United States Patent Office 2,984,558 Patented May 16, 1961

2,984,558

PLASTIC PYROTECHNIC COMPOUND

Edward Rolle, San Diego, and John Q. Tabor, Jr., Los Angeles, Calif., assignors to the United States of America as represented by the Secretary of the Navy

No Drawing. Filed June 10, 1957, Ser. No. 664,858

1 Claim. (Cl. 52—24)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates in general to a pyrotechnic material the rate of combustion of which may be accurately predetermined. More particularly, the invention is directed to a relatively slow-burning plastic compound which may readily be cast or molded at room temperatures without the application of external pressure.

It is customary to manufacture certain types of combustible articles, such for example as flares, safety fuses, and the like, by filling a hollow tube or container with the combustible mixture in powder form (to which a binder may or may not be added) and then subjecting the mixture to a pressure as high as several thousand pounds per square inch. The resulting product has a density dependent upon its composition, upon the degree of moisture present, and upon the amount and duration of the pressure thus applied. The nature of these factors makes them somewhat difficult to accurately control, especially insofar as the degree of ambient humidity is concerned. Hence, pyrotechnic articles fabricated by such a process show quite wide variations in their rate of combustion.

Such variations in burning rate cannot be tolerated in many situations where the article so made is employed as a fuse or timing device, or in the testing of guided missiles or rockets, where specific data as to the performance of the missile is extremely important in dictating possible design changes or modifications. Under such conditions, the missile to be tested may have attached thereto a flare of high luminosity which permits the missile to be tracked by visual and/or photographic methods. The flare is ignited when the missile is launched, and continues to burn for a time sufficient to provide the missile position data desired. To ensure constant burning at high altitudes, as well as reliable ignition at low temperatures, high luminosity, and maximum compactness, the flare is so constructed as to be ignited by exposing the surface of the illuminant to a flame generated by an electrical discharge in a squib filled with some such material as black powder. The squib is held in proximity to the flare illuminant by a protective cap, customarily made of a fusible material which partially melts when the illuminant is fully ignited, at which time both the cap and the squib are ejected and the flare begins to burn at full luminosity as the missile is launched. It is essential that the flare material be fully ignited at the instant of launching, as otherwise tracking during the initial period of missile flight is hampered. On the other hand, ignition obviously should not begin prematurely. It is highly desirable that the squib flame be channeled over the entire surface of the material to be ignited, and that the squib and cap are not ejected before ignition is complete.

While the arrangement set forth above has proven generally satisfactory in practice, the desirability of finding a way to eliminate the fusible flare cap has been recognized. This is due in large part to the fact that this protective cap is ejected in an unpredictable direction at the instant of missile launching, and constitutes a hazard to the launching aircraft. One solution has been to construct the cap of a material which melts completely, such as Rose's alloy, or of a material such as nitrocellulose which is adapted to burn when the flare illuminant is ignited. Such expedients are disclosed in a co-pending United States patent application of Thomas H. Johnson, Ernest M. Kane, and John Q. Tabor, Serial No. 603,458, filed August 10, 1956, Patent No. 2,868,129, and entitled "Flare Device." A further possibility lies in the design of a pyrotechnic member in which both the flare body and cap are formed as a unit from the same consumable material, thus dispensing not only with the separate cap, but also with the hollow tube or container in which the combustible substance is customarily packed.

It is apparent that, in either of the above arrangements, the rate of burning of the consumable material is of great importance. If this rate is constant, then a moment may be chosen for electrical energization of the squib which will produce full illumination of the flare at the instant of missile launching regardless of the ambient temperature. Previously used pyrotechnic materials, as above brought out, are subject to such wide variations in density that the actual burning rate may be considerably higher or lower than that relied upon, thus causing either a delayed or a premature ignition of the flare.

To eliminate such a condition in the above as well as other applications, the present invention provides a combustible plastic substance which may be readily cast or molded at room temperatures without the necessity of supplying external pressure, and which, when hardened, is unusually resistant both to moisture and to wide variations in temperature. Furthermore, the material of the present invention is of uniform density throughout, and exhibits an essentially constant burning rate which may be accurately pretermined or controlled by varying the relative proportions of its constituents. Thus it is admirably suited for use as a pyrotechnic compound which may be cast or molded in the form of a flare, for example, having neither an outer casing nor a separate cap for holding the igniting means.

One object of the present invention, therefore, is to provide an improved pyrotechnic material which may readily be cast or molded at room temperatures without the application of either heat or pressure, and which will harden without developing cracks or fissures.

Another object of the present invention is to provide an improved pyrotechnic material which has an essentially constant rate of burning, which rate may be accurately predetermined or precalculated in accordance with the relative proportions of its basic constituents.

A further object of the invention is to provide a pyrotechnic material particularly adapted for use in flares of the type employed in the testing of guided missiles or rockets.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description.

The combustible material of the present invention consists essentially of a mixture of unsaturated polyester resins, to which is added a stabilizing ingredient, oxidizers, and a fuel which has (at least in part) been comminuted or atomized to a fineness of approximately 325 mesh. As an example, a composition of the following ingredi-

ents, within the respective ranges set forth, has proven highly satisfactory as a pyrotechnic material which hardens without cracking or fissuring at room temperatures and without the application of external pressure. The mixture consists of equal amounts by weight of a resinous compound and a fuel, made up according to the following table:

Resinous compound

Ingredient	Permissible range in percent (By weight)
Resin A	40–70
Resin B	30–60
Benzyl Alcohol (to stabilize product against brittleness)	1–10
Cobalt Napthenate (to accelerate polymerization)	0–10
Methyl Ethyl Ketone Peroxide (as an oxidizer)	.5–6

Resin A is an unsaturated polyester resin having styrene as a reactive monomer, and is derived from propylene glycol, maleic anhydride and phthalic anhydride, the ratio of maleic anhydride to phthalic anhydride being relatively high. One preferred example of Resin A is marketed commercially under the trade name "Laminac Resin #4128."

Resin B is an unsaturated polyester resin having styrene as a reactive monomer, and is of the flexible type based upon diethylene glycol, maleic anhydride and adipic acid. One preferred example of Resin B is marketed commercially under the trade name "Laminac Resin #4134."

The methyl ethyl ketone peroxide may be 60% in 40 dimethyl phthalate mixture or 40% dioctyl phthalate.

Fuel

	Parts
Magnesium powder (70% through 325 mesh)	1
Potassium or ammonium perchlorate, $KClO_4$ or NH_4ClO_4 (as an oxidizer)	2

The resinous compound when prepared is viscous in character. The fuel is added slowly to this resinous compound while the latter is agitated by some means such as a mechanical stirrer. When thoroughly mixed the material is poured into molds and allowed to harden at room temperature. The time required for this hardening process will of course depend upon the size and shape of the product, and if it is necessary to shorten this hardening period the mold may be heated, as in an electric oven, at a temperature which does not exceed approximately 180° Fahrenheit. When allowed to harden naturally, the slow rate of polymerization yields a pyrotechnic article which is unusually free from the cracks and/or other molding defects frequently found in pressed products.

The following table illustrates one particular resinous compound which has been employed satisfactorily in the invention mixture:

Ingredient	Percent by weight
Resin A	56
Resin B	34
Benzyl Alcohol	4
Cobalt Napthenate	2
Methyl Ethyl Ketone Peroxide	4

It will now be appreciated that a pyrotechnic mixture formulated in accordance with the present disclosure requires no complex vacuum or pressure equipment, and utilizes no oven or other heater if time permits normal hardening. Only inexpensive molds are employed in conjunction with a readily obtainable stirrer or other mixing apparatus, and hence the heavy and cumbersome compression loading equipment, used in conventional manufacturing processes, is entirely eliminated. Furthermore, pyrotechnic articles made by the invention method have demonstrated their efficiency and reliability over extended trial periods. As a result, and in view of their lower cost and ease of fabrication, they have largely replaced combustible flares and fuses made in the conventional manner.

Obviously certain modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

We claim:

A consumable pyrotechnic mixture consisting of essentially equal parts by weight of a fuel and a resinous composition, the former consisting of approximately one part by weight of atomized magnesium powder and approximately two parts by weight of potassium perchlorate, the latter consisting of between one and ten percent by weight of benzyl alcohol, less than ten percent by weight of cobalt naphthenate, between one-half and six percent by weight of methyl ethyl ketone peroxide, and the remainder of a mixture of two unsaturated polyester resins each having styrene as a reactive monomer, one of said two resins being derived from propylene glycol, maleic anhydride and phthalic anhydride, the ratio of maleic anhydride to phthalic anhydride being relatively high, the other of said two resins being of the flexible type based upon diethylene glycol, maleic anhydride and adipic acid, the said resin mixture being characterized by its ability to remain in a solid state while the said pyrotechnic mixture is being consumed.

References Cited in the file of this patent

UNITED STATES PATENTS

613,021	Schwartz	Oct. 25, 1898
1,756,255	Meek	Apr. 29, 1930
2,407,131	Brunson et al.	Sept. 3, 1946
2,410,801	Audrieth	Nov. 12, 1946
2,557,667	Kropa	June 19, 1951
2,700,603	Hart et al.	Jan. 25, 1955

FOREIGN PATENTS

580,409	Great Britain	Sept. 6, 1946