Nov. 25, 1969 C. W. BOLIEAU 3,479,954

IGNITER SYSTEM FOR ILLUMINATING COMPOSITIONS

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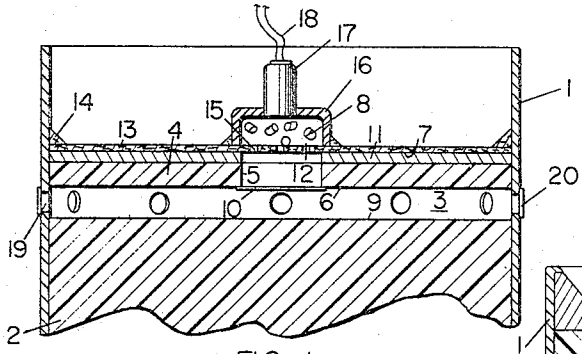

FIG. 1

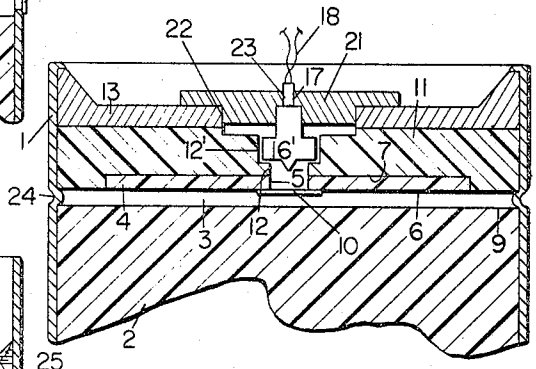

FIG. 4

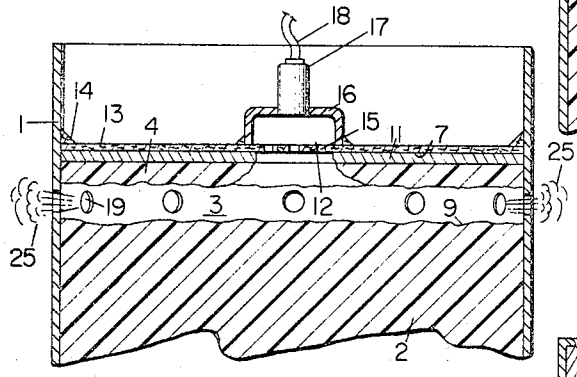

FIG. 2

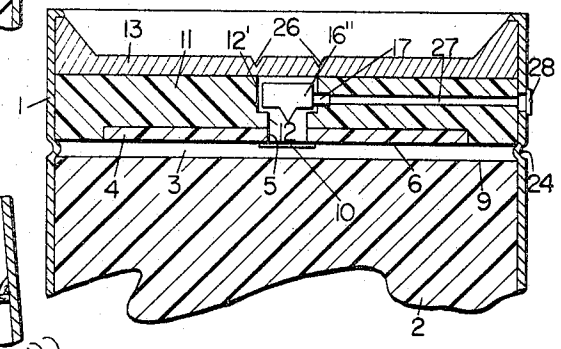

FIG. 5

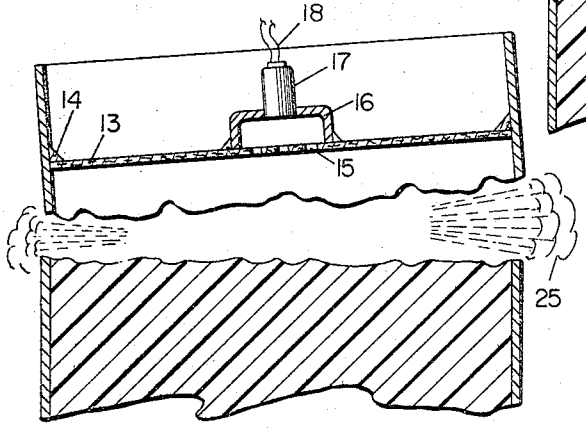

FIG. 3

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IGNITER SYSTEM FOR ILLUMINATING COMPOSITIONS

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ABSTRACT OF THE DISCLOSURE

An igniter system for illuminating flares or candles is provided in which a wafer shaped grain of igniter is spaced apart from the illuminant grain in a casing and combustion products of the igniter are caused to impinge against and flow over the surface of the illuminant grain enroute to venting means in the casing.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to pyrotechnic devices, particularly illuminating flares or candles, and more particularly to improvements in the means for igniting an illuminant composition.

Description of the prior art

Flare illuminants are relatively difficult to ignite. They must be exposed to heat for a longer period of time before igniting than normally is required for igniting typical solid pyrotechnic compositions, such as solid propellants. This is due to the combined ignition deterring effects of high metal content, low oxidizer content, large particle sizes, and low binder content in the illuminant composition, plus the comparatively low pressure present in the device at ignition time.

At present, there are many flare igniter designs employing a wide variety of pyrotechnic materials. These igniters generally are of the igniter-first-fire type mix in which an easily-ignited, first-fire composition is pressed cast or coated directly onto the flare illuminant and is ignited first by a primer in the form of a percussion cap or electrical squib. Since the first-fire mix must be easily ignited by the primer, it usually is composed of pyrotechnic materials which are hazardous to mix and apply. When such a first-fire igniter composition is used to ignite the flare, the igniter burns from its outer surface inwardly to the illuminant. Until the burning surface of the igniter reaches the surface of the illuminant, very little heat is transferred to the illuminant. When the burning surface of the igniter does reach the illuminant surface, the first-fire mix has been almost entirely expended. The entire ignition sequence then is dependent on the conductive heat transfer which occurs at the instant that the combustion zone passes through the first-fire-mix-illuminant interface. This is a marginal ignition situation which frequently results in ignition failures.

SUMMARY OF THE INVENTION

The present invention is directed to improving the reliability of ignition of pyrotechnic compositions of the illuminant composition type having a high metal content and low oxidizer content. It also is directed to improving the safety and simplifying the process of manufacture of illuminant flares, or candles, and other pyrotechnic devices.

The invention comprises a pyrotechnic device having the following characteristics. The igniter is adjacent to, rather than an integral part, of the illuminant composition, or grain, and is separated therefrom by a relatively narrow airspace. The igniter composition preferably is a high burning rate, wafer-formed grain of rocket propellant type of composition. The combustion products of the igniter are caused to impinge against the surface of the illuminant composition and to flow through the airspace between the burning surface of the igniter and the surface of the illuminant and across the latter surface enroute to the atmosphere. Also, the flare device is provided with venting means so arranged that the gaseous combustion products can escape from the device during ignition without creating pressure sufficient to cause structural damage to the casing of the device.

BRIEF DESCRIPTION OF THE DRAWING

The invention and its advantages and benefits will be understood from the detailed description below taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a view mostly in cross-section showing the ignition end of an illuminating candle with an ignition system according to a first embodiment of the invention;

FIGURE 2 is a view of the candle of FIGURE 1 after the primer and initiator have been discharged, and the igniter ignited, showing the illuminant composition in the process of being ignited by the venting combustion products discharging across the surface of the illuminant composition and out through vent holes in the casing;

FIGURE 3 is a view of the candle of FIGURE 1 after the illuminant composition has been ignited and has caused the upper end of the candle to burn away along the vent holes line;

FIGURE 4 is a view mostly in cross-section of a second embodiment of the invention wherein the ignition end of an illuminating candle according to the invention is shown provided with a displaceable plug for venting the combustion products after they sweep across the surface of the illuminant composition; and

FIGURE 5 is a view mostly in cross-section of a third embodiment of the invention wherein the ignition end of an illuminating candle according to the invention is shown provided with a frangible cover plate for venting the combustion products after they sweep across the surface of the illuminant composition.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing, like elements are identified by the same numerals in each of FIGURES 1–5. FIGURES 1–3 pertain to the most preferred embodiment and will be described first. In the figures, there is shown the ignition end of an illuminating candle, encased in a casing **1**, which usually will be made of metal, but which may be made of other casing material, e.g. fiber glass embedded in plastic binder, which may be cylindrical in shape and which may be closed at the end not shown in the drawing. For ease in description, the candle will be assumed to be placed in an upright position with the ignition end on the top side. It is to be understood, however, that the candle can be ignited and will burn in any position. Usually the end not shown will be closed, but in some uses, for example, in candles used in making parachute drops, both ends of the candle may be made with ignition ends according to the invention. The casing **1** is filled to an optimum level with an illuminant composition **2**, which is bonded to the casing with an adhesive composition not shown. An airspace **3** separates the illuminant composition from the igniter **4**.

The airspace **3** preferably extends across the entire exposed end of the illuminant composition **2**, i.e. from wall to wall in the interior of casing **1**. The height of the airspace **3** is determined by the igniting distance between the igniter **4** and the illuminant composition **2**. This distance is dependent on the relative chemical compositions

of the igniter and illuminant and upon the venting means used in combination with the compositions in a particular size of candle. The height of the airspace **3** usually will range from about 1/32 to 1/4 inch and preferably will be from about 1/16 to 1/8 inch. However, in some cases the height may be more or less than these distances without being detrimental to ignition of the illuminant composition **2**.

The igniter **4** preferably is a high burning rate pyrotechnic composition which has a burning rate in the range of about 0.8 to 1.5 in./sec. An especially preferred composition is a molded single grain composition comprising a metal-oxidant igniter material of a type described by S. Zeman, "Metal-Oxidant Igniter Materials," Bulletin of the Second JANAF Symposium on Solid Propellant Ignition, volume 1, October 1956. The igniter **4** preferably is in the form of a thin wafer which extends from wall to wall in the casing **1**, as shown in FIGURES 1–3. However, in some cases, as shown in FIGURES 4–5, the igniter may not extend from wall to wall. In each case, however, the total volume of igniter **4** used in making the wafer will be at least sufficient to generate sufficient heat energy to ignite the illuminate composition **2**. The same volume of igniter thus can be spread thinly from wall to wall, or the igniter **4** can be restricted in its surface area to provide a thicker igniter shape. Preferably the surface area of the igniter **4** on its lower surface **6** opposite the exposed end **9** of the illuminant composition **2** will be at least about 1/4 of the surface area of the exposed end of the illuminant composition **2**. A thicker igniter shape is preferred in combination with a more difficult to ignite illuminant composition, in which case the combustion products of the igniter **4** will be concentrated on a smaller portion of the illuminant surface **9** for a longer period of time, thus further ensuring ignition. The igniter **4** will have a thickness that may range from about 1/64 to 1/4 inch. However, the thickness may be more or less than these dimensions and preferably will be about 1/16 to 1/8 inch.

The igniter **4** is provided with a passageway **5** which passes from its lower surface **6** to its upper surface **7**. The passageway **5** is sufficiently wide to permit the flash flame from initiator pellets **8** to pass therethrough, to impinge against the exposed end **9** of the illuminant composition **2**, and to be deflected against the lower surface **6** of igniter **4**, thereby causing the igniter **4** to ignite. The lower surface **6** of the igniter **4** is generally parallel to the exposed end **9** of the candle. The upper surface **7** of the igniter **4** may be generally parallel to the lower surface **6** but can be irregular in form. The lower outlet of the passageway **5** preferably is covered with a metal foil **10**.

The igniter **4** is supported by a resilient support means **11**, preferably a thermoplastic foam material, e.g. polystyrene or polyurethane foam, to which the igniter **4** is bonded, preferably by casting the igniter **4** composition directly into a molded resilient support means **11** is provided with a passageway **12** which is aligned with the passageway **5** of the igniter **4**, thereby forming a continuous passageway for the flash from the initiator pellets **8**. The support means **11** is bonded to the wall of the casing **1** by adhesive means not shown. The resilient support means **11** serves to hold the igniter **4** securely in place in the casing **1** even under drop test conditions and further prevents the igniter **4** from developing cracks or dropping portions of the igniting material into the airspace **3** in the event cracks did develop from an unusually severe jolt.

The casing **1** is closed by a closure **13** which may be of metal, but which preferably is a thermosetting synthetic resin, e.g. phenol-formaldehyde. The closure **13** is fitted against the flexible support means **11** and preferably is bonded thereto and against the wall of the casing **9** by an adhesive. Additional bonding material may be run around the upper edge of the closure **13** to form a fillet, particularly when the closure **13** is made of metal. The closure **13** can also be cast directly onto the support means **11** and bonded thereto by the hot molding composition. The closure **13** is provided with perforations **15** positioned over the passageway **12**, which serve to retain initiator pellets **8** within the initiator casing **16**, which is bonded to the top surface of closure **13**. The initiator pellets **8** preferably have a nominal formula (in weight percent) of boron, amorphous, 23.7; potassium nitrate, 70.7; and polyester binder 5.6. The pellets **8** are easily ignited by a squib flame from a primer **17** and have a burning rate on the order of 1.5 in./sec. at 15 p.s.i.a. The primer **17** preferably is provided with lead wires **18** leading to electrical spark means not shown.

The casing **1** in the embodiment of FIGURES 1–3 is further provided with venting means openings **19** which are sealed against entrance of atmosphere and moisture by foil tabs **20**, bonded to the casing **1** will by an adhesive not shown. At least one venting mean opening **19** will be used. Preferably a multiplicity will be used. The openings may range in diameter from about 1/32 to 1/2 inch and preferably will be about 1/4 inch in diameter.

The operation of the ignition system of the invention is illustrated more fully in FIGURES 2 and 3. FIGURE 2 shows the candle shortly after the primer **17** has been discharged by an electrical spark causing initiator pellets **8** to ignite, to burn away the metal foil **10**, and ignite the igniter **4**. The illuminant composition **2** is shown ignited by the flow of combustion products **25** from the burning igniter **4** which sweep across the exposed end surface **9** and vent out of the casing **1** through venting means openings **19** after displacing the foil tabs **20**. The gas pressure generated in the casing **1**, essentially is kept low by suitable sizing of the venting means openings **19**, so that combustion products **25** essentially flow across the surface **9** of the illuminant composition **2** and cause the latter to ignite without immediately dislodging the closure **3**. After the illuminant composition **2** is ignited, the heat generated by its flame preferably will burn away the upper end of the casing along the openings **19** substantially as shown in FIGURE 3. Alternatively, the bonding material used to retain the closure **3** by its periphery along the wall of the casing **1** may be selected to melt or burn away, permitting the closure **3** to be blown away by the greater heat and pressure generated by the ignited illuminant composition **2**. The candle then burns freely, generating illumination

In FIGURE 4 is shown an embodiment of the invention wherein the venting means is provided by means of a displaceable plug **21** which fits tightly into the closure **13** and which is provided with a passageway **23** through which passes the wrapper of the lead wires **18** of a primer **17**. An initiator **16'** is positioned into a recess **12'** of the passageway **12** of the resilient support means **11**. The ignitor **4** is supported by the support means **11** and preferably is made of a wafer grain having a smaller diameter than the exposed end **9** of the illuminant composition **2**. The plug **21** can be assembled with the primer **17** and initiator **16'** attached thereto and stored separate from the candle until time for ignition at which time it can be inserted to arm the candle. A substituted plug, not shown, can be used to close the passageway **23** while the candle is in storage. The safety of the candle is thereby enhanced. The casing **1** of the pyrotechnic device, or candle, of the embodiment of FIGURE 4 is provided with an indentation roll mark which is of the desired height of the airspace **3**. The bottom edge of the indentation mark **24** serves as a filling level for the illuminant composition **2**. The upper edge of the mark serves as a support shoulder for the resilient support means **11**.

Upon discharge of the primer **17** of the candle of FIGURE 4, the initiator **16'** projects a flash flame which ignites the igniter **4**. The combustion products, not shown, from the igniter **4** impinge against the exposed end **9** and accumulate in the continuous passageway **12**, **12'** of the resilient support material **11** until sufficient gaseous pres-

sure is created in the candle to displace the plug **21**. The hot combustion products from the burning igniter **4** sweep across the surface **9** and escape through the passageways **12, 12'**, thereby heating the illuminant composition **2** to its ignition temperature. The resilient support material **11** melts and burns away in the flame from the illuminated composition. The closure **13** is likewise burned away or blown away by the loosening of the bonding material at its periphery along the wall. The candle then burns freely, generating illumination.

In FIGURE 5 is shown still another embodiment of the invention. In this embodiment, the closure **13** extends from wall to wall in casing **1**. The closure **13** is provided with an indentation, or scoring line, **26** which facilitates fracturing and venting of the closure **13** at a low pressure, e.g. 17–18 p.s.i.a., when the igniter **4** is ignited, thus permitting the combustion products to sweep across the exposed end **9** of the illuminant composition **2** and vent through passageways **12** and **12'**. The initiator **16''** in this embodiment is ignited by a flash flame from primer **17** which itself is discharged by percussion means, not shown, preferably actuated by a lanyard, not shown attached to a firing mechanism not shown, accessible through a passageway **27** in the casing **1**, covered by a removable coverplate **28**. Upon ignition of the illuminant composition **2**, the resilient support means **11** and the closure **13** are burned or blown away, permitting the candle to burn freely to generate illumination. The casing **1** in this embodiment, like that in FIGURE 4, is provided with an indentation mark **24** to achieve the same results.

The ignition system of the present invention for pyrotechnic device is especially useful for igniting illuminated compositions. However, it will be clear to those skilled in the art that the ignition system can be applied with advantage and benefit to the ignition of solid propellant rockets and other pyrotechnic devices.

The invention enhances the reliability of ignition of illuminant compositions which are high in metal fuel content, e.g. aluminum and magnesium, and low in oxidizer, e.g. ammonium or potassium perchlorate. It enhances the safety of manufacture of the igniters in that less sensitive compositions can be used and the igniter can be kept separate from the illuminant composition, thus minimizing the danger of accidental ignition. The resilient support means further enhances safety of the candle, or other pyrotechnic device, in that more positive bonding or securing of the igniter can be achieved to protect the igniter from becoming dislodged in drop tests and handling and storage operations. The efficiency of the igniter is enhanced many times in that substantially all of the combustion products are directed against the illuminant composition at flame temperatures as generated, thus far surpassing the conductance of heat from a surface burning igniter of the first-fire mix type. This improvement in flare ignition exposes the illuminant surface to direct heating for a much longer time which will greatly increase ignition reliability. By placing of the igniter opposite the illuminant, both are heated initially by the initiator flame; the igniter ignites first and then exposes the illuminant composition to radiative, convective, and conductive heat transfer.

I claim:

1. A pyrotechnic device for providing illumination, comprising the combination of a container having a sealable open end, a pyrotechnic illuminant composition in said container, said composition having an exposed end surface, an igniter for said composition, a primer for said igniter, means for discharging said primer, and a closure for said open end, said device being further characterized in that:

the igniter is shaped in the form of a substantially solid wafer having a first extensive surface and a second surface substantially parallel to said first surface, said first surface has a surface area greater than about one quarter of the exposed end surface of said composition, said igniter surfaces are connected by a passageway, the igniter is positioned with its first surface disposed substantially parallel to the exposed end surface of the illuminant composition and is essentially separated therefrom by an airspace measuring not more than an igniting distance;

a thermoplastic resilient support means is provided for the igniter, said support means has a first extensive surface and a second surface substantially conforming to the second surface of the igniter and a passageway between said surfaces, said igniter has its second surface bonded to the second surface of said support means with its passageway aligned to form a continuous passageway with that of the support means;

means are provided in said support means to support the primer, said primer having its discharge end positioned to discharge into said continuous passageway;

the support means is supported by the closure, said closure being positioned in the open end of the container with its periphery sealingly contacting the inner wall of the container; and

venting means are provided in said device at a location determined to cause combustion products of the igniter to impinge against the surface of the illuminant composition and to flow through said airspace across and in contact with the surface of the illuminant composition enroute to said venting means.

2. A pyrotechnic device according to claim **1** wherein the venting means comprises at least one passageway through the closure to the atmosphere, said passageway being closed with a closure means which is displaceable by combustion products of the device.

3. A pyrotechnic device according to claim **1** wherein the venting means comprises at least one passageway through the container wall to the atmosphere, said passageway being positioned in the wall opposite the airspace between the igniter and illuminant composition surfaces, said passageway being closed with sealing means displaceable by combustion products of the device.

4. A pyrotechnic device according to claim **1** wherein the igniting distance measures from about 1/32 to 1/4 inch.

5. A pyrotechnic device according to claim **1** wherein the igniting distance is preset in the casing by an indentation mark at the filling level for the illuminant composition.

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