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CASTABLE ILLUMINANT FLARE COMPOSITION AND METHOD
FOR MAKING FLARE BODY THEREWITH
Filed Feb. 10, 1969 3 Sheets-Sheet 1

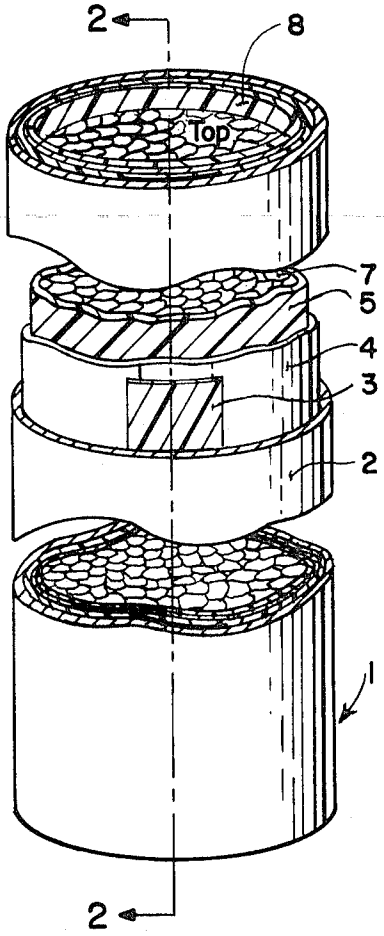


Fig.1

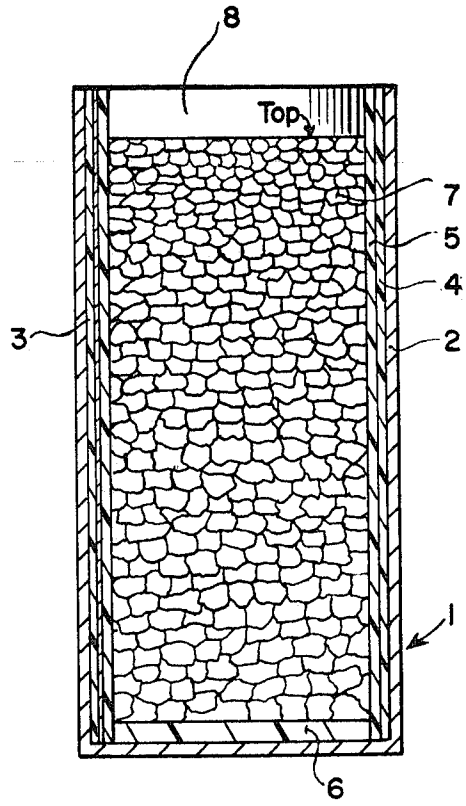


Fig.2

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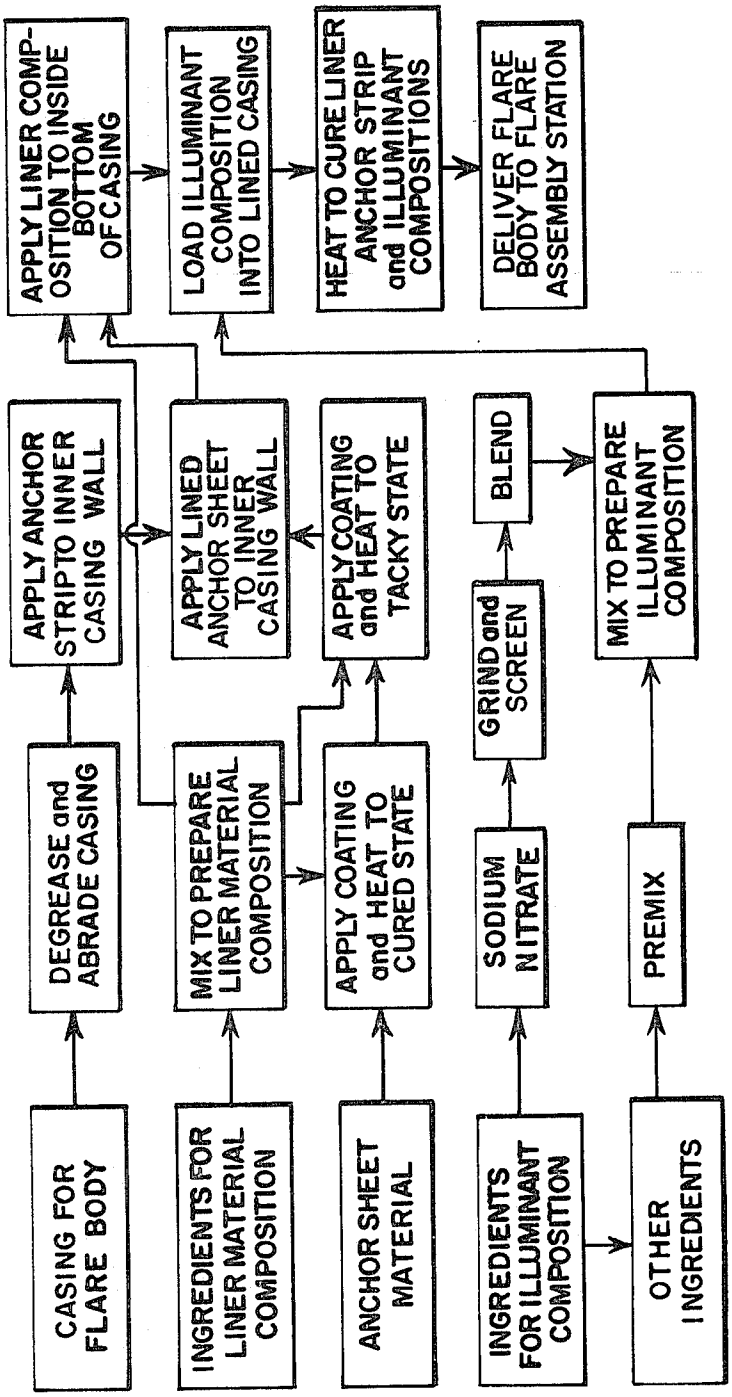


Fig.3

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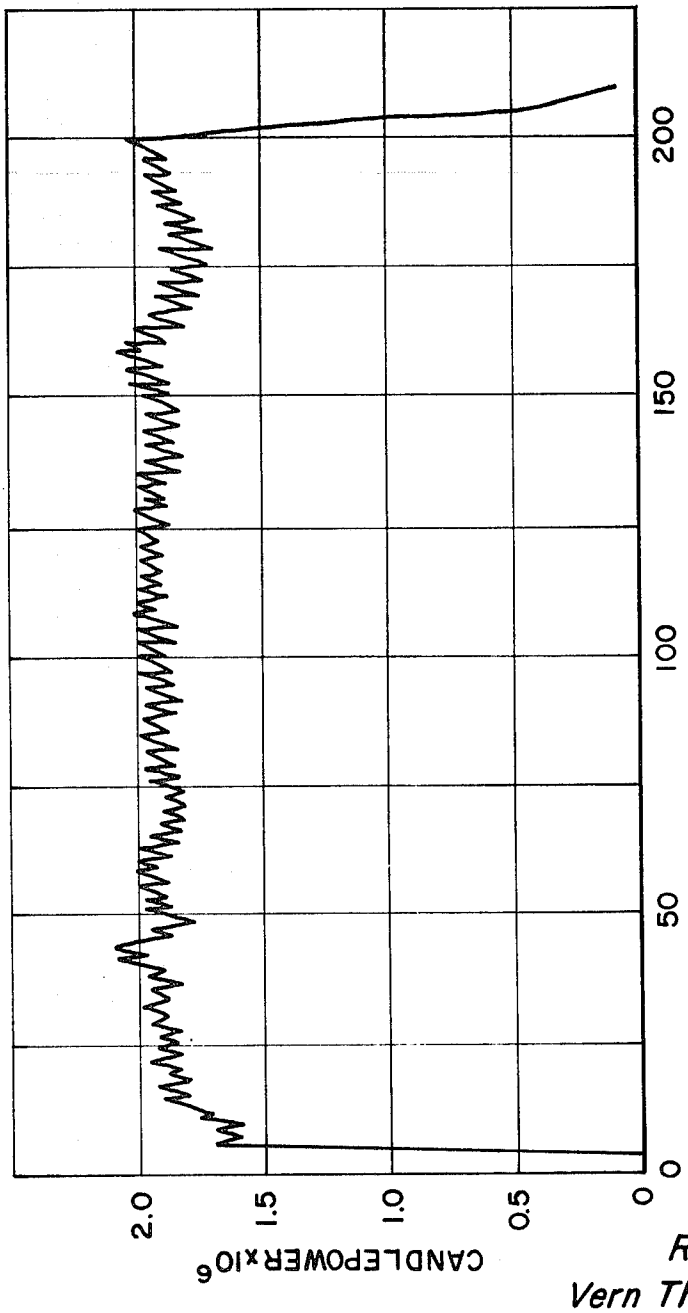


Fig. 4

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3,605,624

CASTABLE ILLUMINANT FLARE COMPOSITION AND METHOD FOR MAKING FLARE BODY THEREWITH

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U.S. Cl. 102—37.8 14 Claims

ABSTRACT OF THE DISCLOSURE

A flare body for a parachute type flare providing superior brilliance and sustained output of illumination even after 14 days of 24-hour temperature cycling between —65 and 165° F. is obtained by means of a novel, castable illuminant flare composition comprising an uncured, high oxygen content liquid polymeric binder material, particularly a liquid saturated polyester polymer/liquid epoxy resin system, which is loaded into a flare body casing lined on its inner bottom and side surfaces with at least partially cured liner material comprising the binder material and further comprising an anchor sheet material bonded completely on its inner surface to the outer surface of the liner and on its outer surface to the inner casing wall essentially only by a relatively narrow anchor strip of material running from the top to the bottom of the casing. The loaded casing and its contents then are heated to cure the polymeric binder material in the composition, liner and anchor strip.

CROSS-REFERENCE TO RELATED APPLICATION

A parachute-type illuminating flare in which the illuminant flare body of the present invention may be used is disclosed and claimed in copending application Ser. No. 787,079 filed Dec. 26, 1968.

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates to high intensity relatively prolonged burning time, parachute-type illuminating flares, particularly of the type used in military operations. The invention more particularly relates to the composition of the illuminant grain and to the method by which the illuminant grain is retained in the flare body casing.

Description of the prior art

Castable pyrotechnic compositions comprising a polymeric binder are known. Such compositions are taught, for example, in U.S. 2,700,603, in which 5 to 40 percent of a liquid plastic of the group consisting of polyfunctional mercaptans, polyesters and dichlorostyrene catalyzed with peroxides or tin compounds is used for the binder and cured at room temperature.

Casing bonding of castable pyrotechnic compositions to a casing liner bonded to the casing also is known and is taught, for example, in U.S. 3,212,256, in which a liner of a thermoplastic material, particularly polyurethane rubber, is cast to the inner wall of a rocket and the propellant grain of the rocket is bonded to the liner by means of a unique surface preparation, namely, methyl-α-cyanoacrylate containing sulfur dioxide.

SUMMARY OF THE INVENTION

The present invention is directed to providing an improved illuminating flare body which will provide intensely brilliant light for at least several minutes while suspended by parachute in aerial applications such as for aerial photography and military missions. Since such flares must be ready for instant use at various air densities under a wide variety of temperature and climate conditions which cause expansion and contraction of the flare casing and grain and must withstand transportation shock and vibration forces in ground and air vehicles, the physical integrity of the illuminant composition must be such that the composition will not crack, pulverize or otherwise develop flaws which will cause the flare to function erratically or to fail to function. For example, the expansion and contraction of the illuminant composition in its casing due to temperature changes, which may range from about —65 to 165° F., may cause the illuminant composition, or grain, to pull away from the liner which is normally used in pyrotechnic devices such as flares and rockets. In such an event, the grain may burn along the side of the grain causing a side-burning effect which considerably shortens the burning time of the flare. Furthermore, the casing, which, in a flare of the type described herein, is usually made of aluminum metal or magnesium metal or one of the alloys of such metals, usually has a different coefficient of expansion from that of the liner and of the grain, and the liner may have a different coefficient of expansion from that of the grain. Also, in rarified atmospheres, the oxygen content of the air will be less than that at ground level and will adversely affect the burning rate of the grain if the ingredients of the illuminant composition must depend on oxygen from the air to sustain their combustion. Positive ignition of the grain under all the temperature conditions that may be encountered in arctic as well as temperate and tropical temperature zones also must be obtained by the illuminating flare. The amount of light intensity which may be obtained during burning or the flare is still another, and most important objective to be attained. This factor can be expressed in candlepower per second per gram of grain, and the higher this factor the better the illuminating efficiency of the flare.

The objects of the invention, as well as other advantages and benefits are obtained by means of novel, castable flare illuminant composition comprising an uncured, high oxygen content polymeric binder material which is loaded into a flare body casing lined on its inner bottom surface and on its inner wall surface with liner composition material comprising the above binder material and having at least its grain-facing surface cured only to a tacky state, the liner, preferably, in turn being bonded to a second cured or partially cured layer of the same liner material further bonded to an anchor sheet of combustible sheet material, the latter material being bonded by means of an uncured layer of the liner material by its back surface, along a relatively narrow anchor strip running parallelly to the long axis of the casing, to the inner wall of the casing. The loaded flare body casing is then heated to cure all the illuminant grain, liner and anchor strip.

The illuminant flare when made according to the invention and assembled into an aerial type flare withstands shock and air transport vibration after 24-hour temperature cycling for 14 days at temperatures in the range of —65 to 165° F. It functions properly when deployed from an aircraft at an elevation of several miles and provides as much as 50,000 candlepower per second per gram of grain.

The high oxygen content polymeric binder used in the practice of the invention preferably is a binder system

comprising a liquid saturated polyester polymer having a carbon to hydrogen to oxygen ratio of about 2:2.5:1 and having a viscosity at 25° C. of about 450 to 550 poise mixed with a liquid epoxy resin having a viscosity at 25° C. of about 500 to 900 centipoise.

The method of case bonding of the liner comprises bonding the liner to a sheet of combustible material, preferably a thin sheet of kraft process paper, and then bonding the sheet along a narrow strip of its outer surface to a narrow strip of liner material, referred to herein as an anchor strip, bonded to a corresponding area of the casing inner wall. Bonding of a portion only of the sheet only to a portion of the casing wall rather than bonding the entire sheet to the entire inner wall surface of the casing, permits the liner and illuminant grain to expand and contract independently of the casing while still being firmly held by the anchor strip in the position in which it is placed in the casing during assembly and during burning.

On ignition and during burning of the flare, the end-surface of the grain, of the liner, of the sheet material and of the casing burn away at substantially the same rate. Because of the efficiency of the bonding of the liner to the grain, side-burning does not occur, as might occur if the liner-to-grain bond were defective.

BRIEF DESCRIPTION OF THE DRAWING

The cast flare illuminant and its method of manufacture are illustrated in the drawing wherein:

FIG. 1 is a fragmented view of the illuminant flare body showing the cured illuminant with portions of the casing wall, anchor strip, anchor sheet, liner and illuminant composition cut away to show the arrangement of these parts;

FIG. 2 is a cross-sectional view of the illuminant flare taken along the line 2—2 of FIG. 1 and additionally showing the bottom liner relative to the other parts;

FIG. 3 is a process diagram depicting the various steps of the assembly operations; and

FIG. 4 is an illumination output trace of an illumination flare made according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The illuminant flare of the present invention in its preferred embodiment may be better understood from the drawing. In the drawing, FIGS. 1 and 2 illustrate the construction of the flare, FIG. 3 illustrates the method of constructing the flare, and FIG. 4 illustrates the candle power output of an 18-inch flare of about 4.65 inch diameter.

Referring to FIGS. 1 and 2, the illuminant flare **1** comprises a casing **2**, preferably of aluminum, to which is bonded a strip **3** of cured liner composition material, further described below. A thin layer of combustible anchor sheet **4**, preferably kraft process paper, is shown bonded, preferably along its overlapped seams, to an anchor strip **3** of cured liner composition. A side liner **5** of cured liner composition material is shown bonded to the complete inner wall of anchor sheet **4**. A bottom liner **6** of cured liner composition material is shown bonded directly to the inner bottom wall of the casing **2**. Cured illuminant composition **7** is shown bonded directly to the side liner **5** and the bottom liner **6**. The illuminant composition **7** is loaded into the linered casing so that its top, as shown, is sufficiently below the open end **8** of the casing **2** to provide room for insertion and support of ignition means, not shown. The illuminant flare body **1** substantially in the form shown is ready for assembly into a parachute-flare of the type described in the copending application, above.

The method of constructing the illuminant flare **1** in a preferred embodiment is illustrated in FIG. 3 taken in conjunction with FIGS. 1 and 2. An aluminum casing **2** of thin wall construction for the illuminant composition is degreased and abraded to prepare it for application of a strip **3** of flowable uncured liner composition to the casing.

The flowable uncured liner composition preferably is prepared by homogeneously blending together in a dry atmosphere the ingredients showing in Table 1 in about the proportions listed there.

TABLE 1.—LINER COMPOSITION

Ingredients	Parts by weight (p.b.w.) Preferred	Range
WITCO Formrez F-17-80 ($C_{2.0}H_{2.55}O_{.0}$) (saturated, carboxyl-terminated polyester liquid polymer).	100	95 to 110.
Epon 812 (trifunctional epoxy resin curing agent, medium viscosity, reaction product of glycerol and epichlorohydrin).	20.7	17 to 23.
Iron Octoate (ferric ethylhexoate)	0.09	0.05 to 0.15.
Thermax (carbon black insulation filler)	54.0	50 to 60.
Cab-O-Sil (hydrated silica insulation filler)	5.5	4 to 8.

The uncured liner composition preferably has a viscosity of a thick syrup. It may be applied to the inner wall of the casing **2** by means of a brush or roller to form the anchor strip **3** by running the brush or roller from the bottom of the casing to the open end thereof, forming an anchor band of sufficient width and thickness to hold the anchor sheet **4** and liner **5** in place when the latter items are inserted into the casing, as described below. Preferably, in a casing **2** having an inner diameter of about 4 to 5 inches, the anchor strip **3** will be about 2 to 3 inches in width. While a wider anchor strip may be used, it should not be so wide that the purpose of the strip, i.e. providing for expansion-contraction movement of the casing **2** about the linered illuminant composition **7**, would be defeated. The anchor strip **3** need have a thickness at least sufficient to bond the anchor sheet **4** to the casing **2**. Usually a thickness of several thousandths of an inch will be adequate. The anchor strip **3** may be semi-cured by heating the casing to about 100° F. for about 24 hours.

The uncured liner composition is also used to coat one side of anchor sheet **4** material, which preferably is in the form of a continuous roll of the material having a width of about the depth of the inner wall of the casing, by applying the composition to the sheet by brush or roller means. However, the composition is preferably applied in the form of a solution or suspension of the composition in an organic solvent, e.g. methylene chloride, by spraying the solution onto one surface, preferably the top surface, of the sheet as it is unrolled, and evaporating the solvent.

The anchor sheet **4** provides a convenient means for controlling the overall thickness of the liner **5**, which itself serves as the principal side-burning inhibitor and shock insulation means for the illuminant composition **7** in the manner, e.g., well-known in the rocket propellant art. The combination of the anchor sheet **4** and the liner **5** should be sufficient in thickness to provide adequate inhibiting and insulation of the illuminant composition **7** grain over the temperature range from about —65 to 165° F. under conditions of mechanical shocks and vibration of transportation both on ground level and in the air. The combination should be of minimum thickness for the above purpose in order to be able to provide maximum light output per cross-sectional area of the flare **1**. Also, its oxygen requirements for combustion purposes should not be dependent on the illuminant composition **7**, but should be self-contained. The ingredients of the liner composition **5** of Table 1 contain sufficient oxygen for this purpose. The thickness of the kraft process paper anchor sheet **4** material thus may be about 0.005 to 0.010 inch, and the thickness of the liner about 0.015 to 0.05 inch to provide a satisfactory combination of liner-anchor sheet.

The uncured liner composition material is built up on the anchor sheet **4** to about the desired thickness and then is cured by heating to about 150° F. for about 24 hours. The cured liner surface is then given a second coating to build up the remainder of the desired thickness and the

second coating is partially cured by heating at about 100° F. to a tacky state only. The liner-anchor sheet combination is cut to a length somewhat greater than the inner circumference of the casing, preferably being sufficiently greater in length to provide an overlap of the ends of about ¼ to 1 inch. The cut liner-anchor sheet is then wrapped around an expandable mandrel having an outer diameter such that when the sheet and mandrel are inserted into the casing, the mandrel can be expanded to press the liner-anchor sheet snugly against the inner wall of the casing. The overlapped seam **9** preferably is positioned so that it seats against the anchor strip **3** and adheres there to the uncured liner composition of the strip. The surface of the mandrel preferably is coated with a synthetic resin, e.g. polytetrafluorethylene, which is no-adherent to the tacky surface of the liner **5**.

The inner bottom of the casing **2** is next lined with a layer of the uncured liner composition to form a shock and vibration insulator bottom liner **6**. The thickness of the liner **6** is about the same as the thickness of the liner-anchor sheet combination.

The lined casing **2** is now ready for loading with uncured illuminant composition **7**. The composition **7** is a flowable mass prepared by homogeneously mixing the ingredients shown in Table 2 in about the proportions listed there.

TABLE 2.—ILLUMINANT COMPOSITION

Ingredients	Parts by weight (p.b.w.) Preferred	Range
WITCO Formrez F-17-80 ($C_{2.0}H_{2.55}O_{1.0}$) (saturated, carboxyl-terminated polyester liquid polymer).	100	95 to 110.
ERLA 0510 (trifunctional epoxy resin curing agent, medium viscosity).	20.5	12 to 25.
Iron linoleate (catalyst)	0.09	0.05 to 0.15.
Magnesium granules (chipped and balled, 50 to 200 mesh).	825	500 to 1,000.
Sodium nitrate (crystalline, prilled and ground):		
Medium grind, 150 micron average	135	115 to 150.
Fine grind, 5 micron average	270	225 to 300.

The mixing of the illuminant composition ingredients of Table 2 is carried out in a dry inert atmosphere to avoid moisture pickup. Preparatory to the mixing, the sodium nitrate is ground, if necessary, and screened to provide a medium-sized fraction of particles averaging about 150 microns in cross-section and a fine-sized fraction of particles averaging about 5 microns in cross-section. The two fractions then are blended in the ratio of about 1 part medium-sized to 2 parts fine-sized particles before adding to the mixer. Mixing is carried out for about 20 to 30 minutes in a known manner in the temperature range of 120°±5° F. in accordance with the usual safety practices.

The mixed uncured illuminant composition is a flowable crumbly mass. The mass is fed by a conveyor to a loading station where it is loaded in increments into the lined casing **2**. Each increment is tamped into place with a pug type tamper to obtain a densely packed load free of voids and crevices. The mixture has a pot life of about 8 to 24 hours at 60 to 100° F. and can readily be handled without danger of premature set-up.

The loaded casing **2** is conveyed to a curing room and subjected to a curing temperature of about 130 to 140° F. for about 48 to 72 hours and/or until cured to a Shore C hardness value of 40 or higher.

Typical physical and performance properties of the cured illuminant grain ambient (70–75° F.) temperatures are shown in Table 3.

TABLE 3

Physical and performance properties of illuminant flare

Modulus, p.s.i.	7,600
Maximum stress, p.s.i.	150
Strain at cracking, in./in.	0.03
Strain at maximum stress, in./in.	0.03
Cured density, gm./cc.	1.57
Shore C hardness	40
Adhesion of grain to liner tensile cup adhesion, p.s.i.:	
At −65° F.	196
At −80° F.	48.5
At −165° F.	14.5
Rate of burning, in./sec.	0.087–0.092
Illumination output, candlepower/sec./gm.	50,000

The cured illuminant composition in the lined casing **2** is herein referred to as a flare body **1**. After the curing step, the flare body **1** is cooled and then is conveyed to a flare assembly station where it is fitted with ignition means and other components for deployment as a parachute-type illumination flare.

Flare bodies made according to the invention were subjected to, and successfully passed, the requirements of the following tests:

(1) Temperature conditioning MIL–STD–331, Item 105; at −65° F. for 24 hr. and 165° F. for 24 hours.

(2) Temperature cycling for 14 days at temperatures ranging from −65 to 165° F.; MIL–STD–331, Item 105.

(3) Aircraft vibration requirements MIL–E–5272C, Item 12.

(4) Transporation vibration requirements MIL–STD–331, Item 104.

Tests results obtained on burning illumination flares made according to the present invention as compared to flares made by the prior art method, which involved high pressure, press loading techniques, such as those described in U.S. 2,700,603, are shown in Table 4. The tests were made with flares loaded into a casing **2** containing a grain measuring 18 inches in length and 4.625±0.031 inches in diameter.

TABLE 4.—ILLUMINANT FLARE TEST RESULTS

Flare number	Conditioning test temperature	t_b (sec.)	r_b (in./sec.)	Average output (cp.)	Efficiency (cp./sec./gm.)
Pressed (old)	Ambient/ambient	175	0.093	1.60×10^6	38,500
Do	do	176	0.092	1.63×10^6	39,500
1/1 (new)	Aircraft vibration/ambient	206	0.087	1.86×10^6	42,000
1/2 (new)	Transportation vibration/ambient	207	0.087	1.95×10^6	54,400
1/3 (new)	Ambient/ambient	190	0.091	1.83×10^6	49,400
1/6 (new)	14 day temperature cycling/ambient	194	0.089	1.90×10^6	52,000
Average (old)		175.5	0.0925	1.615×10^6	39,000
Average (new)		199.2	0.0885	1.885×10^6	52,075
Percent change (new/old)		13.5	−4.4	16.7	33.5

NOTE.—t_b=time of burning, seconds; r_b=rate of burning, inches/seconds: cp.—candlepower.

The test data show that compared to the prior art pressed illuminant flare the novel illuminant flare of the present invention, even after being subjected to all the stringent test conditions described above, has (a) a burning time which is 13.5% longer, (b) a burning rate which is 4.4% slower, (c) a candlepower output which is 16.7% greater, and (d) an efficiency, measured as candlepowers of output per second per gram of grain, which is 33.5%

higher. Therefore, it is seen that the invention provides a highly superior illuminant flare and a method for its manufacture.

The thermal coefficient of expansion of the illuminant grain compared to that of the aluminum of the casing is shown in Table 5.

TABLE 5

Thermal coefficients of expansion

Temperature range, ° C.:	Coefficient of linear expansion cm./cm./° C.
Casing:	
−100–+100	240×10^{-7}
Grain:	
−100–−29	273.6×10^{-7}
−29–0	408.0×10^{-7}
−0–100	544.6×10^{-7}

The data in Table 5 show that the linear coefficient of expansion of the grain is from 113 to 226% greater than that of the casing. The adverse effects of the above great difference in relative amounts of linear expansion, and conversely, of contraction are overcome by the method of construction and the structure of the illuminant flare in accordance with the invention.

FIG. 4 illustrates a typical illumination output trace for an illuminant flare made according to the invention and used in carrying out the above tests. The trace represents the illumination output obtained while burning a flare on a test tower 67 feet above ground level. The average illumination produced was 1.79×10^6 candlepower, which is about equivalent to 1.97 to 2.01×10^6 candlepower in a photometric tunnel.

While specific ingredients have been used to describe and illustrate the invention, it is to be understood that other ingredients having equivalent properties may be substituted for those shown in order to practice the invention and to obtain the benefits and advantages thereof.

The liquid polymeric binder material used in practicing the invention preferably is a mixture of liquid saturated polyester polymer and liquid epoxy resin. Preferably, the liquid saturated polyester polymer is a carboxyl-terminated polyester polymer such as a carboxyl-containing low molecular weight, aliphatically saturated, substantially completely condensed, polymeric polyester of a saturated aliphatic diol, a dicarbocylic acid free from ethylenic unsaturation, and a polyfunctional compound free from ethylenic unsaturation and containing at least three functional groups selected from the group consisting of polyols, polycarboxylic acids and polycarboxylic acid anhydrides, said polymeric polyester being liquid at a temperature between about 25 and about 50° C., having an acid content between about 0.1 and about 1.5 milliequivalents per gram, an average of between about 2.5 and about 15 carboxylic groups per molecule, an average molecular weight between about 700 to about 10,000 and free from hydroxyl groups. Such polymers are known and are taught, for example, in U.S. 3,182,041, incorporated herein by reference. Preferred liquid saturated polyester polymers are those having a high oxygen content combined with the carbon and hydrogen content of the polymer. Especially preferred are liquid saturated polyester polymers having a carbon to hydrogen to oxygen ratio of about 2 to 2.55 to 1 and a viscosity at 25° C. of 480 to 520 poise. Polyesters prepared from saturated diacids, e.g. saturated fatty acids, such as succinic and glutaric acids and their anhydrides, are especially preferred.

Liquid epoxy resins and solutions thereof are also well-known. The epoxy resins are formed by the reaction of a 1,2-epoxy compound and a dihydric phenol. The preferred 1,2-epoxy resins are prepared by the reaction of epichlorhydrin with bis-phenol-A (2,2-bis-(4-hydroxyphenyl)-propane), generally in alkaline solution. Epoxy resins also are prepared from other 1,2-epoxy compounds including, for example, polyglycidyl ethers of ethylene glycol, propylene glycol, trimethylene glycol, diethylene glycol, triethylene glycol, glycerol, dipropylene glycol, etc. Similarly, other dihydric phenols may be employed, including resorcinol, catechol, hydroquinone, 4,4'-dihydroxybenzophenone, 1,1-bis-(4-hydroxyphenyl)-butane, 1,5-dihydroxynaphthylene, etc. It is understood that the epoxy resins formed from the various reactants mentioned above are not necessarily equivalent and, furthermore, that the exact composition of the epoxy resins are dependent upon the molecular proportions of the epoxy compound and dihydric phenol employed in its preparation. Preferred liquid epoxy resins are those having an epoxide equivalent (weight of resin in grams containing 1 gram of epoxy) of about 175 to 210 and a viscosity of about 500 to 900 centipoises. When a solvent is used, organic solvent such as toluene, xylene and ketones, e.g. acetone, are preferably used. The liquid epoxy resin serves as a curing agent for the polyester polymer. Polyfunctional epoxy resin is especially preferred, particularly, a trifunctional epoxy resin wherein the functional group is hydroxyl or amino.

While the liquid epoxy resins are preferred as curing agents for the polyester polymer, other polyfunctional curing agents may also be used, for example, polyfunctional aziridines, e.g. trifunctional derivatives of ethylenimine and other alkylenimine derivatives, and other curing agents such as those taught in U.S. Pat. 3,182,041, above.

The binder material is accelerated in its curing by the addition of a small amount of catalyst for the curing agent. Preferably, the curing rate catalyst is a metal salt of a fatty acid, e.g. iron linoleate. Such compounds are commonly referred to as metallic soaps. They are insoluble soaps of such fatty acids as stearic, naphthenic, octoic or 2-ethylhexoic, rosin (resinates), or tall oil (tallates) with the heavier metals such as aluminum, calcium, cadmium, copper, iron, lead, tin or zinc. Sufficient catalyst is used to obtain a curing rate which will give a pot life of about 8 to 24 hours. The amount will usually be from about 0.5 to about 0.9 part per 100 parts of liquid saturated polyester polymer, but may be more or less as found desirable.

Generally, it is desirable that the amount of curing agent used be present in at least stoichiometric amount relative to the polyester polymer, in order to provide complete cure of the polyester polymer. The amount of catalyst used then controls the rate at which the cure occurs.

The cured polymeric binder material whether present in the illuminant composition, in the liners or in the anchor strip should have adequate bonding strength to form a strong bond between the ingredients in the illuminant and liner compositions, and the surfaces to which the cured compositions are bonded.

The magnesium used in the illuminant composition is preferable in a particulate form of metal fuel. While magnesium is preferably used for its white light producing capability, it may be desirable in some cases to use other metals used in pyrotechnic devices as metal fuels in place of some of the magnesium, e.g. aluminum, or magnesium and zirconium and their hydrides, cerium and uranium. The metal fuel is preferably used in a ratio of about 5 to 10 parts by weight relative to the polymeric binder material.

Sodium nitrate is preferably used as the oxidizer for the magnesium fuel of the pyrotechnic combination in the illuminant composition. However, in some cases it may be advantageous to use another metal nitrate, e.g., lithium nitrate, taking due precautions in handling the latter because of its greatly hygroscopic nature. When white light is not essential, color producing metal nitrates, such as barium or strontium nitrate, may be used advantageously. The metal nitrate is preferably used in at least a stoichiometric amount relative to the metal fuel ingredient of the illuminant composition.

The anchor sheet 4 material preferably is a thin kraft process paper. However, the material may also be a sheet form of other material to which the liner composition material will bond. Primarily, the anchor sheet 4 provides

an efficient means for controlling the thickness of the liner. It also serves as a reinforcing cover for the liner. Additionally, it must have adequate strength to permit it to serve as an intermediate bond between the liner **5** and the anchor strip **3**. Furthermore, the anchor sheet material should be combustible so that it will be consumed and not interfere with combustion of the aluminum casing. It is preferred that all the flare body components be consumable so that no danger is created by falling debris from the burning flare. Accordingly, other anchor sheet materials include linen or cotton webbing, combustible synthetic plastic or resin materials such as polyurethane, polyesters, polyethers, polysulfide rubber, polyhydrocarbon rubber, e.g. hydroxyterminated polybutadiene rubber, and the like.

In some cases it may be advantageous to eliminate the anchor sheet **4**, particularly, when the liner is made by another method than that described above, e.g. by forming it by extrusion means. In such cases, the liner can be made thicker, if necessary, and can be bonded directly to the anchor strip in the manner described above.

The filler materials used in the liner composition material for making the liner **5** and the anchor strip **3** may be one or more materials useful as reinforcing agents in the plastics art, such as carbon black, clays, slate flour, aluminum oxide, silicon dioxide, magnesium silicate, iron oxide and rayon or other synthetic resin or plastic floc. In general a total of from about 50 to 100 parts of fillers will be advantageous for practice of the invention.

Sufficient filler material should be used to reinforce the liner so that it will have sufficient cohesive strength to withstand the shearing and abrasive forces encountered in compacting the illuminant composition into the lined casing while also retaining sufficient resilience to permit it to absorb shock and vibration and to expand and contract over entire temperature range to which the illuminant flare may be subjected.

Many modifications and variations of the present invention will be obvious to those skilled in the art of formulating illuminant compositions, bonding resins, and constructing illuminant flares and other pyrotechnic devices. It is therefore to be understood that such other modifications and variations that fall within the scope of the claims hereof are intended to be included therein.

We claim:

1. In an illuminating flare for use in parachute type flares in the temperature range of about −65 to 165° F. and comprising a casing having an open end, cured, cast illuminant composition in said casing, a shock and vibration side liner positioned in the casing between the inner wall of the casing and bonded to the adjacent side surface of the illuminant composition, and a shock and vibration resistant bottom liner positioned in the casing between the inner bottom surface thereof and the adjacent bottom surface of the illuminant composition, the improvement which comprises a means for avoiding damage to the liner-illuminant composition bond and to the composition by forces of contraction and expansion, said means comprising:

an anchor sheet having an inner surface and an outer surface, said inner surface covering said liner on its outer side surface and extending substantially from the bottom of the casing to the open end thereof and having its outer surface positioned inside said casing adjacent to the inner wall thereof and being bonded on its inner surface to all said side surface of the liner,

and an anchor strip bonded to the inner wall of said casing and extending substantially from the bottom of the casing to the open end thereof,

said anchor sheet having a portion of its outer surface bonded to said anchor strip from the bottom of the casing to the open end thereof.

2. The illuminating flare of claim **1** wherein the anchor sheet is kraft process paper.

3. The illuminating flare of claim **1** wherein said illuminant composition, said liners, and said anchor strip each comprises a cured, organic polymeric binder material having a high oxygen content combined with its carbon and hydrogen contents.

4. The illuminating flare of claim **3** wherein the cured polymeric binder material comprises cured carboxyl-containing low molecular weight, aliphatically saturated, substantially completely condensed, polymeric polyester of a saturated aliphatic diol, a dicarboxylic acid free from ethylenic unsaturation, and a polyfunctional compound free from ethylenic unsaturation and containing at least three functional groups selected from the group consisting of polyols, polycarboxylic acids and polycarboxylic acid anhydrides, said polymeric polyester being liquid at a temperature between about 25 and about 50° C., having an acid content between about 0.1 and about 1.5 milliequivalents per gram, an average of between about 2.5 and about 15 carboxylic groups per molecule, an average molecular weight between about 700 and about 10,000 and free from hydroxyl groups.

5. The illuminating flare of claim **4** wherein the cured polymeric binder in at least the liners and the illuminant composition are of the same composition.

6. The illuminating flare of claim **4** wherein the anchor strip comprises the product formed by heating and curing in situ on said casing inner wall a composition comprising per 100 parts by weight of said liquid saturated polymeric polyester (a) at least a stoichiometirc amount of polyfunctional curing agent for said polymer, (b) a catalytic amount of a catalyst for the curing agent, and (c) a reinforcing amount of at least one filler material.

7. The illuminating flare of claim **4** wherein the liners comprise the product formed by heating and curing a liner material composition comprising per 100 parts by weight of said liquid saturated polymeric polyester (a) at least a stoichiometric amount of curing agent for said polymer, (b) a catalytic amount of a catalyst for the curing agent, and (c) a reinforcing amount of at least one filler material.

8. The illuminating flare of claim **4** wherein the castable illuminant flare composition comprises the product formed by heating and curing in situ in the liner a homogeneous illuminant flare composition mixture comprising per 100 parts by weight of said liquid saturated polyester polymer (a) at least a stoichiometric amount of curing agent for said polymer, (b) a catalytic amount of a catalyst for said curing agent, (c) metal fuel and (d) a metal nitrate in at least a stoichiometric amount relative to the metal fuel.

9. The illuminating flare of claim **8** wherein the catalyst is a metal salt of a fatty acid.

10. The illuminating flare of claim **8** wherein the metal nitrate is sodium nitrate.

11. The illuminating flare of claim **8** wherein the curing agent is selected from polyfunctional epoxy resins and polyfunctional aziridines.

12. The illuminating flare of claim **8** wherein the curing agent is selected from polyfunctional epoxy resins and polyfunctional aziridines.

13. The illuminating flare of claim **7** wherein the curing agent is selected from polyfunctional epoxy resins and polyfunctional aziridines.

14. In combination in a pyrotechnic device and arranged in order from the interior to the exterior of the device, a pyrotechnic composition, a shock and vibration absorbing liner bonded to said pyrotechnic composition and completely enclosing the outer surface of the sides thereof, an anchor sheet bonded to the liner and completely enclosing the outer surface of the side of the liner, a substantially flat anchor strip having an inner surface and outer surface, said inner surface being

bonded to the adjacent surface of the anchor sheet and said outer surface being bonded to said casing.

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ROBERT F. STAHL, Primary Examiner

U.S. Cl. X.R.

102—103

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,605,624 Dated September 20, 1971

Inventor(s) Vern Thomas Dinsdale, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 37, after "burning, "or" should read -- of --. Column 4, Table 1, line 11, "$C_{2.0}H_{2.55}O_{.0}$)" should read -- ($C_{2.0}H_{2.55}O_{1.0}$) --. Column 5, line 16, "no adherent" should read -- non-adherent --. Column 8, line 56, after "or", "magnesium" should read -- magnesium-aluminum --. Column 10, line 60, claim reference numeral "8" should read -- 6 --.

Signed and sealed this 24th day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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