

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 015 401 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

08.12.2004 Bulletin 2004/50

(21) Application number: **98936941.8**

(22) Date of filing: **22.07.1998**

(51) Int Cl.7: **C06C 9/00, C06C 5/00**

(86) International application number:
PCT/US1998/015064

(87) International publication number:
WO 1999/011587 (11.03.1999 Gazette 1999/10)

(54) **METHOD OF FORMING FLARES HAVING IGNITERS FORMED FROM EXTRUDABLE IGNITER COMPOSITIONS**

HERSTELLUNGSVERFHREN VON LEUCHTSÄTZEN MIT AUS EXTRUDIERBAREN
ZÜNDMITTELZUSAMMENSETZUNGEN HERGESTELLTEN ZÜNDMITTELN

METHODE DE PREPARATION DE FUSEES ECLAIRANTES POSSEDANT DES DISPOSITIFS DE
MISE A FEU CONSTITUES PAR DES COMPOSITIONS EXTRUDABLES DE MISE A FEU

(84) Designated Contracting States:
DE FR GB SE

(30) Priority: **04.09.1997 US 57501 P**
21.07.1998 US 119518

(43) Date of publication of application:
05.07.2000 Bulletin 2000/27

(73) Proprietor: **ALLIANT TECHSYSTEMS INC.**
Edina, Minnesota 55436 (US)

(72) Inventors:
• **NIELSON, Daniel, B.**
Brigham City, UT 84302 (US)
• **LUND, Gary, K.**
Malad, ID 83252 (US)

• **BLAU, Reed, J.**
Corinne, UT 84301 (US)

(74) Representative: **Beacham, Annabel Rose**
Frank B. Dehn & Co.,
European Patent Attorneys,
179 Queen Victoria Street
London EC4V 4EL (GB)

(56) References cited:

EP-A- 0 310 580	CH-A- 240 427
DE-A- 3 243 425	DE-U- 9 416 123
FR-A- 2 015 074	FR-A- 2 235 348
FR-A- 2 441 598	GB-A- 566 786
GB-A- 1 231 181	US-A- 2 416 639
US-A- 3 257 801	US-A- 3 338 764
US-A- 5 610 364	

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 1 015 401 B1

Description**BACKGROUND OF THE INVENTION**5 1. Field of the Invention

[0001] The present invention relates to a method of forming a flare comprising an extrudable igniter composition.

10 2. Background Information

[0002] Igniter compositions ought to satisfy a number of design criteria. The igniter composition, when formed, should be sufficiently robust to remain in operable form prior to deployment of the device to be ignited, such as a flare or other device.

[0003] One of the commonly proposed igniter systems uses solid particles consisting of B/KNO₃ which, when ignited, initiate combustion of the specified gas generant composition.

[0004] Other recent efforts in the civilian market have focused on developing alternative cost-effective igniter compositions or igniter compositions which are more easily manufactured. These efforts have included proposals to use a hot-melt thermoplastic resin matrix together with a particular igniter composition, such as KNO₃. This effort sought to marry a commercially available hot melt adhesive, such as one designed for so-called "glue-guns" with a common alkali metal oxidizer. This effort to improve performance was less than satisfactory. Extrudability and igniter performance proved difficult to control, and the repeatable ballistic performance desired has not yet been demonstrated.

[0005] Accordingly, despite these and still other efforts, relevant objectives remain unattained. A simpler, more cost-effective igniter composition for flares and decoys or other devices remains desired. In particular, efforts are still ongoing towards providing an igniter composition which avoids the need for hot melting so-called adhesives, and thus the consequent risks associated with processing a pyrotechnic material at an elevated temperature, but which is facile to manufacture and would be sufficiently robust.

[0006] It would, therefore, be a significant advance to provide igniter compositions capable of being used as an igniter which satisfactorily address these concerns in the industry.

30 **SUMMARY AND OBJECTS OF THE PRESENT INVENTION**

[0007] The present invention offers a method of forming flares incorporating one or more of the herein disclosed igniter sticks.

[0008] The extrudable igniter is readily manufactured at low cost to obtain a physically robust product. The igniter can be manufactured without the use of a thermoplastic melt or hot-melt mixing equipment, and thus avoids the potential hazards associated with processing at such elevated temperatures. The extrudable Igniter composition from which the igniter stick can be formed is suitably processed at ambient temperatures into robust products which have sufficiently relatively selectable ignition characteristics. The igniter stick can have other configurations, provided the configuration is consistent with the objectives herein disclosed. The extrudable Igniter composition can be used to form a solid. or hollow igniter "stick" capable of igniting a flare or propellant composition in a flare or other pyrotechnic device.

BRIEF DESCRIPTION OF THE DRAWING45 **[0009]**

Figure 1 illustrates an exemplary flare device (a XM212 type flare) in longitudinal cross-section which includes an igniter stick formed from the extrudable igniter composition.

Figures 2, 3, 4 and 5 illustrate diameter cross-sectional views of flares provided with igniter sticks fabricated from the disclosed extrudable igniter composition.

50 **DETAILED DESCRIPTION OF THE INVENTION**

[0010] The extruded igniter sticks formed by the method of the invention can be characterized as having a configuration designed for rapid deflagration at a high temperature upon ignition. Upon ignition an igniter stick is capable of igniting another pyrotechnic composition. In flares, such as the XM212 flare, the igniter sticks are sized to be capable of complete end to end ignition, e.g., complete flame transition, in a short time, such as less than 10 milliseconds.

[0011] The igniter compositions which are capable of being extruded comprise a combination of a water-soluble binder, water-soluble or dispersable oxidizing agent, water-soluble or dispersable fuel, and a selected amount of water.

By preference, the extrudable compositions are essentially compositionally homogeneous.

[0012] The binder is a water-soluble binder, comprising at least one member selected from the group consisting of a water-soluble gum present in an amount of about 2 weight percent to about 10 weight percent based on the total amount of dry ingredients in the extrudable igniter composition, poly-N-vinyl pyrrolidone, polyvinyl alcohols and copolymers thereof, polyacrylamide, sodium polyacrylates, copolymers based on acrylamide or sodium acrylate, and water-soluble gelatin. These water soluble gums include naturally occurring gums, such as guar gum, acacia gum, modified celluloses and starches. A detailed discussion of "gums" is provided by C.L. Manteil, *The Water-Soluble Gums*, Reinhold Publishing Corp., 1947, which is incorporated herein by reference. It is presently considered that the water-soluble binders improve mechanical properties or provide enhanced crush strength. The suitable fuels and oxidizers can be water soluble or water insoluble. Suitable fuels and oxidizers can be inorganic or organic.

[0013] In the formulation from which the extrudate igniter stick is formed, the binder concentration is such that a sufficiently mechanically robust extrudate is obtained. The extrudate, such as an igniter stick, should be capable of retaining its shape, e.g. maintaining its integrity, prior to ignition. By preference, the extruded igniter stick is capable of being received (inserted) in a pyrotechnic composition, e.g. a suitably configured bore (e.g. central bore) in a propellant composition, and of shattering or fracturing when ignited. In general, the binder can be in a range of, for example, of about 2 % by weight to about 10 % by weight, and more particularly about 3% by weight to about 7% by weight, relative to the dry ingredients in the formulation. The binder can be comprised of more than one binder material.

[0014] The igniter composition includes at least one oxidizer, which is preferably water soluble or at least water dispersible. The oxidizer can therefore be organic or inorganic, although inorganic oxidizers are presently preferred. Organic oxidizers which are dispersible in a binder so that a sufficiently homogeneous igniter composition is obtainable include amine nitrate salts, nitro compounds, nitramine, nitrate esters, and amine perchlorates, of which methyl ammonium nitrate, methyl ammonium perchlorate are exemplary. Other candidates include RDX and HMX, CL-20 and PETN. Inorganic oxidizers include oxidizing ionic species such as nitrates, nitrites, chlorates, perchlorates, peroxides, and superoxides. Typifying these inorganic oxidizers are metal nitrates such as potassium nitrate or strontium nitrate, ammonium nitrate, meta) perchlorates such as potassium perchlorate, and metal peroxides such as strontium peroxide. In general, the oxidizer is ordinarily present in an amount effective to ensure oxidation of at least the fuel in the igniter and can be in a range of, for example, of about 40% by weight to about 90% by weight, and more particularly about 70% by weight to about 85% by weight, relative to the dry ingredients in the formulation.

[0015] The igniter composition can be formulated with an additional fuel, assuming that the binder may be capable of functioning as a secondary, not primary, fuel for the igniter composition. These additional fuels include powdered metals, such as powdered aluminum, zirconium, magnesium and/or titanium, among others; metal hydrides such as zirconium or titanium hydride; and so-called metalloids, such as silicon and boron which are capable of being sufficiently "dispersible" in the binder. Water-soluble or water-dispersible fuels include, e.g., guanidine nitrate, cyano compounds, nitramines (RDX and/or HMX), CL-20, tetranitrocarbazoles, organic nitro compounds, and may, if desired, be "multi-modal" in particle size distribution. Water dispersible materials can be added in substantially even particle size distribution or in multi-modal distributions depending on the ignition characteristics desired.

[0016] Water dispersible fuels are, by present preference, used in fine particulate form, such as powder or ground to sufficient fine particles, to ensure adequate distribution during the manufacturing process. By preference, an at least substantially even distribution in the resultant extrudable igniter composition is desired. In general, the fuel is in pulverulent form, such as 100 μ or less, such as, for example, from about 1 μ to 30 μ . Metals in powder form may have, if desired, a smaller particle size range, such as from about 1 to 20 μ , or even smaller such as 1 to about 5 μ . The amount of fuel -- other than the binder -- can be in a range of, for example, of about 5 to about 30% by weight, and more particularly about 10% by weight to about 20% by weight, relative to the dry ingredients in the formulation.

[0017] The present igniter sticks and related grains can incorporate, if desired, a reinforcement. Suitable reinforcement can be achieved with fibers, such as combustible fibers, which can serve to both strengthen the extruded igniter stick, and, upon appropriate selection of the reinforcement, improve igniter performance. The fibers are preferably generally shorter in length (low aspect ratio). Fibers incorporated into extrudable igniter formulations include, for instance, polyolefin fibers, polyamide fibers, polyester fibers and poly (2,2-(m-phenylene)-5,5-bisbenzimidazole ("PBI")) fibers. Polyolefin fibers include polyethylene ("PE") fibers, such as PE fibers having an outer diameter of about 0.005 mm and higher, such as to about 0.8 mm, and a length in a range of 0.1 mm to about 3.2 mm, of which the Spectra 900 brand of polyethylene fiber from Allied-Signal is illustrative. Suitable polyamide fibers, such as Nylon 6 fibers, can have a suitably selected diameter, such as 19 microns, and a length of 1.5 mm to about 6.4 mm. Suitable polyester fibers include high tenacity polyester fibers having lengths of about 1.5 mm to about 6.4 mm, and a suitable diameter of about 25 microns. PBI fibers include those having lengths on the order of 0.8 mm to 3.2 mm. Representative reinforced igniter sticks and the formulations therefor are reported in the Examples.

[0018] The composition in extrudable form for use in the method of the invention is readily obtainable, for instance, by mixing binder, fuel, oxidizer and the selected amount of water for such a period of time to achieve an at least substantially even distribution of the fuel and oxidizer throughout the binder. The method involves mixing a water-

soluble binder and a selected amount of water to form a pre-mix, and admixing the pre-mix with (a) first the fuel and then the oxidizer, or (b) the oxidizer and then the fuel, or (c) a combination of the oxidizer and fuel. The amount of water is generally such that the resultant product has a consistency which is extrudable, but, by preference, is not runny. In principle greater amounts of water can be used but some manufacturing concerns may arise, including an increase in waste water laden with varying amounts of pyrotechnic species (fuel, oxidizer etc.).

[0019] The igniter composition thus formed is capable of being extruded to the desired physical geometry.

[0020] Among the suitable flares are those known to those skilled in the art as thrust flares of which the MJU-10 flare is exemplary. Other flares such as M-206 flares (which may or may not be spectrally matched) or a near IR flare, such as a M-278 type flare, are also suitably combined with one or more igniter sticks. The suitable flares are not restricted to the aforementioned MJU-10, M-206 or M-278 flares. For instance, a so-called standard 6.99 cm (2.75 inch) (cross-section diameter) flare, including visible illuminating flares, are suitably provided with at least one igniter stick. Non-commercial flare variants of the standard flare, such as the M-257 type flare, are also suitably provided with one or more igniter sticks. Advantageously, the igniter stick decreases the costs, decreases the fabrication time, and simplifies the design of flares, including the ignition system for a thrust flare such as the MJU-10 flare. Igniter sticks can be used in a great number of decoy devices which include decoy flares which are deployed to defend against an incoming threats, and particularly against heat-seeking missiles. The igniter sticks improve the reliability of flare ignition by decreasing out-of-place first fire, and the safety of manufacturing flares by eliminating the use of flammable solvents commonly used when applying traditional first fires. Suitable flares and/or flare compositions for combination with at least one igniter stick are described in Encyclopedia of Chemical Technology, 20:680-697 (4th ed, 1996), including the references cited therein, the complete disclosure of which is incorporated herein by reference.

[0021] The well-known Jane's Handbook describes flares and other solid propellant devices suitably used in combination with the igniter sticks.

[0022] Extrusion and extruders are described generally in Encyclopedia of Polymer Science and Engineering, 16:570-631 (2nd Edition 1996), including references cited therein, the complete disclosures of which are incorporated herein by reference.

[0023] Figure 1 illustrates, in cross-section, a type of flare known as a XM212 flare, in the longitudinal cross section view, the casing is a suitable pressure enclosure fabricated from steel or other material capable of being used for a flare application. The cartridge case 18 can have a vented housing 17. One closed end is defined by the forward closure 19. The opposing end of the XM212 flare includes an aft closure 12, spacers 13, an ignition system with igniter 15, protective cap 10 and a piston 11. In a preferred embodiment, a solidified (extruded) igniter stick 16, which may be solid or hollow, extends lengthwise (completely or partially) through the propellant grain as shown in Figure 1. The igniter stick is formed by extruding the hereinabove described extrudable igniter composition, allowing the extrudate to solidify, and inserting it into the propellant grain (preferably before its cured.) A selected propellant composition 14 surrounds the igniter stick. A so-called rapid deflagration cord, if desired, can be disposed lengthwise, e.g., such as loosely sleeved, within a hollow igniter stick. Although not illustrated, more than one igniter stick can, if desired, be used.

[0024] Cross sectional "diameter" views of flare casings with propellant and igniter sticks are shown in Figures 2-5. In the diameter cross-sectional view of Figure 2, the flare case 28 can, if desired, have a foam layer 22 (e.g. a foamed nitrocellulose liner) sprayed on its interior surface before propellant 24 is loaded. A center bore having a pre-selected geometry 26 sleeves a hollow igniter stick 20 (in end view such as quargum binder/B/ KNO_3).

[0025] In the diameter cross-sectional view of Figure 3, the flare case 38 has been loaded with propellant 34 and provided with a centrally positioned hollow igniter stick 36. Optionally, additional solid or hollow igniter sticks 32 can be provided.

[0026] In the diameter cross-sectional view of Figure 4, flare case 48 is loaded with propellant 44, and a centrally positioned shaped bore of pre-selected geometry. The centrally positioned bore may have an igniter stick 42 with igniter sticks 46 (in strip form) disposed radially in the slots from the bore. The igniter sticks are fitted within the slots, and preferably are not loosely fitted.

[0027] In the diameter cross-sectional view of Figure 5, the flare case 58 is shown loaded with propellant 54 and a centrally positioned igniter stick having multiple axial bores therein.

[0028] The igniter stick can, if desired, be fitted with a peelable glove/sleeve prior to its insertion into the propellant grain. This can protect an igniter stick during the manufacturing process or during storage before use.

[0029] The igniter sticks are preferably inserted into the propellant grain before the latter is cured.

[0030] The invention is further described with reference to the following non-limiting Examples.

Examples

Example 1

[0031] To a 3.8 l (one gallon) Baker-Perkins planetary mixer, 1170 g (78%) of 35 micron potassium nitrate and 105

g (7%) of Cytec Cyanamer® N-300 brand polyacrylamide (15 million MW) were added. These ingredients were then blended remotely in the dry state for one minute. To this blend, 217.5 g (14.5 parts per 100 of igniter formulation) of water were added and mixed for five minutes. The mix blades and inner surface of the mix bowl were scraped with Velostat (conductive plastic) spatulas followed by 15 additional minutes of mixing. To the resulting thick white paste, 225 g (15%) of amorphous boron powder (90-92% purity) were added and mixed remotely for five minutes. While wearing approved protective clothing, the blades and bowl were again "scraped down" manually and the formulation was mixed for ten additional minutes. The resulting brown, dough-like material was granulated to -4 mesh and fed into a Haake 25 mm single-screw extruder. The igniter formulation was extruded through a 12 point star die with a maximum diameter of 0.84 cm (0.33") and a minimum diameter of 0.76 cm (0.30"). The die included a central 0.203 cm (0.080") diameter pin, thus producing a hollow rod-like configuration. The extruded igniter formulation was cut into 17.8 cm (7") lengths. Before drying, a 19.1 cm (7.5") length of 0.18 cm (0.07") diameter Teledyne RDC (rapidly deflagrating cord) was inserted into the 0.20 cm (0.08") diameter perforation. The igniter sticks were dried at 74°C (165°F) overnight. The igniter sticks were tested to evaluate their performance as an igniter in an inflator which was designed for passenger side automotive safety bags. The igniter sticks performed satisfactorily.

Example 2

[0032] A series of extruded igniter stick formulations containing boron, potassium nitrate, a water-soluble binder, and optionally, fibers for reinforcement were prepared. These formulations are reported in Table I. The formulations were first mixed on a 10 g and then a 30 g scale to determine their sensitivity towards stimuli including impact, friction, electrostatic discharge, and heat (Table II). In general, carbohydrate-based binders exhibited the greatest sensitivity with respect to ABL friction. Formulations containing methyl cellulose, guar gum, and locust bean gum as the binder were also used to prepare igniter sticks.

[0033] The remaining formulations were mixed on a 325 g scale in a one pint Baker-Perkins planetary mixer. Potassium nitrate and the respective water-soluble binder were blended remotely in the dry state for one minute. To this blend, the respective amount of water (Table III) was added and the slurry was mixed for five minutes. As in Example 1, the bowl and blades were "scraped down". At this point, fibers were added to fiber-containing formulations and the dough was mixed for an additional 5 minutes. All formulations were mixed for 10 additional minutes before adding boron. One half of the boron was added at this point followed by five minutes of mixing. The rest of the boron was then added followed by an additional five minutes of mixing. After a final "scrape down", the formulation was mixed for an additional ten minutes. The resulting brown, dough-like material was granulated to -4 mesh and fed into a Haake 25 mm single-screw extruder. The igniter formulation was extruded through a 12 point star die with a maximum diameter of 0.84 cm (0.33") and a minimum diameter of 0.775 cm (0.305"). The die included a centrally located 0.20 cm (0.80") diameter pin. The extruded igniter formulation was cut into 17.8 cm (7") lengths. Before drying, a 19.1 cm (7.5") length of 0.18 cm (0.07") diameter Teledyne RDC (rapidly deflagrating cord) was inserted. Ten additional 5.1 cm (2") lengths were extruded. The igniter sticks were dried at 74°C (165 F) overnight.

[0034] important factors in determining useful formulation include quality of the grain after drying, actual performance as an igniter, and drying rate. Leaching of a mixture of KNO_3 and binder to the surface of the grain may occur for some formulations during drying. Leaching in the perforation is not desired. Leaching was found to be least important in formulations containing tragacanth gum, Cyanamer® A-370 and Cyanamer® P-21 (Table III). igniter sticks from the formulations containing Cyanamer® A-370 and Cyanamer® P-21 were evaluated in content with an inflator device. Relative drying rates of 10 : 1.7 : 1 were calculated for formulations containing Cyanamer® N-300, Cyanamer® P-21 and Cyanamer® A-370, respectively. Thus, the formulation containing Cyanamer® A-370 was shown to dry quickly, with minimal KNO_3 leaching producing a grain that ignites gas generant with minimal ignition delays.

[0035] It is important to develop an extruded igniter stick for flares and other solid propellant devices that will withstand decades of jolts and vibrations while in service prior to deployment. Thus, a durability test method was developed for the extruded igniter sticks. Durability tests were performed in 3-point bending, with the load applied at mid-span. Bending was selected since tensile, compressive, and shear stresses are all present. Also, the sample configuration lends itself to this type of loading. A span of 3.8 cm (1.5 inches) was used, with the loads applied using 0.32 to 0.64 cm ($\frac{1}{8}$ - to $\frac{1}{4}$ -inch) diameter dowel pins. A nominal preload of 0.32 kg (0.7 pounds) was applied. The sample was then subjected to 1,000 loading cycles with the following conditions: cyclic amplitude 0.076 mm (0.003 inch), frequency 10 Hertz. After the cyclic loading, the samples were tested to failure at a displacement rate of 0.51 cm (0.2 inches) per minute. The durability of each sample is reported as the area under the load-displacement curve. For simplicity, the units are maintained as calibrated (load in 4.4 N (pounds-force), displacement in 2.54×10^{-3} cm (milli-inches)). Therefore, the reported durability has units of $2.54 \times 10^{-3} \text{cm} - 4.4 \text{ N}$ (milli-inch-pounds). All testing was performed at lab ambient temperature ($24 \pm 2.8^\circ\text{C}$) ($75^\circ \pm 5^\circ\text{F}$). Durability test results indicated enhanced durability of extruded igniter formulations containing fibers, e.g., formulation #13 and #15 in Table III.

Table I
Examples of Igniter Formulations Designed for
Extrusion with Water.

Form. #	%KNO ₃	%Boron	Binder	%Binder	Fiber	%Fiber
1	78.00	15.00	Cyanamer [®] N-300 ¹	7.00	none	0.00
2	77.50	15.50	Methyl Cellulose	7.00	none	0.00
3	76.30	16.70	Cyanamer [®] A-370	7.00	none	0.00
4	77.80	15.20	Cyanamer [®] P-21	7.00	none	0.00
5	78.00	15.00	Cyanamer [®] N-300LMW	7.00	none	0.00
6	76.50	16.50	Tragacanth Gum	7.00	none	0.00
7	76.50	16.50	Locust Bean Gum	7.00	none	0.00
8	76.50	16.50	Karaya Gum	7.00	none	0.00
9	78.00	15.00	PAM 1000MW	7.00	none	0.00
10	76.50	16.50	Guar Gum, FG-1, H. V.	7.00	none	0.00
11	77.00	16.00	Gelatin, Bovine Skin	7	none	0.00
12	78.50	12.50	Cyanamer [®] N-300	7.00	C Fiber,	2.00
13	78.50	12.50	Cyanamer [®] N-300	7.00	C Fiber,	2.00
14	78.50	12.50	Cyanamer [®] N-300	7.00	SiC	2.00
15	75.70	14.50	Cyanamer [®] N-300	6.80	Saffil [®] T-une	2.00

¹Cyanamer is a registered trademark of Cytec Industries Inc. for specialty polymers of polyacrylamide, sodium polyacrylate or copolymers thereof.

Table II
Safety Characteristics of Extruded Igniter Formulations

Forml.	Binder	Fiber	ABL ¹	ABL Sliding ²	ABL Sliding ³
1	Cyanamer [®] N-300	none	80 GL	800 @ 8 ft/s GL	362.9
2	Methyl Cellulose	none	6.9 GL	240 @ 6 ft/s YL	108.9
3	Cyanamer [®] A-370	none	21 GL	800 @ 8 ft/s GL	362.9
4	Cyanamer [®] P-21	none	21 GL	800 @ 8 ft/s GL	362.9
6	Tragacanth Gum	none	21 GL	320 @ 8 ft/s GL	345.2
7	Locust Bean Gum	none	13 GL	180 @ 6 ft/s YL	61.6
8	Karaya Gum	none	21 GL	240 @ 8 ft/s GL	108.9
9	PAM 10000MW	none	41 GL	800 @ 8 ft/s GL	362.9
10	Guar Gum, FG-1	none	11 GL	100 @ 6 ft/s YL	45.4
11	Gelatin, Bovine	none	33 GL	800 @ 8 ft/s GL	362.9
12	Cyanamer [®] N-300	C Fiber, Fortafil [®] F5C	33 GL	800 @ 8 ft/s GL	362.9
13	Cyanamer [®] N-300	C Fiber, Pyrograph [™] III	41 GL	800 @ 8 ft/s GL	362.9
14	Cyanamer [®] N-300	SIC Whiskers, Silar [®]	41 GL	800 @ 8 ft/s GL	362.9
15	Cyanamer [®] N-300	Safin [®] Tuna 500	51 GL	420 @ 8 ft/s GL	190.5

¹Units are in centimeters.

²Units are in pounds.

³Units are in Kg @ 244 cm/s

Table III
Test Result Summary for Extruded Igniters

Form.	Binder ID	Additive ID	Water	Durability ¹	%Perf Blockage ²
1	Cyanamer [®] N-300	none	14.5	55	100
3	Cyanamer [®] A-370	none	12.5	40	9
4	Cyanamer [®] P-21	none	11.5	34	45
5	Cyanamer N-300LMW	none	14.5	69	100
6	Tragacanth Gum	none	19	32	33
8	Karaya Gum	none	14.5	25	100
9	PAM 10000MW ⁴	none	14	NA	NA
11	Gelatin, Bovine Skin	none	10.5	44	100
12	Cyanamer [®] N-300	C Fiber,	16.5	69	100
13	Cyanamer [®] N-300	C Fiber,	16.5	97	83
14	Cyanamer [®] N-300	SIC Whiskers,	17.5	51	100
15	Cyanamer [®] N-300	Saffil [®] Towe	15.5	94	100

¹The parts per 100 of water added to the formulation necessary to allow efficient single-screw extrusion.

²Units are in milli-inch-pounds, $(2.54 \times 10^{-3} \text{ cm} - 4.4 \text{ N})$.

³The percentage of blocked perforations was determined from six or more 0.84 cm (0.33") OD, 0.20 cm (0.08") ID, 5.1 cm (2") L igniter sticks.

⁴Formulation No. 9 did not extrude very well.

Example 3

[0036] A series of igniters containing fibers were formulated with the goal of enhancing durability of the extruded igniter sticks as seen from Table IV. All formulations exhibited favorable safety characteristics. Samples (325 g) of each formulation were mixed in a Baker-Perkins pint mixer with 13.5 parts/100 of water. After dry blending the KNO₃ and Cyanamer® A-370 for one minute, the water was added followed by five minutes of mixing. The fiber was then added in two increments and the boron in three increments with three minutes of mixing after each addition. After a final "scrape down", the formulation was mixed for an additional ten minutes. The resulting brown, dough-like material was granulated to -4 mesh and fed into a Haake 25 mm single-screw extruder. The igniter formulation was extruded through a 12 point star die with a maximum diameter of 0.84 cm (0.33") and a minimum diameter of 0.775 cm (0.305"). The die included a centrally located 0.38 cm (0.15") diameter pin. The extruded igniter formulation was cut into 17.8 cm (7") lengths. Ten additional 5.1 cm (2") lengths were extruded. The igniter sticks were dried at 74°C (165 F) overnight.

[0037] There were no signs of KNO₃/binder leaching outside of the igniter grains after drying. Grains were ignited with the ignition plume of an ES013 squib directed into the 0.38 cm (0.15") ID perforation in the grain. The igniter grain was held in a 1.0 cm (0.4") ID, 1.2 cm (0.49") wall, cylindrical fixture with approximately 95 evenly distributed 0.277 cm (0.109") ID holes drilled along its length and diameter. The times required for the flame front to reach the opposite end of the grain after ignition by the squib are reported in Table V. The times were determined from 1000 frames/second video. Generally, only a few milliseconds were required. Durability of 5.1 cm (2") long grains was determined as described in Example 2. The results are reported in Table V. By far, the formulation containing 2% polyethylene fibers exhibited the greatest durability. Firings were conducted using igniter grains from formulations #3 and #19 with RDC inserted into the 0.38 cm (0.15") perforation. Formulation #19 with polyethylene fibers produced the least amount of delay before the pyrotechnic composition was ignited.

Table IV

Igniter Formulations containing Cyanamer® A-370 and Selected Fibers.					
Form	%KNO ₃	%Boron	%Cyanamer® A-370	Fiber ID	%Fiber
3	76.30	16.70	7.00	none	0.00
16	76.70	14.30	7.00	Pyrograph™ III, Micro	2.00
17	74.80	16.20	7.00	Saffil®, Type 590, Micro	2.00
18	74.80	16.20	7.00	Nextel®, 1/8" Ceramic	2.00
19	77.20	13.80	7.00	Allied, Spectra 900, 1/8"	2.00
20	76.50	14.50	7.00	Celanese 1/8" PBI	2.00
(1/8" = 0.32 cm)					

Table V

Test Result Summary for Potential Extruded Igniters Containing Fibers.					
Form	Fiber ID	Ignition ²	Ignition ²	Durability ^{3,4}	Coefficient
3	none	2	2	96	39
3 ¹	none, 0.318cm (0.125") ID	9	8	101	25
16	Pyrograph™ III, Micro	5		65	39
17	Saffil®, Type 590, Micro	1		107	4

¹Formulation 3 with grains having a 0.318 cm (0.125") ID instead of the nominal 0.38 (0.15") ID.

²Time required for the flame front on a 17.8 cm (7") grain ignited on one end to reach the opposite end. The time is in milliseconds. The data were acquired as described in Example 3.

³The same as in footnote 1 but cured epoxy blocking the 0.38 cm (.15") ID perforation at the opposite end from where ignition was initiated.

⁴Units are in milli-inch-pounds (2.54 x 10⁻³ cm - 4.4 N).

(1/8" = 0.32 cm)

EP 1 015 401 B1

Table V (continued)

Test Result Summary for Potential Extruded Igniters Containing Fibers.					
Form	Fiber ID	Ignition ²	Ignition ²	Durability ^{3,4}	Coefficient
18	Nextel®, 1/8" Ceramic	3		76	69
19	Allied, Spectra 900, 1/8"	17	1	357	17
20	Celanese 1/8" PBI	13		126	22

²Time required for the flame front on a 17.8 cm (7") grain ignited on one end to reach the opposite end. The time is in milliseconds. The data were acquired as described in Example 3.

³The same as in footnote 1 but cured epoxy blocking the 0.38 cm (.15") ID perforation at the opposite end from where ignition was initiated.

⁴Units are in milli-inch-pounds (2.54×10^{-3} cm - 4.4 N).
($\frac{1}{8}$ " = 0.32 cm)

[0038] In formulations 16, 17, 18, 19 and 20, respectively, the "fiber ID" can be characterized as carbon fiber, alumina fiber, aluminosilicate, polyethylene, and polybenzimidazole.

Example 4

[0039] An extrudable igniter composition was obtained by forming a pre-mix of guar gum (5.0 wt%, 0.25 gram) and water (deionized 15.0 wt%, 1.75 grams); combining the pre-mix with potassium nitrate (average particle size of about 26 microns, 75 wt%, 3.75 grams); and adding thereto fuel, boron (amorphous; 20.0 wt%, 1.00 gram).

Example 5

[0040] An extrudable igniter composition was obtained as in Example 4, but 20.0 wt% of water was used.

Example 6

[0041] An extrudable igniter composition was prepared as in Example 4, except that the amount of fuel, boron, was increased to 22.0 wt% (1.10 grams) and the amount of binder, guar gum, was reduced to 3.0 wt% (0.15 gram).

Example 7

[0042] An extrudable igniter composition was prepared according to the procedure of Example 4, except that the binder was polyacrylamide (cyanamer "N-300" from American Cyanamid, 5.0 wt%, 0.25 gram).

Example 8

[0043] An extrudable igniter mixture is prepared by adding potassium nitrate (210 grams) and a polyacrylamide (14 gram; cyanamer "N-300" from American Cyanamid) to a bowl; adding water (44.8 grams), to the bowl and mixing for 1 minute; and adding boron (amorphous; 56.0 grams) thereto followed by mixing for about four minutes.

Example 9

[0044] An extrudable igniter composition was prepared as in Example 8, except that the amount of water is 50.4 grams, the potassium nitrate and binder are first dry-blended together before adding the water and mixing 1 minute. The powdered boron is then added and the mixing is continued for four minutes.

Example 10

[0045] The igniter composition prepared according to Example 8 was granulated, dried and pressed into 1.3 cm ($\frac{1}{2}$ inch) diameter by 2.5 cm (1 inch) long pellets. The pellets were then inhibited on all but one face and combusted in a closed pressurized vessel at 6.9×10^6 , 13.8×10^6 , and 20.7×10^6 N/m² (1000, 2000 and 3000 psi) via ignition of the uninhibited face. Burning rates of 10.6 cm/s (4.16 ips), 10.97 cm/s (4.32 ips) and 11.23 cm/s (4.42 ips) respectively,

were observed.

Example 11

[0046] A portion of the wet igniter composition prepared as described in Example 9 was placed in a 5.1 cm (2 in) diameter ram extruder and forced through an appropriate die so as to provide a center perforated cylindrical extrudate of approx 0.8 cm (0.3 in) diameter with a perforation diameter of approx 0.15 cm (0.06 in). This extrudate was partially dried and cut into 17.8 cm (7 in) lengths prior to final drying. The resulting igniter sticks were then tested in a gas generating device consisting of a tubular metal cylinder approx 20.3 cm (8 in) long by approx 5.1 cm (2 in) diameter dosed at both ends and provided with radial ports. One of the end closures was further provided with an initiating squib. The igniter stick was retained in the center of the tube and a 17.8 cm (7 in) length of rapid deflagration cord (RDC) placed in the center perforation of the stick. The gas generating device was then filled with a charge of gas generant pellets and tested in a closed tank. Comparable results were obtained with the igniter stick in contrast to those obtained with a conventional ignition train in which a perforated metal tube filled with a like quantity of ignition powder and the RDC replaces the igniter stick/RDC combination. In all cases ignition of the gas generant pellets was observed to occur within 8 msec.

Example 12

[0047] Two fifty gram mixes formulated from 20 percent boron, 75 percent potassium nitrate, 5 percent Cytec Cyan-amer® N-300 brand polyacrylamide (15 million molecular weight), and 17.5 weight percent of water were produced. The mixes were combined and then loaded into a 5.1 cm (2.0 inch) diameter RAM extruder. The RAM was pressurized to 2.1×10^6 N/m² (300 psi) to extrude the ignitor sticks. The igniter composition was originally extruded into 0.254 cm (0.100 inch) diameter solid sticks and also into 0.254 cm (0.100 inch) diameter with a 0.076 cm (0.030 inch) diameter center perforation. The igniter sticks were cut into 15.2 cm (6 inch) lengths and dried at 57°C (135°F) overnight prior to use. The center perforated ignitor sticks were successfully demonstrated in an XM-212 decoy flare. Two XM 212 grains were fabricated. One with the traditional slurry first fire and the other with three center perforated igniter sticks. A flare configuration with an igniter stick is shown in Figure 1.

Example 13

[0048] The igniter sticks were also incorporated in the main ignition system of a MJU-10 decoy flare. The MJU-10 flare requires a larger igniter than the XM-212 flare. Therefore, the igniter formulation was extruded through a 12 point star die that has a 0.84 cm (0.33 inch) maximum diameter a 0.76 cm (0.30 inch) minium diameter. The extrusion die also included a 0.20 cm (0.80 inch) diameter pin used to produce a center perforated grain. The extruded igniter sticks were cut to 12.7 cm (5.0 inch) lengths and then dried at 57°C (135°F) for 24 hours. The igniter sticks were then inserted into the center perforation of the MJU-10 flare grain. The MJU-10 flare was successfully ignited with the igniter stick.

[0049] In view of the foregoing, the igniter stick will decrease the cost, decrease the fabrication time, and simplify the design of an ignition system for the thrusted MJU-10 flare.

[0050] In view of the Examples, igniter sticks can be used in a great number of decoy flare devices. They will aid in improving the reliability of flare ignition by decreasing out-of-place first fire, and also improve the safety of manufacturing flares by eliminating the use of flammable solvents commonly used when applying traditional first fires.

Claims

1. A method of forming a flare comprising a case propellant contained within the case, and an igniter system comprising an extruded dry igniter element deflagrating upon ignition for igniting the propellant of the flare, the extruded dry igniter element being formed from an extrudable igniter composition, said method comprising:

dissolving at least one water-soluble binder into an aqueous solvent,
mixing the dissolved binder with at least one oxidizer agent and at least one fuel to form the extrudable igniter composition, and
extruding and drying the extrudable igniter composition,

wherein the water-soluble binder comprises at least one member selected from the group consisting of a water-soluble gum present in an amount of about 2 weight percent to about 10 weight percent based on the total amount of dry ingredients in the extrudable igniter composition, water-soluble gelatin, poly-N-vinyl pyrrolidone,

polyvinylalcohol, a copolymer of poly-N-vinyl pyrrolidone and polyvinylalcohol, polyacrylamide, sodium polyacrylates, and a copolymer of polyacrylamide and polyacrylate.

2. The method of claim 1, wherein the water-soluble binder comprises poly-N-vinyl pyrrolidone.
3. The method of claim 1, wherein the water-soluble binder comprises polyvinylalcohol.
4. The method of claim 1, wherein the water-soluble binder comprises gum.
5. The method of claim 1, wherein the water-soluble polymeric binder comprises polyacrylamide.
6. The method of any of claims 1 to 5, wherein the oxidizer is present in an amount of from about 40 weight percent to about 90 weight percent relative to the dry ingredients used in formulating the extrudable igniter composition.
7. The method of any of claims 1 to 6, wherein the oxidizer comprises an organic oxidizer.
8. The method of any of claims 1 to 6, wherein the oxidizer comprises at least one ionic species selected from the group consisting of nitrates, nitrites, chlorates, perchlorates, peroxides, and superoxides.
9. The method of any of claims 1 to 8, wherein the extrudable igniter composition further comprises fibers.
10. The method of claim 9, wherein the fibers comprise at least one of polyolefin fibers, polyamide fibers, polyester fibers, and poly(2,2'-(m-phenylene)-5,5-bisbenzimidazole fibers).
11. The method of claim 1, wherein:
 - the binder comprises at least one member selected from the group consisting of poly-N-vinyl pyrrolidone, polyvinylalcohol, copolymers thereof, and gum;
 - the oxidizer is present in an amount of about 40 weight percent to about 90 weight percent relative to the dry ingredients used in formulating the extrudable igniter composition, and the oxidizer contains at least one ionic species selected from the group consisting of nitrates, nitrites, chlorates, perchlorates, peroxides, and superoxides; and
 - the extrudable igniter composition contains low-aspect ratio fibers, the fibers comprising at least one of polyolefin fibers, polyamide fibers, polyester fibers, and poly(2,2'-(m-phenylene)-5,5-bisbenzimidazole fibers).
12. The method of any of claims 1 to 11, wherein the extruded igniter element is configured as an igniter stick.
13. The method of claim 1, wherein the fuel comprises boron and the oxidizer comprises potassium nitrate.
14. The method of claim 13, wherein the water-soluble polymeric binder comprises at least one member selected from the group consisting of polyacrylamide, sodium polyacrylates, and a copolymer thereof.
15. The method of claim 14, wherein the boron is present in an amount of about 5 weight percent to about 30 weight percent, the potassium nitrate is present in an amount of about 40 weight percent to about 90 weight percent, and the binder is present in an amount of about 2 weight percent to about 10 weight percent.
16. The method of claim 15, wherein the extrudable igniter composition further comprises, as one of the ingredients, guanidine nitrate.

Patentansprüche

1. Verfahren zum Bilden eines Leuchtsatzes, umfassend einen Behälter, Treibmittel, das in dem Behälter enthalten ist und ein Zündsystem, umfassend ein extrudiertes trockenes Zündmittelelement, das bei Zündung verbrennt, zum Zünden des Treibmittels des Leuchtsatzes, wobei das extrudierte trockene Zündmittelelement gebildet wird aus einer extrudierbaren Zündmittelzusammensetzung, wobei das Verfahren umfasst:

Lösen mindestens eines wasserlöslichen Bindemittels in einem wässrigen Lösungsmittel,

Mischen des gelösten Bindemittels mit mindestens einem Oxidationsmittel und mindestens einem Brennstoff, um die extrudierbare Zündmittelzusammensetzung zu bilden, und Extrudieren und Trocknen der extrudierbaren Zündmittelzusammensetzung,

worin das wasserlösliche Bindemittel mindestens einen Bestandteil umfasst, ausgewählt aus der Gruppe, bestehend aus einem wasserlöslichen Gummi, der in einer Menge von etwa 2 Gewichtsprozent bis etwa 10 Gewichtsprozent, basierend auf der Gesamtmenge trockener Bestandteile in der extrudierbaren Zündmittelzusammensetzung, vorliegt, wasserlöslicher Gelatine, Poly-N-vinylpyrrolidon, Polyvinylalkohol, einem Copolymer aus Poly-N-vinylpyrrolidon und Polyvinylalkohol, Polyacrylamid, Natriumpolyacrylaten und einem Copolymer aus Polyacrylamid und Polyacrylat.

2. Verfahren nach Anspruch 1, worin das wasserlösliche Bindemittel Poly-N-vinylpyrrolidon umfasst.

3. Verfahren nach Anspruch 1, worin das wasserlösliche Bindemittel Polyvinylalkohol umfasst.

4. Verfahren nach Anspruch 1, worin das wasserlösliche Bindemittel Gummi umfasst.

5. Verfahren nach Anspruch 1, worin das wasserlösliche Bindemittel Polyacrylamid umfasst.

6. Verfahren nach einem der Ansprüche 1 bis 5, worin das Oxidationsmittel in einer Menge von etwa 40 Gewichtsprozent bis etwa 90 Gewichtsprozent, bezogen auf die bei der Formulierung der extrudierbaren Zündmittelzusammensetzung verwendeten trockenen Bestandteile, vorliegt.

7. Verfahren nach einem der Ansprüche 1 bis 6, worin das Oxidationsmittel ein organisches Oxidationsmittel umfasst.

8. Verfahren nach einem der Ansprüche 1 bis 6, worin das Oxidationsmittel mindestens eine ionische Spezies umfasst, ausgewählt aus der Gruppe, bestehend aus Nitraten, Nitriten, Chloraten, Perchloraten, Peroxiden und Superoxiden.

9. Verfahren nach einem der Ansprüche 1 bis 8, worin die extrudierbare Zündmittelzusammensetzung weiterhin Fasern umfasst.

10. Verfahren nach Anspruch 9, worin die Fasern mindestens eine aus Polyolefinfasern, Polyamidfasern, Polyesterfasern und Poly(2,2'-(m-phenylen)-5,5-bisbenzimidazolfasern umfassen.

11. Verfahren nach Anspruch 1, worin:

das Bindemittel mindestens einen Bestandteil umfasst, ausgewählt aus der Gruppe, bestehend aus Poly-N-vinylpyrrolidon, Polyvinylalkohol, Copolymeren davon und Gummi;

das Oxidationsmittel in einer Menge von etwa 40 Gewichtsprozent bis etwa 90 Gewichtsprozent der trockenen Bestandteile vorliegt, die beim Formulieren der , extrudierbaren Zündmittelzusammensetzung verwendet werden, und das Oxidationsmittel mindestens eine ionische Spezies enthält, ausgewählt aus der Gruppe, bestehend aus Nitraten, Nitriten, Chloraten, Perchloraten, Peroxiden und Superoxiden; und

die extrudierbare Zündmittelzusammensetzung Fasern mit niederem Aspektverhältnis enthält, wobei die Fasern mindestens eine aus Polyolefinfasern, Polyamidfasern, Polyesterfasern und Poly(2,2'-(m-phenylen)-5,5-bisbenzimidazolfasern umfassen.

12. Verfahren nach einem der Ansprüche 1 bis 11, worin das extrudierte Zündmittelelement als ein Zündmittelstab konfiguriert ist.

13. Verfahren nach Anspruch 1, worin der Brennstoff Bor umfasst und das Oxidationsmittel Kaliumnitrat umfasst.

14. Verfahren nach Anspruch 13, worin das wasserlösliche polymere Bindemittel mindestens einen Bestandteil umfasst, ausgewählt aus der Gruppe, bestehend aus Polyacrylamid, Natriumpolyacrylaten und einem Copolymer davon.

15. Verfahren nach Anspruch 14, worin das Bor in einer Menge von etwa 5 Gewichtsprozent bis etwa 30 Gewichtsprozent vorliegt, das Kaliumnitrat in einer Menge von etwa 40 Gewichtsprozent bis etwa 90 Gewichtsprozent vor-

liegt und das Bindemittel in einer Menge von etwa 2 Gewichtsprozent bis etwa 10 Gewichtsprozent vorliegt.

16. Verfahren nach Anspruch 15, worin die extrudierbare Zündmittelzusammensetzung weiterhin als einen der Bestandteile Guanidinnitrat umfasst.

Revendications

1. Procédé d'élaboration d'une fusée lumineuse comprenant un boîtier, un agent propulseur contenu dans le boîtier et un système d'allumeur comportant un élément d'allumeur sec extrudé faisant l'objet d'une déflagration lors d'un allumage en vue d'allumer l'agent propulseur de la fusée lumineuse, l'élément d'allumeur sec extrudé étant formé d'une composition d'allumeur extrudable, ledit procédé consistant :

à dissoudre dans un solvant aqueux au moins un liant soluble dans l'eau,
à mélanger le liant dissous avec au moins un agent oxydant et au moins un combustible pour former la composition d'allumeur extrudable, et
à extruder et faire sécher la composition d'allumeur extrudable,
procédé selon lequel le liant soluble dans l'eau comprend au moins un élément choisi parmi le groupe constitué d'une gomme soluble dans l'eau présente en une quantité d'environ 2 pour cent en poids à environ 10 pour cent en poids sur la base de la quantité totale des ingrédients à l'état sec dans la composition d'allumeur extrudable, d'une gélatine soluble dans l'eau, de poly-N-vinyl pyrrolidone, d'un alcool polyvinylique, d'un copolymère de poly-N-vinyl pyrrolidone et d'alcool polyvinylique, d'un polyacrylamide, de polyacrylates de sodium, et d'un copolymère de polyacrylamide et de polyacrylate.

2. Procédé selon la revendication 1, dans lequel le liant soluble dans l'eau comprend de la poly-N-vinyl pyrrolidone.

3. Procédé selon la revendication 1, dans lequel le liant soluble dans l'eau comprend un alcool polyvinylique.

4. Procédé selon la revendication 1, dans lequel le liant soluble dans l'eau comprend une gomme.

5. Procédé selon la revendication 1, dans lequel le liant polymère soluble dans l'eau comprend un polyacrylamide.

6. Procédé selon l'une quelconque des revendications 1 à 5, dans lequel l'oxydant est présent en une proportion d'environ 40 pour cent en poids à environ 90 pour cent en poids par rapport aux ingrédients à l'état sec utilisés pour former la composition d'allumeur extrudable.

7. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel l'oxydant comprend un oxydant organique.

8. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel l'oxydant comprend au moins une espèce ionique choisie parmi le groupe constitué de nitrates, de nitrites, de chlorates, de perchlorates, de peroxydes et de superoxydes.

9. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel la composition d'allumeur extrudable comprend en outre des fibres.

10. Procédé selon la revendication 9, dans lequel les fibres comprennent au moins l'un des éléments constitués par des fibres de polyoléfine, des fibres de polyamide, des fibres de polyester et des fibres de poly(2,2'-(m-phénylène)-5,5-bisbenzimidazole).

11. Procédé selon la revendication 1, dans lequel.:

le liant comprend au moins un élément choisi dans le groupe constitué d'une poly-N-vinyl pyrrolidone, d'un alcool polyvinylique, de copolymères de ceux-ci et d'une gomme ;
l'oxydant est présent en une proportion d'environ 40 pour cent en poids à environ 90 pour cent en poids par rapport aux ingrédients à l'état sec utilisés pour former la composition d'allumeur extrudable, et l'oxydant contient au moins une espèce ionique choisie parmi le groupe constitué de nitrates, de nitrites, de chlorates, de perchlorates, de peroxydes et de superoxydes ; et
la composition d'allumeur extrudable contient des fibres à faible rapport d'aspect, les fibres comprenant au

moins l'un des éléments constitués par des fibres de polyoléfine, des fibres de polyamide, des fibres de polyester et des fibres de poly(2,2'-(m-phénylène)-5,5-bisbenzimidazole.

5 **12.** Procédé selon l'une quelconque des revendications 1 à 11, dans lequel l'élément d'allumeur extrudé est façonné sous forme d'une charge d'allumeur.

13. Procédé selon la revendication 1, dans lequel le combustible comprend du bore et l'oxydant comprend du nitrate de potassium.

10 **14.** Procédé selon la revendication 13, dans lequel le liant polymère soluble dans l'eau comprend au moins un élément choisi parmi le groupe constitué d'un polyacrylamide, de polyacrylates de sodium, et d'un copolymère de ceux-ci.

15 **15.** Procédé selon la revendication 14, dans lequel le bore est présent en une proportion d'environ 5 pour cent en poids à environ 30 pour cent en poids, le nitrate de potassium est présent en une proportion d'environ 40 pour cent en poids à environ 90 pour cent en poids et le liant est présent en une proportion d'environ 2 pour cent en poids à environ 10 pour cent en poids.

20 **16.** Procédé selon la revendication 15, dans lequel la composition d'allumeur extrudable comprend en outre, comme constituant l'un des ingrédients, du nitrate de guanidine.

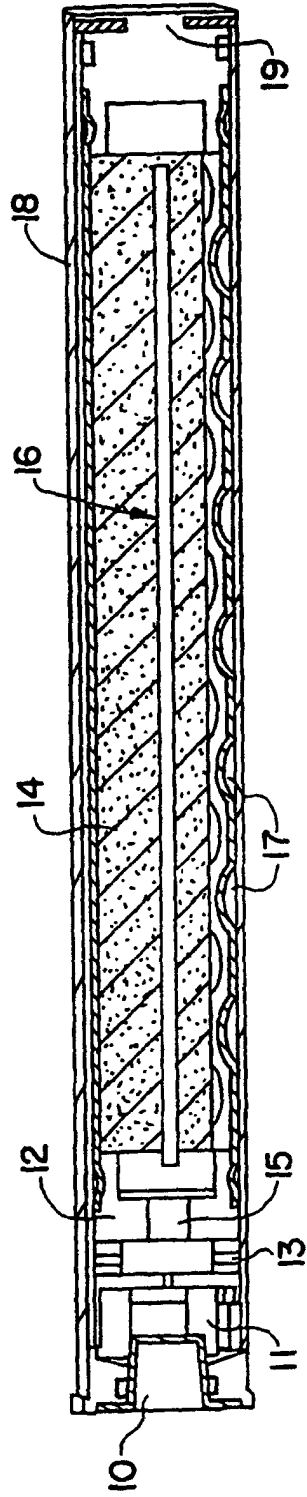


FIG. 1

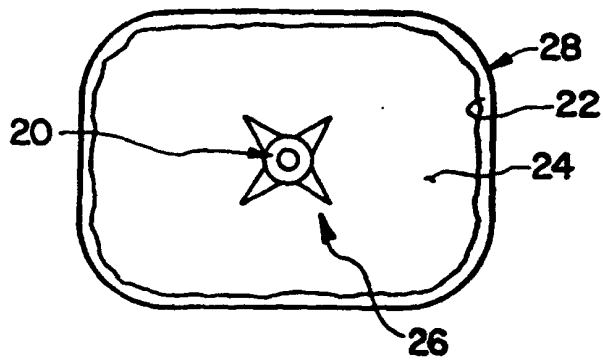


FIG. 2

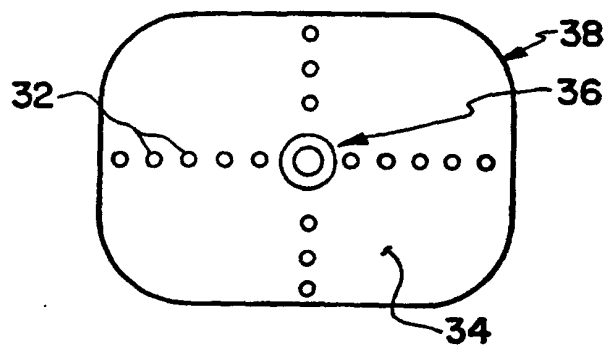


FIG. 3

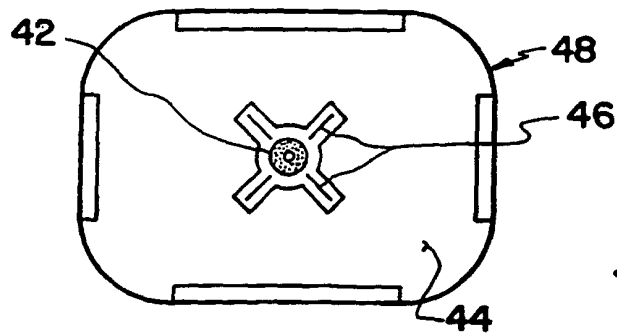


FIG. 4

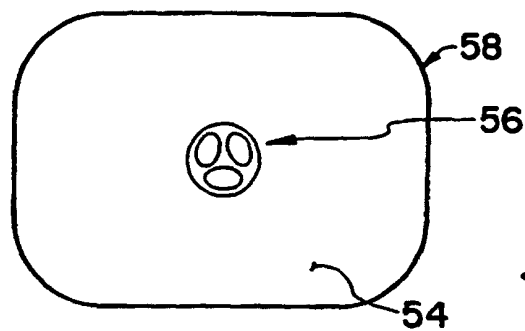


FIG. 5