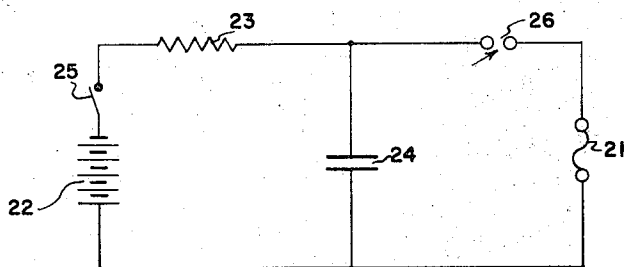
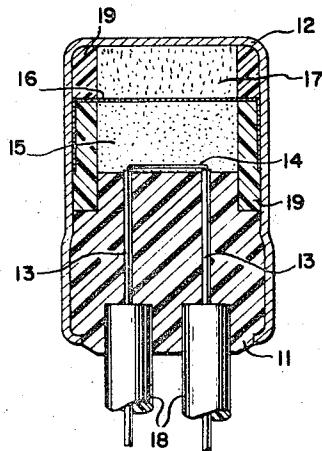


Fig. 2

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PYROTECHNIC COMPOSITIONS

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1 Claim. (Cl. 149—44)

This invention relates to pyrotechnic compositions, and relates particularly to compositions suitable for use in electric squibs or detonators.

Electric squibs or detonators are used in many fields requiring the generation of a small controlled explosion or of a flame for ignition or detonation of a larger explosive or combustible body. These squibs or detonators often rely upon the fusion of a very fine wire, heated electrically, to ignite a thermally sensitive material surrounding the wire. The thus-ignited substance may be employed to ignite one or more intermediate charges to bring about detonation or ignition of a principal body of explosive or combustible material.

The necessity for rapid functioning of squib or detonator devices when even small electrical currents are passed through the igniter wire has necessitated the frequent prior art use in such devices of highly sensitive explosives in combination with igniter wires of high resistance and small cross-section. The danger of accidental ignition of such devices by high temperatures, physical impact, or currents generated in the ignition wire by stray electromotive fields is large.

The recent demand for squibs or detonators for igniting the propellant charge in rocket motors, or for activation of explosive charges initiating stage separation, thrust reversal, destruction, etc., in rocket motors, has emphasized the need to have a highly safe squib or detonation device. The accidental detonation of a squib in the ignition system of a large rocket motor, for example, could be catastrophic.

Thus, the design of squibs or detonators has recently been modified to make use of the so-called "exploding bridgewire." In these squibs, the sudden passage of a current at high current density through an igniter wire is used to cause rapid, explosive, deterioration of the wire. The "explosion" generated by such passage of a short duration pulse of high voltage and current through the ignition wire is used to ignite a pyrotechnic charge surrounding the wire, which charge can be further employed to trigger other charges in an ignition train.

The present invention concerns pyrotechnic compositions for use in such an exploding bridgewire igniter. The compositions are such as will not ignite when the bridgewire is heated or fused by D.C. voltages, static charges, radio frequency energies, or other extraneous sources of electrical energy which cause heating at a low rate of the bridgewire or the pyrotechnic composition adjacent thereto. The compositions further are highly thermally stable, outstandingly immune to accidental ignition by impact, and are resistant to detonation even by the discharge of low voltage pulses through the bridgewire.

The use of the pyrotechnic compositions of the invention in exploding bridgewire igniters permits the functioning of these igniters at times varying from 20 microseconds to several milliseconds, depending on the input energy, over a temperature range greater than from -70° F. to 160° F., and at altitudes of up to more than 300,000 feet.

A better appreciation of the invention and of its many advantages can be had by reference to the accompanying drawings, in which

FIGURE 1 is a front view, partly in section, of one type of exploding bridgewire squib in which the pyro-

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technic compositions of the present invention are useful; and

FIGURE 2 is a diagram of a conventional electrical circuit suitable for use in exploding a bridgewire squib such as is shown in FIGURE 1.

In particular, FIGURE 1 shows an exploding bridgewire squib comprising base plug 11, such as of plastic, partially enclosed within cap 12, such as of metal, and enclosing lead wires 13 which are bridged within the squib by bridgewire 14. Primary charge 15, comprising a composition according to the present invention, is adjacent to bridgewire 14, and is separated by thin, rupturable closure 16, such as of aluminum foil 1 mil thick, from secondary charge 17 within the squib. The secondary charge may comprise conventional ignition or detonating materials such as mixtures of boron and ammonium perchlorate, aluminum and ammonium perchlorate, or lead styphnate. Insulating members 18, which may be of nylon, protect lead wires 13 on their entry and exit from base plug 11. Spacers 19, suitably of a material such as a phenolic resin, circumferentially surround primary charge 15 and secondary charge 17.

FIGURE 2 shows a circuit in which the bridgewire squib is represented schematically by bridgewire 21, which may be, for example, a fine gold wire 2 mils in diameter. The circuit also contains high voltage power source 22, for example generating 1800–2300 D.C. volts, charging storage condenser 24, which may, for example, be of 1 microfarad capacitance, through resistor 23. Switch 25 permits charging of condenser 24, and ionization gap switch 26 permits discharge of condenser 24 through bridgewire 21. In such a circuit, discharge of condenser 24 is achieved by supplying a trigger signal to gap switch 26, causing ionization and permitting current to flow across the gap. Because of the low impedance and inductance of the circuit, a large surge of current can be made to flow through bridgewire 21, causing it to vaporize with explosive violence. In such a circuit, the current flowing through the bridgewire may be at a current density greater than one million amperes per square centimeter, and peak current is reached in less than five microseconds. The bridgewire itself may be of a noble metal such as a platinum-iridium or platinum-rhodium alloy, generally of a diameter of about 2 mils and between 0.05 and 1.10 inch in length.

The pyrotechnic compositions of the invention, which are used to advantage in the exploding bridgewire squib, comprise a finely divided metallic fuel and one or more finely divided inorganic oxidizing agents, optionally in the presence of a finely divided combustible synthetic resin which may function both as an oxidizing agent and as a carrier for the finely divided inorganic substances. As a metallic fuel, a metallic aluminous metal such as aluminum or alloys of aluminum with magnesium, silicon, titanium, or other readily oxidizable active metals can be used. Alternatively, mixtures of finely divided aluminum and finely divided magnesium, silicon, titanium, or other readily oxidizable active metals can be employed.

The finely divided metal or metals are suitably used in the form of metal flakes, in "atomized" form, or as a mixture of these two forms. Atomized materials, particularly aluminum, have the advantage of high purity and high reactivity as compared with flake metals, and are advantageously employed in sizes within a range of 15–35 microns. Smaller particles of an average size of between 5–15 microns are also suitable. Atomized material is somewhat more susceptible to ignition by electrostatic charges because of its lower electrical conductivity as compared with flake metals. For this reason, it is often combined with flake metals such as flake aluminum to alleviate the problem of static sensitivity.

When flake materials are employed, they are preferably so comminuted that about 90 percent of the metal will pass a 325 mesh (44 micron) screen.

The metal fuel is employed in combination with lead monoxide as an oxidizing agent. The lead monoxide oxidizer may be replaced in part with ferric oxide. The inorganic oxidizing materials are preferably finely divided to have a particle size which will pass a 200 mesh (74 microns) screen.

The pyrotechnic compositions of the invention advantageously contain a minor portion, about 3–20 percent by weight, of the finely divided aluminous metallic fuel, and about 97–80 percent by weight of lead monoxide oxidizer. When the lead monoxide is replaced in part by finely divided ferric oxide, the final composition should contain about 10–20 percent by weight of ferric oxide, for best results.

The metal-lead monoxide mixture can also be combined with a synthetic organic resin as earlier mentioned. In particular, the mixture has been advantageously combined with "Teflon" (polytetrafluoroethylene). The "Teflon" powder acts both as an oxidizer and a bulking agent, making the pyrotechnic mixture fluffy and preventing caking or packing due to vibration or handling. It is believed that the electrostatic properties of the polymer also make it hold the finely divided fuel and oxidizer in intimate contact on its surface, promoting their rapid reaction. In such applications, the "Teflon" is suitably finely divided to have a particle size of about 20–50 microns, preferably 35 microns.

Suitably, the inorganic mixture can be mixed with finely-divided polyethylene or polytrifluorochloroethylene ("Kel F") in a similar manner. Also, the inorganic materials may suitably be coated with a thin film of commercial silicone oils by moistening the inorganic mixture with the oils dispersed in a solvent, conveniently hydrocarbon materials such as hexane or benzene. On evaporation of the solvent, the oil is deposited on the inorganic particles as a thin film.

When aluminum and lead monoxide mixtures are combined with a synthetic polymer such as polytetrafluoroethylene, a portion of the lead monoxide is replaced by the polymer such that the final composition contains about 8–15 percent by weight of the polymer.

The mixtures found best for use in bridgewire igniters have the following compositions:

	Percent by weight
Aluminum	3–18
Lead monoxide	82–97

When ferric oxide is used in combination with lead monoxide as an oxidizing agent, the preferred compositions are as follows:

	Percent by weight
Aluminum	5–20
Ferric oxide	10–20
Lead monoxide	60–85

In combination with polytetrafluoroethylene, the preferred compositions are as follows:

	Percent
Aluminum	3–15
"Teflon"	8–15
Lead monoxide	72–89

The compositions above described have many properties which make them particularly suitable for use in exploding bridgewire igniters. Thus, they are extremely stable in long term storage, even at high temperatures. The individual ingredients are relatively inert. Also, the compositions are not prone to detonate when subjected to heat or impact. Finally, the compositions are not hygroscopic.

In other embodiments, the fuel-oxidizer mixtures, particularly those containing "Teflon," can be pressed into pellets or other bulk shapes, with the polymer acting as

a lubricant, binder, and oxidizer. Alternatively, the polymer can be used as a binder in pellet or other compacted forms after moistening with a suitable liquid such as n-hexane. Although such compacted compositions are not specifically adaptable to use in exploding bridgewire igniters, they retain the many safety advantages of the powdered compositions, such as a high ignition temperature, resistance to detonation by impact, etc., and can be employed where ignition is accomplished, for example, by an intense flame from a conventional squib or initiator.

The success of a pyrotechnic composition comprising a weak, stable, oxidizing agent such as lead monoxide in combination with an active metal such as aluminum is believed surprising. Specifically, the reaction of aluminum and lead monoxide, with or without the presence of additional oxidizing agents, gives an "igniting power" that could not be predicted from considerations of thermal output alone. For example, tests have shown that exploding bridgewire squibs containing a pyrotechnic composition of 12 percent flaked aluminum, 12 percent "Teflon," and 76 percent lead monoxide have an ignition delay time of 1 millisecond or less, although they have a heat of explosion of only 478 calories per gram. In comparison, comparable exploding bridgewire squibs containing a conventional mixture of boron and potassium nitrate have an ignition delay time of 5 to 10 milliseconds, although the heat of explosion of this mixture is 1650 calories per gram.

The following specific examples are given by way of illustration, and are not to be construed as limiting on the scope or spirit of the invention.

Example 1

	Parts by weight
Atomized aluminum (5–35 micron)	6.6
Polytetrafluoroethylene powder (35 micron)	11.4
Lead monoxide (200 mesh)	82.0

Example 2

	Parts by weight
Flaked aluminum (325 mesh)	6.6
Powdered polytetrafluoroethylene (35 micron)	11.4
Lead monoxide (200 mesh)	82.0

Example 3

	Parts by weight
Flaked aluminum (325 mesh)	12
Powdered polytetrafluoroethylene (35 micron)	12
Lead monoxide (200 mesh)	76

Example 4

	Parts by weight
Atomized aluminum (35 micron)	10.8
Lead monoxide (200 mesh)	89.2

Example 5

	Parts by weight
Atomizer aluminum (35 micron)	20
Ferric oxide (200 mesh)	20
Lead monoxide (200 mesh)	60

What is claimed is:

A pyrotechnic composition consisting essentially of a fluffy mixture of about 3–15 percent by weight of finely divided aluminum, about 72–89 percent by weight of finely divided lead monoxide, and about 8–15 percent by weight of finely divided polytetrafluoroethylene.

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**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

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August 3, 1965

Samuel Zeman et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 45, for "1.10" read -- 0.10 --.

Signed and sealed this 12th day of July 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

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Commissioner of Patents