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(54) Title: CHEMILUMINESCENT IMPACT ACTIVATED PROJECTILE

(57) Abstract: The present invention relates to a non-pyrotechnic, self-illuminating projectile useful for marking, target illumination, or targeting adjustment which produces chemiluminescent light upon impact with an object. Because the production of light is delayed until impact, the projectile is not visualized until impact and the intensity of light upon impact is greater than light produced by projectiles that provide intermixing of light generating chemicals during flight.

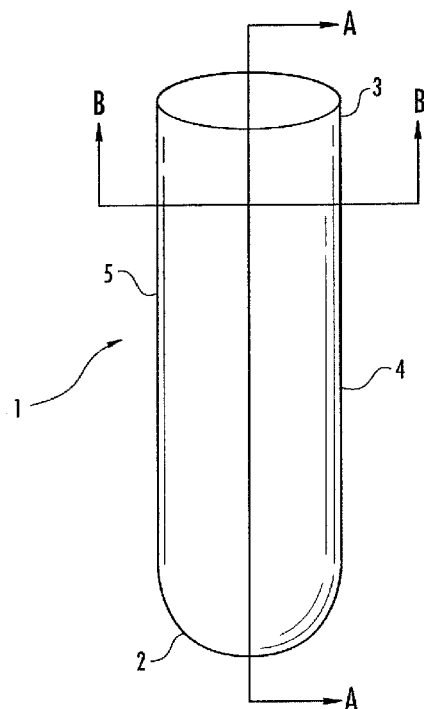


FIG. 1



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CHEMILUMINESCENT IMPACT ACTIVATED PROJECTILE

FIELD OF THE INVENTION

This invention relates to light emitting projectiles for marking an impact area, more particularly to
5 a long range, long-flight time chemiluminescent projectile used for tactical and training exercises by military and law enforcement personnel which prevents light production resulting from forces associated with firing of the weapon, thereby retaining the amount of chemical light generated to
10 occur as the projectile impacts the target area and releases its contents.

BACKGROUND OF THE INVENTION

Military and law enforcement personnel worldwide employ a variety of projectile launching weapons, both
15 direct-fire and ballistic in nature. Payloads include lethal and non lethal explosive charges, chemical agents such as tear gas, smoke, and combinations of elements to illuminate an area or target for remote reconnaissance. In addition, in the training of military and law enforcement personnel, a
20 need exists for detecting the accuracy and effectiveness of the trainee's ability to strike an intended target in daylight or darkness. This is important not only for personnel training, but also to determine the effectiveness of various equipment systems, and as a means of calibrating
25 such systems. Training with explosive or pyrotechnic devices presents inherent health and safety hazards to the training personnel, such as in the case where a pyrotechnic charge fails to perform as required, resulting in unexploded ordinance.

Various devices are currently employed for marking the destination of projectiles. Many such devices utilize pyrotechnics which produce a flash of light and smoke to indicate the projectile impact site. One such device employs titanium tetrachloride which produces a cloud of smoke when it reacts with the moisture in the air on impact. A second such device is a red phosphorus bearing projectile which emits a flash of light upon impact. These devices, however, have inherent problems. Devices utilizing titanium tetrachloride, are ineffective for night time detection as they only emit smoke. Devices utilizing phosphorus generate light and can be seen during day or night time. However, light production is a result of burning, resulting in fire hazard potential for any materials, such as trees, shrubs, or grasses, that may contact the burning phosphorus.

Chemiluminescent lighting devices have been used as an alternative to devices utilizing pyrotechnics. Chemiluminescent systems provide light by the use of a chemical reaction not dependent upon any electrical power or batteries. The long storage life and the excellent quality of light produced from current chemiluminescent systems have made the product a mainstay in the industry for emergencies. Projectiles utilizing chemiluminescent systems have an advantage in that they do not utilize pyrotechnics, and therefore are not a source of ignition for objects which come into contact with the chemicals. They are also useful in day and night detection and can produce both visible and non-visible light.

Chemiluminescent light production generally utilizes a two-component system to chemically generate light. Light is produced by combining the two components, which are usually in the form of chemical solutions referred to as the

"oxalate" component and the "activator" component. The two components are kept physically separate by a sealed, frangible, glass vial containing one component which is housed within an outer flexible container containing the other component. Typically, this outer container is sealed to contain both the second component and the filled, frangible vial. Forces created by intimate contact with the internal vial, e.g. by flexing, cause the vial to rupture, thereby releasing the first component, allowing the first and second components to mix and produce light. Since the objective of this type of device is to produce usable light output, the outer vessel is usually composed of a clear or translucent material, such as polyethylene or polypropylene, which permits the light produced by the chemiluminescent system to be transmitted through the vessel walls. These devices may be designed so as to transmit a variety of colors by either the addition of a dye or fluorescent compound to one or both of the chemiluminescent reactant compositions or to the vessel. Furthermore, the device may be modified so as to only transmit light from particularly chosen portions thereof.

Chemiluminescent projectiles are currently used by the military to provide tracking and marking capabilities, thus eliminating training with explosive or pyrotechnic devices which present inherent health and safety hazards to the training personnel. In many cases, however, military forces training on gunnery accuracy in larger calibers (40 mm to 155 mm) often desire to train with non-explosive chemiluminescent ammunition. Typical chemical light reactions initiate with a bright burst of light that quickly diminishes and then asymptotically approaches zero. Approximately 80% of the available light is emitted within the first 20% of the total glow duration. When training for

accuracy, a brief, bright burst of light is desired that rapidly extinguishes so that the impact of subsequent rounds can be accurately determined. Chemical light training munitions have their formulas catalyzed such that the entire
5 reaction occurs in approximately one minute. In larger, long range calibers, chemiluminescent munitions that produce light upon the firing of the weapon, in combination with the long flight times, can result in a majority of the chemical light reaction occurring before the munition impacts the target
10 area and releases its signal.

PRIOR ART

The production of devices capable of emitting light through chemical means is well-known in the art. Lightsticks, for example, are taught in U.S. Pat. No. 3,539,794, while
15 other configurations have also been the subject of many U.S. patents, e.g. 3,749,620; 3,808,414; 3,893,938; 4,635,166; 4,814,949 and 5,121,302, the contents of which are herein incorporated by reference.

Various chemiluminescent and non- chemiluminescent
20 projectiles have been developed which provide marking and tracking capabilities. U.S. Pat. No. 3,940,605 discloses a chemiluminescent lighting apparatus for generating an illuminated marker material for delivery to a desired area. Two fluids to be mixed are contained in separate chambers and
25 are separated from a mixing chamber by means of frangible disc-shaped members. A hollow gas generator expels gas when a squib fractures one of its walls. The force of the escaping gas exerts pressure on the two fluids sufficient to fracture the frangible disc members allowing mixing action in the
30 mixing chamber. The mixed fluid chemically reacts to produce light and flows from the mixing chamber to a light

transmittable material where it is stored to provide an illuminated area.

U.S. Patent 3,983,817 discloses a spotting projectile having an interior cylinder receiving a piston in gas-sealing slideable relation so that gas trapped in the cylinder is compressed by forward inertial movement of the piston when the projectile impacts. The compressed gas ejects a powder charge carried by the piston rearwardly from the projectile to form a visible cloud.

U.S. Pat. Nos. 4,640,193 and 4,682,544 teach a container adapted for insertion into a device wherein the container has fitted into its hollow interior the components required to form therein and eject therefrom, upon impact and detonation, a chemiluminescent light emitting material, inclusive of a reactive enhancer.

U.S Patent 4,932,672 discloses an impact actuated nonlethal hand grenade having a flexible, resilient casing containing a pressurized marking fluid. The casing has an opening and a ball received within the opening, whereby, when the hand grenade is thrown, the subsequent impact of the grenade with an object and the resulting hydrostatic shock through the fluid within the grenade will dislodge the ball from the opening allowing the discharge of fluid from the opening and onto surrounding objects.

U.S Patent 4,944,521 discloses a war game marking grenade with a piercing mechanism to pierce an enclosed gas cylinder. The gas from the cylinder is directed into channels and impels gelatin enclosing fluid marking spheres exteriorly of the grenade for marking purposes.

U.S Patent 5,018,449 discloses a paint dispersing training grenade that includes a grenade body having dispersing passages, a plug received in one end of the bore,

a piston resiliently urged by a spring toward the plug, a rupturable colorant containing capsule positioned between the piston and the plug, a separable release lever, and an inertial delay mechanism engaged between the grenade body and the piston. The delay mechanism includes pivotable delay levers engaged with the piston at one end and having wheels rollably engaging a surface of the grenade body at another end. When the release lever is separated, movement of the piston by the spring is resisted by startup inertia of the wheels in rotating. When the inertia is overcome, the piston forcibly ruptures the capsule and propels the colorant out of the grenade body through the dispersion passages.

U.S. Pat. No. 5,018,540 teaches a luminescent paintball which comprises a double chamber projectile capsule that contains two chemical agents which, when mixed together on impact, provide a chemically luminescent spot for marking at night. The chambers are provided with a double barrier which assures necessary shelf life and complete separation of the active ingredients.

U.S. Patent 5,035,183 discloses a two-piece polymer projectile consisting of an aerodynamically shaped, thin-shelled, frangible cap, adapted to be filled with a flowable substance for marking upon impact, the fluid sealed within the projectile by a rear plug. The rear plug is relatively rigid in order to contain the expansive effect of propellant gases; a recessed compartment in the rear plug contributes to creating a forward centre of gravity for the projectile; the barrel rifling is engaged by the projectile in the region of the rear plug only, whereby positive engagement with the barrel rifling imparts spin without bursting the cap portion of the projectile; an indentation region on the nose of the

cap facilitates flexing of the score lines for rapid and efficient bursting of the cap on impact.

U.S. Patent 5,257,936 discloses an inert training grenade intended to be fired by a rifle and a propellant cartridge, comprising a metal tube and with a front solid part which closes off the tube. This front part carries a hollow nose containing a marking substance. The nose is sufficiently resistant to withstand the shot, but is destructible on impact.

U.S. Patent 5,590,886 discloses a reusable, mechanically powered Paint Ball Grenade utilizing 0.68 or smaller diameter paint balls. Once thrown downrange the actuator will function upon impact allowing the grenade halves to collapse with the force of the primary spring, crushing the paint balls against cutters and causing the paint to be hydro mechanically dispersed about the exterior of the device.

U.S. Patent 6,619,211 discloses a practice ammunition projectile comprises a head which bursts when the projectile strikes a target and contains a marking agent which optically indicates the point of impact after the head has burst. The marking agent consists of several chemical components which are each contained in separately breakable compartments within a burstable hood at the head of the projectile.

U.S. Patent 6,931,993 discloses a chemiluminescent tracer/ marker munition design where the projectiles are activated upon launch and travel either independently from the gun (e.g. scatter pattern) or are dispersed after a containment housing opens after firing.

U.S. Patent 6,990,905 discloses a non-lethal chemiluminescent marking projectile that provides site

identification capability of a target upon impact. The projectile contains a breakable container system and a foam filler. The container system breaks on a setback impact that is exerted during firing and initial launch, causing the
5 chemiluminescent reagents to mix and be absorbed into the foam filler, such that upon impact of the projectile with the target, the foam filler marks the target with the mixed chemiluminescent reagents diffused therein.

U.S Patent 7,055,438 discloses a flameless tracer/
10 marker consisting of a hollow frangible projectile containing bags or ampoules containing the reagents required for the desired target effect are ruptured by the force of impact upon the target, allowing said reagents to intermix and disperse whence the projectile shatters on impact.

15 U.S. Patent RE 40,482 discloses chemiluminescent training munitions that activate or break the chemiluminescent material containing frangible containers upon setback or firing of the munition.

While each of the cited prior art references
20 describe marking projectiles, these projectiles have proven less effective for providing a training projectiles that 1) does not utilize pyrotechnic or other stored energy mechanisms, 2) that remotely deploys light of an adherent nature capable of adhering to and moving with a target 3)
25 deploys visible/non-visible light with limited in flight detection, and 4) prevents firing forces from mixing chemiluminescent materials, thereby reducing the loss of the most intense portion of light production which occurs early in the reaction cycle.

30 Therefore, what is needed is a training projectile that safely provides day and night visibility which is initiated upon impact with a target. While the projectile

may be used for short range, a need exists for a long range, long-flight time projectile that prevents light production resulting from set-back or firing forces, thus providing the majority of the chemical light reaction to occur as the
5 munition impacts the target area and releases its signal.

SUMMARY OF THE INVENTION

The present invention relates to a non-pyrotechnic, self-illuminating projectile useful for marking, target illumination, or targeting adjustment which produces
10 chemiluminescent light upon impact with an object. Because the production of light is delayed until impact, the projectile is not visualized until impact and the intensity of light upon impact is greater than those projectiles that provide intermixing of light generating chemicals upon a
15 firing force or during flight.

The term "chemiluminescent reactant components" as used herein is interpreted to mean a mixture of components, such as the oxalate or activator, or individual components, such as oxalic acid ester, and a fluorescer, which when
20 intermixed produces a chemiluminescent reaction. While the two component system typically requires the "oxalate" component and the "activator" component to be separated, separation may occur within a single frangible container or using several frangible containers containing various
25 reactants. In either case, rupture of the containers causes intermixing and results in light production.

In a particular embodiment, the light emitting projectile for marking a target upon impact comprises a projectile body having a first end, a second end, a plurality
30 of side walls, a base plate, and an interior portion therein. The inner portion includes chemiluminescent reactant

components contained within a plurality of frangible containers which are exemplified as, albeit not limited to, a form of ampoules. At least one chemiluminescent reaction activator element is releasably attached to the base plate.

5 Impact of the projectile with a target produces sufficient force to release the chemiluminescent reaction activator element within an inner channel. As the chemiluminescent reaction activator element moves within the inner channel, it contacts the ampoules. Contact of the ampoules results in
10 releasing and intermixing of the chemiluminescent reactant components, resulting in the generation of light.

In an alternative embodiment, the light emitting projectile for marking a target upon impact comprises a projectile body having a first end, a second end, a plurality
15 of side walls, a base plate, and an interior portion therein. The inner portion includes chemiluminescent reactant components contained within one or more chambers separated by membranes. At least one chemiluminescent reaction activator element is releasably attached to the base plate. Impact of
20 the projectile with a target produces sufficient force to release the chemiluminescent reaction activator element from the base plate. Chemiluminescent light is produced by penetration of the membranes by the chemiluminescent reaction activator element, which results in intermixing of the
25 chemiluminescent reactant components.

A unique aspect of the instant invention therefore, is the use of an inertial mass, such as a chemiluminescent reaction activator element which is secured in such a fashion so as to be released only upon final impact of the device
30 resulting from failure of the securing structure or mechanism. Release of chemiluminescent reaction activator element controllably ruptures the ampoules or membranes

containing chemiluminescent reagents, causing the intermixing of the chemiluminescent reagents and the production of light. The effect of this type of design results in the initiation of the chemiluminescent light production being delayed until impact. The advantage of such a projectile is in providing a projectile that can not be visualized until impact and provides intense light production at the point of impact as compared to diminished light intensity during flight time as is the case with setback force activated devices.

The instant invention allows illumination to occur either entirely within the confines of the projectile or to be dispersed upon impact. By eliminating any pyrotechnics from the projectile, the likelihood of collateral damage or indirect injury is virtually eliminated. By delaying the intermixing of the chemiluminescent reagents until impact, the projectile allows use of highly catalyzed reactions with relatively short durations and prevents the most intense portion of the reaction cycle from being wasted during flight. By providing for the use of non-visible chemiluminescent reagents with or without additional marking materials, the instant invention lends itself to stealthy tactical or training applications.

A further advantage of using a secured inertial mass design in contrast to a free moving inertial mass design is that the projectile can readily withstand routine testing, such as drop tests, typically applicable to munitions. Impulse forces realized during such testing can be readily calculated and the strength of the securing force required can be derived. In this manner the minimum strength required to survive such tests may be calculated and used in the construction of a final product having securing forces conveniently above those of the test requirements while

simultaneously well below those encountered in actual deployment. In this way, one skilled in the art with comprehensive knowledge of material properties could tailor the secured mass design to optimally suite numerous projectile applications functioning over a wide range of velocities and impact forces.

Accordingly, it is a primary objective of the instant invention to provide a chemiluminescent projectile which provides a mechanism for controlling light activation until impact upon a target.

It is a further objective of the instant invention to provide a chemiluminescent projectile which utilizes a secured, releasable inertial mass for controlling light activation until impact upon a target.

It is a further objective of the instant invention to provide a chemiluminescent projectile which provides illumination to occur within the projectile.

It is yet another objective of the instant invention to provide a chemiluminescent projectile which provides dispersal of illumination upon impact with a target.

It is a still further objective of the invention to provide a chemiluminescent projectile which reduces the likelihood of collateral damage or indirect injury by eliminating the use of pyrotechnics.

It is a further objective of the instant invention to provide a chemiluminescent projectile which provides delayed intermixing of chemiluminescent reactant components until impact.

It is yet another objective of the instant invention to provide a chemiluminescent projectile which provides for use of highly catalyzed reactions with relatively short durations.

It is a still further objective of the invention to provide a long range, long-flight time chemiluminescent projectile which prevents light production resulting from set-back or firing forces, thus providing the majority of the chemical light reaction to occur as the projectile impacts the target area and releases its contents.

It is a further objective the invention to provide a chemiluminescent projectile which prevents firing forces from mixing chemiluminescent materials, thereby reducing the loss of the most intense portion of light production which occurs early in the reaction cycle.

It is yet another objective of the instant invention to provide a chemiluminescent projectile which provides stealthy tactical and training applications.

It is a still further object of this invention to provide a chemiluminescent projectile which produces light visible to the human eye.

Another objective of this invention is to provide a chemiluminescent projectile which produces infrared or ultraviolet light.

Other objectives and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings wherein are set forth, by way of illustration and example, certain embodiments of this invention. The drawings constitute a part of this specification and include exemplary embodiments of the present invention and illustrate various objectives and features thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of the chemiluminescent projectile.

Figure 2 is a cross-sectional view of the chemiluminescent projectile taken along line A of Figure 1.

Figure 3 depicts is a cross-sectional view of the chemiluminescent projectile taken along line B of Figure 1A.

5 Figure 4 illustrates a cross-sectional view of the chemiluminescent projectile illustrating use of pins for securing the chemiluminescent reactant activator element.

Figure 5 illustrates a cross-sectional view of the chemiluminescent projectile illustrating use of threading for
10 securing the chemiluminescent reactant activator element.

Figure 6 illustrates a cross-sectional view of the chemiluminescent projectile illustrating use of magnets for securing the chemiluminescent reactant activator element.

Figure 7 illustrates an alternative embodiment of
15 the chemiluminescent projectile prior to impact with a target.

Figures 8A-8E illustrate various connecting methods for connection of membranes to the chemiluminescent projectile projectile.

20 DETAILED DESCRIPTION OF THE INVENTION

Referring to Figures 1-3, illustrated is a projectile **1** having a first leading end **2**, referring generally to the end that makes contact with a target, and a second trailing end **3**. The body of projectile **1** is further
25 defined by side walls **4** and **5**. A base plate **6** sealingly engages the projectile body adjacent to the second end **3**, thus forming an inner portion **7**. Although the figure illustrates a generally cylindrical shape body having a rounded front end, any shape is within the scope of the
30 invention. Located within inner portion **7** is a plurality of ampoules **8** made of rupturable materials, such as glass or

plastic, and which contain chemiluminescent reactant components.

Typical chemical light systems employ various chemiluminescent reactant components, including an oxalate ester, hydrogen peroxide, a fluorescer, and a catalyst. In its most basic form the two-component, liquid phase oxalate ester chemical light system must comprise an "oxalate component" comprising an oxalic acid ester and a solvent, and a "peroxide component" comprising hydrogen peroxide and a solvent or mixture of solvents. In addition, an efficient fluorescer must be contained in one of the components. An efficient catalyst, necessary for maximizing intensity and lifetime control, may be contained in one of the components. In typical use, the chemiluminescent reactant components are divided until time of use by placing the oxalate ester and dye in one solution and hydrogen peroxide and catalyst in a second solution. To generate light, the two solutions are intermixed. The instant invention takes advantage of this system by placement of chemiluminescent reactant components, or combinations thereof, within the plurality of ampoules to produce light in various spectrums, including visible light at different wavelengths, infrared light, and ultraviolet light.

Oxalates useful in the present invention include but are not limited to bis(2,4,5-trichloro-6-carbopentoxyphe-nyl) xalate; bis(2,4,5-trichlorophenyl)oxalate; bis(2,4,5-tribromo-6-carbohexoxyphenyl)oxalate; bis(2-nitrophenyl)oxalate; bis(2,4-dinitrophenyl)oxalate; bis(2,6-dichloro-4-nitrophenyl) oxalate; bis(2,4,6-trichlorophenyl) oxalate; bis(3-trifluoromethyl-4-nitrophenyl)oxalate; bis(2-methyl-4,6-dinitrophenyl)oxalate; bis(1,2-dimethyl-4,6-

dinitrophenyl)oxalate; bis(2,4-dichlorophenyl)oxalate;
bis(2,4-dinitrophenyl)oxalate; bis(2,5-dinitrophenyl)oxalate;
bis(2-formyl-4-nitrophenyl)oxalate;
bis(pentachlorophenyl)oxalate; bis(1,2-dihydro-2-oxo-1-
5 pyridyl)glyoxal; bis(2,4-dinitro-6-methylphenyl)oxalate; and
bis-N-phthalimidyl oxalate.

Oxalate solvents useful in the present invention include, but are not limited to a propylene glycol dialkyl ether containing one to three propylene moieties and each
10 alkyl group is independently a straight-chain or branched-chain alkyl group containing up to 8 carbon atoms. Especially preferred first solvents are propylene glycol dialkyl ethers containing two propylene moieties such as dipropylene glycol dimethyl ether, dipropylene glycol diethyl ether and
15 dipropylene glycol di-t-butyl ether. The particularly preferred first solvent comprises dipropylene glycol dimethyl ether, dibutyl phthalate, butyl benzoate, propylene glycol dibenzoate, and ethyl-hexyl diphenyl phosphate.

Peroxides useful in the present invention include
20 but are not limited to hydrogen peroxide; sodium peroxide; sodium perborate; sodium pyrophosphate peroxide; urea peroxide; histidine peroxide; t-butyl-hydroperoxide; and peroxybenzoic acid.

Activator solvents useful in the present invention
25 include, but are not limited, to dimethyl phthalate, triethyl citrate, and ethylene glycol dibenzoate.

Fluorescers useful in the present invention include but are not limited to 1-methoxy-9,10-bis(phenylethynyl) anthracene, perylene, rubrene, 16,17-didecycloxyviolanthrone,
30 2-ethyl-9,10-bis(phenylethynyl)anthracene; 2-chloro-9,10-bis(4-ethoxyphenyl)anthracene; 2-chloro-9,10-bis(4-methoxyphenyl) anthracene; 9,10-bis(phenylethynyl) anthracene;

1-chloro-9,10-bis(phenylethynyl)anthracene; 1,8-dichloro-9,10-bis(phenylethynyl)anthracene; 1,5-dichloro-9,10-bis(phenylethynyl)anthracene; 2,3-dichloro-9,10-bis(phenylethynyl)anthracene; 5,12-bis(phenylethynyl)tetracene; 9,10-diphenylanthracene; 1,6,7,12-tetraphenoxy-N,N'-bis(2,6-diisopropylphenyl)-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetraphenoxy-N,N'-bis(2,5-di-*t*-butylphenyl)-3,4,9,10-perylene dicarboximide; 1,7-di-chloro-6,12-diphenoxy-N,N'-bis(2,6-diisopropylphenyl)-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetra(*p*-bromophenoxy)-N,N'-bis(2,6-diisopropylphenyl)-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetraphenoxy-N,N'-di-neopentyl-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetra(*p*-*t*-butylphenoxy)N,N'-dineopentyl-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetra(*o*-chlorophenoxy)-N,N'-bis(2,6-diisopropylphenyl)-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetra(*p*-chlorophenoxy)-N,N'-bis(2,6-diisopropylphenyl)-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetra(*o*-fluorophenoxy)-N,N'-bis(2,6-diisopropylphenyl)-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetra(*p*-fluorophenoxy)-N,N'-bis(2,6-diisopropylphenyl)-3,4,9,10-perylene dicarboximide; 1,6,7,12-tetraphenoxy-N,N'-diethyl-3,4,9,10-perylene dicarboximide; 1,7-dibromo-6,12-diphenoxy-N,N'-bis(2-isopropylphenyl)-3,4,9,10-perylene dicarboximide; 16,17-dihexyloxyviolanthrone; rubrene; and 1,4-dimethyl-9,10-bis(phenylethynyl)anthracene.

Catalysts useful in the present invention include but are not limited to sodium salicylate; sodium-5-fluorosaliclylate; sodium-5-chlorosalicylate; sodium-5-bromosalicylate; sodium trifluoroacetate; potassium salicylate; potassium pentachlorophenolate; lithium salicylate; lithium-3-chlorosalicylate; lithium-5-

chlorosalicylate; lithium-3,5-dichlorosalicylate; lithium-3,5,6-trichlorosalicylate; lithium-2-chlorobenzoate; lithium-5-t-butylsalicylate; lithium trifluoroacetate; rubidium acetate; tetrabutylammonium salicylate; tetrabutylammonium
5 tetrafluoborate; tetraethylammonium benzoate; tetrabutylammonium benzoate; tetrabutylammonium hexafluorophosphate; tetraethylammonium perchlorate; tetrabutylammonium perchlorate; tetraoctylammonium perchlorate; tetrabutylammonium-2,3,5-trichlorobenzoate;
10 tetramethylammonium trifluoroacetate; magnesium salicylate; magnesium-5-t-butyl-salicylate; magnesium-3-chlorosalicylate; magnesium-3,5-dichloro-salicylate; and magnesium-3,5,6-trichlorosalicylate.

Ampoules **8** are supported by and orientated within
15 the inner portion by a holding element **9**. In a preferred embodiment, ampoules **8** are orientated perpendicular to the longitudinal axis **26** or the direction of travel of projectile **1**. Holding element **9** is molded from any suitable material such as but not limited to metals, plastics, or foam
20 materials including but not limited to cross-linked polyethylene foams, polyester polyurethane foams, polyether polyurethane foams, ether-like-ester foams, coated polyurethane foams designed to prevent moisture, oils, or other reagents from penetrating the foam, expanded
25 polystyrene foams, or other foams made of plastics, metals, ceramics, elastomers and rubber materials, thermoplastic, thermoset, or the like. To support ampoules **8**, holding element **9** has one or a plurality of openings which engage, hold, and secure at least a portion of each of the ampoules
30 **8**. Positioned within holding element **9** is a longitudinally extending inner channel **10** which provides a passage way for at least one chemiluminescent reaction activator element **11**.

At least a portion of each of the ampoules is exposed to the inner channel **10**.

Chemiluminescent reaction activator element **11** has a body portion **12** and a triangularly shaped front portion **13** having a blunt end (see for example Figure 2) or a sharp, pointed end (see for example Figure 7). In the non-impacted state, body portion **12** attaches to base plate **6**. In this manner, front portion **13** of chemiluminescent reaction activator element **11** is directed toward front portion **2** of projectile **1**. Chemiluminescent reaction activator element **11** is secured to base plate **6** by various mechanical and/or physical mechanisms known to one of skill in the art. For example, chemiluminescent reaction activator element **11** can be designed as an integral part of the base plate or can be interconnected by frictional forces or press fitting. Figure 4 illustrates the use of one or more pins which attach to either side wall **4** or a portion of the holding element. The pin extends into the chemiluminescent reaction activator element, see pin **14**, or extends through the chemiluminescent reaction activator element, attaching to side wall **5** or the opposite portion of the holding element, see pin **15**. Figure 4 illustrates a particular embodiment utilizing threading. Chemiluminescent reaction activator element contains threading **16** and is designed to fit into threading receiving area **17** construed within the holding element. Both the pins and the threading are designed to dislodge or break apart upon impact of the projectile to allow release of the chemiluminescent reaction activator element **11** and movement within the channel **10** upon an impact force. Figure 5 illustrates the use of magnetic bonding as a securing mechanism. In this embodiment, magnet **18** and/or **19** is positioned near the chemiluminescent reaction activator

element **11**. To aid in the magnetic bonding, chemiluminescent reaction activator element **11** is made of, or coated with, a magnetic material. Additional embodiments include the use of magnets or magnetic materials within the base plate as well.

5 Finally, an alternative securing method includes the use of adhesives placed on the chemiluminescent reaction activator element **11**, base plate **6**, or combinations thereof. The strength of the bonding is designed such that impact forces results in release of the chemiluminescent reaction activator
10 element **11**.

In practice, projectile **1** is utilized as large or small caliber munitions or as a component of a bullet cartridge containing the projectile, in various large or small calibers, a propellant, i.e. gunpowder, and a primer.
15 Either the individual projectiles or the bullet cartridge can then be loaded into a weapon, and fired. In use, as the projectile is fired from the weapon and subject to the initial firing force, chemiluminescent reaction activator element **11** remains connected to base plate **6**. Because
20 chemiluminescent reaction activator element **11** remains connected, the contents of ampoules **8** do not intermix and the projectile cannot produce chemiluminescent light upon either firing or during flight. However, as the projectile travels along a trajectory and contacts a target, the force of impact
25 releases chemiluminescent reaction activator element **11** from base plate **6**, causing chemiluminescent reaction activator element **11** to move within inner channel **10** in a direction towards the direction of travel, i.e. towards first end **2**. As chemiluminescent reaction activator element **11** moves, the
30 front portion **13** of the chemiluminescent reaction activator element **11** contacts ampoules **8** which causes rupture of the ampoules. As the ampoules rupture, the contents contained

within are released, causing intermixing of the chemiluminescent reactant components and light production. Since the object of this type of device is to produce usable light output, the projectile is usually composed of a clear or translucent material, such as polyethylene or polypropylene, which permits the light produced by the chemiluminescent system to be transmitted through the projectile walls. Additionally, the projectile may be constructed of materials which are biodegradable and/or inert.

The effect of this type of design results in the initiation of the chemiluminescent light production being delayed until impact. While the projectile cannot be visualized until impact, the design of the projectile provides intense light production at the point of impact as compared to diminished light intensity for those projectiles in which light is produced during flight time as seen with setback force activated devices.

In addition to the chemiluminescent components, marker material **22**, such as fluorescent marker powder, dyes including but not limited to water soluble dyes such as Brown HT; Quinoline Yellow; Indigo Carmine; Brilliant Blue FCF; Ponceau 4R; Sunset Yellow; Indigotine; Fast Green FCF; Alura Red AC, and inert filler **23**, such as but not limited to marble dust (calcium carbonate), granulated or powdered PVC resin with or without additional dyes, glass beads, sand, plastic resin pellets, or the like, are contained within the inner portion **7**. The marker material and/or filler materials can be separated from the holding element **9** and compartmentalized within the inner portion by use of one or more membranes, **20** and **21**, which form one or more chambers **24** and **25**.

Depending on the construction of the projectile, illumination can occur entirely within the confines of the device or can be dispersed upon impact. If the device is made of non-frangible materials, light production can be maintained within the device. In addition, the projectile can be constructed such that any light produced can be visualized over the entire projectile or limited to a portion of the projectile body. For example, light production can be limited to a defined portion by utilizing one or more membranes, **20** and **21** which separate holding element **9** from the rest of the inner portion of the projectile, thus creating separate compartments. Membrane **20** can be constructed of a material that is not punctured or penetrated by the chemiluminescent reaction activator element **11** as it is released from the base plate, thereby limiting any chemiluminescent light produced to that area. In an alternative embodiment, the holding element may be made of a permeable material that absorbs the liquids released from the ampoules, thus trapping them to a confined area.

The inner portion of the projectile may also be filled with optional marking dye **22**, inert filler **23** capable of absorbing the chemiluminescent reagents and further contributing the overall mass of the projectile, or a mix of filler and marker dye. Dispersement of the projectile contents to a target may be accomplished by constructing the projectile from a frangible material. As the projectile impacts a target, the frangible materials fail, resulting in release of the projectile's contents. Apertures **27** within the side walls or other parts of the projectile provide an alternative method of providing dispersement of chemiluminescent light to a target. Moreover, as chemiluminescent reaction activator element **11** is released

and travels through the inner channel, it can act as a piston to disperse the chemiluminescent reactant components through such apertures.

Figure 7 illustrates an alternative illustrative embodiment of the chemiluminescent projectile. Similar to the previous embodiments, projectile **201** includes a first leading end **202**, a second trailing end **203**, and side walls **204** and **205**. A base plate **206** sealingly engages the projectile body adjacent to the second end **203**, thus forming an inner portion **207**. Inner portion **207** contains chemiluminescent reaction activator element **211** which attaches to base plate **206**. Side walls **204** and **205** may be continuous or, as illustrated, designed as multicomponents having a first member portion **208** adjoining a second member portion **209**. Interconnection of first member portion **208** and a second member portion **209** may be accomplished by various mechanisms known to one of skill in the art, such as by press-fitting or use of threading. Chemiluminescent reaction activator element **211** is prevented from rearward and/or lateral movements movement by attachment to base **206**, and optionally use of a membrane or shield **212**, or other mechanisms, i.e. pins, magnets, as described previously. The second member portion **209** may contain marker dye **213**, inert filler **214**, or some combination of the two materials. First member portion **208** is further divided by one or more rupturable membranes **215**, **216**, and **217** that form inner compartment **218** and **219**. Compartments **218** and **219** contain the chemiluminescent reactant components.

Membranes may be comprised of any suitable materials, such as aluminum foil or polyethylene and can be attached to the projectile by coating with a heat-sealable polymer varnish intended to adhere through application of heat to the body of the projectile. The heat-sealable polymer

varnish is preferably non-reactive with any of the chemiluminescent components and will not affect the production of light if contacted with the chemiluminescent components. Figures 8A-8E represents illustrative
5 embodiments of membrane attachment methods. One or more of membranes **215**, **216**, or **217** can be attached to the projectile via heat sealing directly to shoulders **220** formed within the side walls **204** and **205**, see Figure 8A, to a cylindrical element **221** with shoulders **222**, see Figure 8B, or without
10 shoulders **222**, see Figure 8C, or through use of sealing lips or flanges **223** molded into the projectile body, see Figure 8D. Figure 8E illustrates sealing of membrane **215** directly into the side walls **204** and **205**.

Upon impact with the target, chemiluminescent
15 reaction activator element **211** is released from the base plate **206**, resulting in motion toward first leading end **202**. Chemiluminescent reaction activator element **211** is made of a material strong enough to puncture the membranes, thus allowing intermixing of the chemiluminescent reactant
20 components, marker materials, inert filler, or combinations thereof. The configuration of the chemiluminescent reaction activator element **211** may be adjusted for different desired functionality. For example, a larger diameter chemiluminescent reaction activator element could act as a
25 piston and forcibly move the chemiluminescent reagent mixture forward where it could then be expelled through one or a more apertures (not illustrated) located within the perimeter of the projectile.

It is to be understood that while a certain form of
30 the invention is illustrated, it is not to be limited to the specific form or arrangement herein described and shown. It will be apparent to those skilled in the art that various

changes may be made without departing from the scope of the invention and the invention is not to be considered limited to what is shown and described in the specification and drawings/figures.

5 One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objectives and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments, methods, procedures and techniques described herein are presently
10 representative of the preferred embodiments, are intended to be exemplary and are not intended as limitations on the scope. Changes therein and other uses will occur to those skilled in the art which are encompassed within the spirit of the invention and are defined by the scope of the appended
15 claims. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the
20 invention which are obvious to those skilled in the art are intended to be within the scope of the following claims.

CLAIMS

What is claimed is:

Claim 1. A light emitting projectile for marking a target upon impact comprising:

a projectile body having a first end, a second end, side walls, and an interior portion therein;

chemiluminescent reactant components;

a base plate constructed to sealingly engage said projectile body adjacent said second end; and

at least one chemiluminescent reaction activator element releasably attached to said base plate, wherein impact of said projectile with a target produces a force sufficient to release said chemiluminescent reaction activator element, said release of said chemiluminescent reaction activator element resulting in the intermixing of said chemiluminescent reactant components and the generation of light.

Claim 2. The light emitting projectile for marking a target upon impact according to Claim 1 wherein said chemiluminescent reactant components are housed within at least one frangible container.

Claim 3. The light emitting projectile for marking a target upon impact according to Claim 2 wherein at least a portion of said at least one frangible container is secured by a holding element.

Claim 4. The light emitting projectile for marking a target upon impact according to Claim 3 wherein said holding element further includes a longitudinally extending inner channel.

Claim 5. The light emitting projectile for marking a target upon impact according to Claim 4 wherein a portion of said at least one ampoule is exposed to said inner channel.

Claim 6. The light emitting projectile for marking a target upon impact according to Claim 5 wherein said chemiluminescent reaction activator element is constructed and arranged to move within said inner channel.

Claim 7. The light emitting projectile for marking a target upon impact according to Claim 6 further including filler material, marking material, or combinations thereof.

Claim 8. The light emitting projectile for marking a target upon impact according to Claim 7 further including at least one membrane separating said holding element and said filler material, marking material, or combinations thereof.

Claim 9. The light emitting projectile for marking a target upon impact according to Claim 6 wherein said projectile is frangible.

Claim 10. The light emitting projectile for marking a target upon impact according to Claim 6 wherein said projectile is non-frangible.

Claim 11. The light emitting projectile for marking a target upon impact according to Claim 6 wherein said chemiluminescent reactant components produce visible light.

Claim 12. The light emitting projectile for marking a target upon impact according to Claim 6 wherein said chemiluminescent reactant components produce infrared light.

Claim 13. The light emitting projectile for marking a target upon impact according to Claim 6 wherein said chemiluminescent reactant components produce ultraviolet light.

Claim 14. The light emitting projectile for marking a target upon impact according to Claim 6 wherein said projectile is made from biodegradable material.

Claim 15. The light emitting projectile for marking a target upon impact according to Claim 6 further containing one or more apertures for expulsion of said intermixed chemiluminescent components to a target area.

Claim 16. The light emitting projectile for marking a target upon impact according to Claim 1 wherein said chemiluminescent reactant components are housed within at least one chamber separated by at least one or more membranes.

Claim 17. The light emitting projectile for marking a target upon impact according to Claim 16 wherein said side walls contain a first member adjoining a second member.

Claim 18. The light emitting projectile for marking a target upon impact according to Claim 16 wherein said chemiluminescent reactant components produce visible light.

Claim 19. The light emitting projectile for marking a target upon impact according to Claim 16 wherein said chemiluminescent reactant components produce infrared light.

Claim 20. The light emitting projectile for marking a target upon impact according to Claim 16 wherein said chemiluminescent reactant components produce ultraviolet light.

1/4

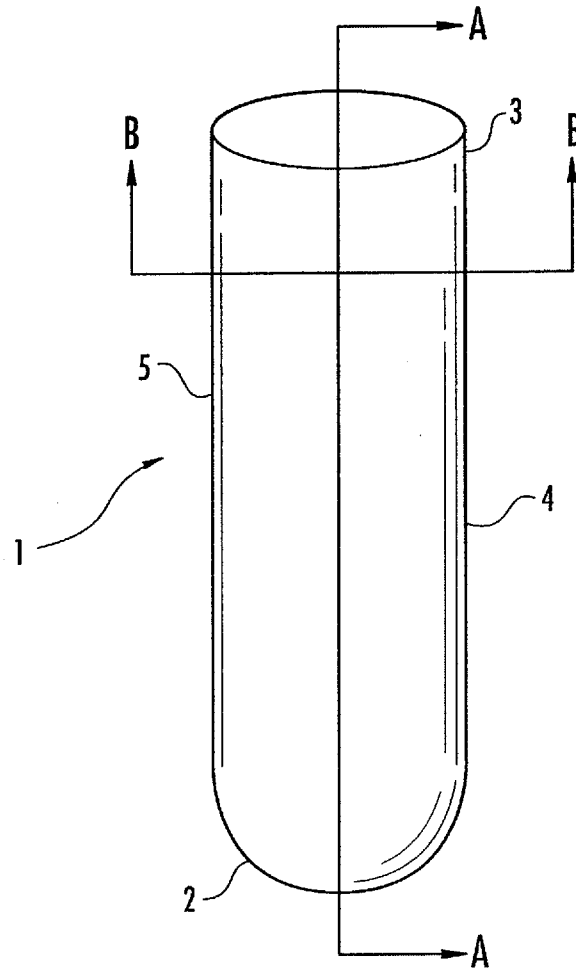


FIG. 1

2/4

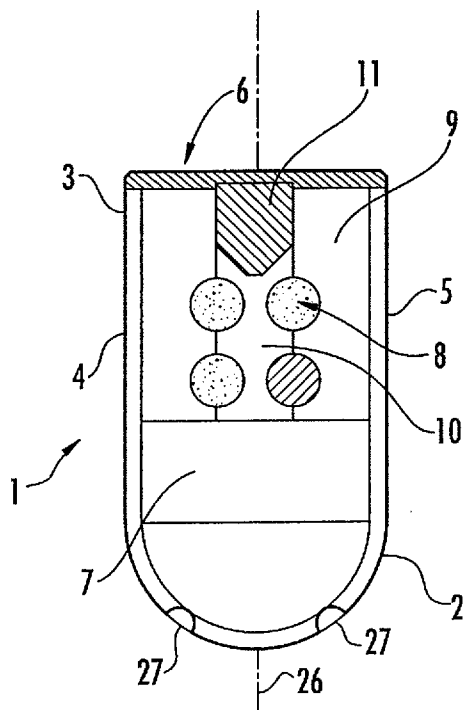


FIG. 2

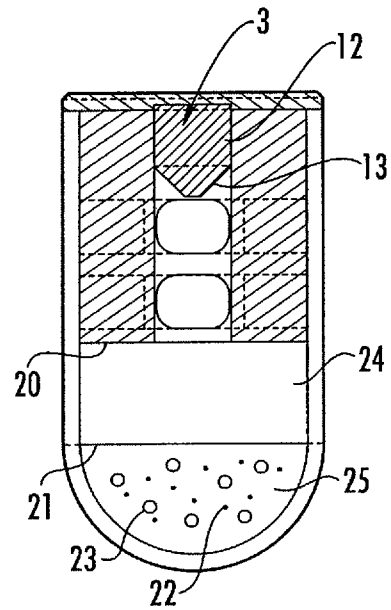


FIG. 3

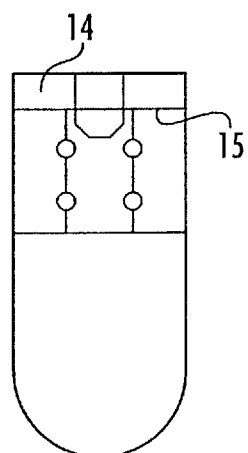


FIG. 4

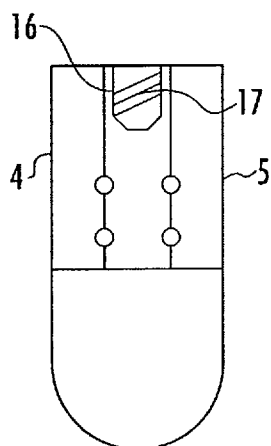


FIG. 5

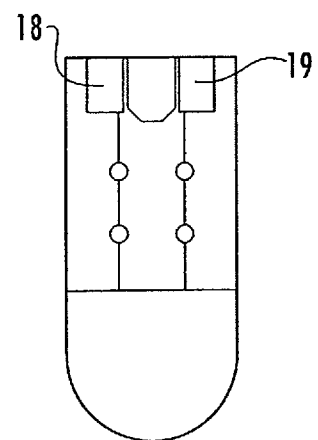


FIG. 6

3/4

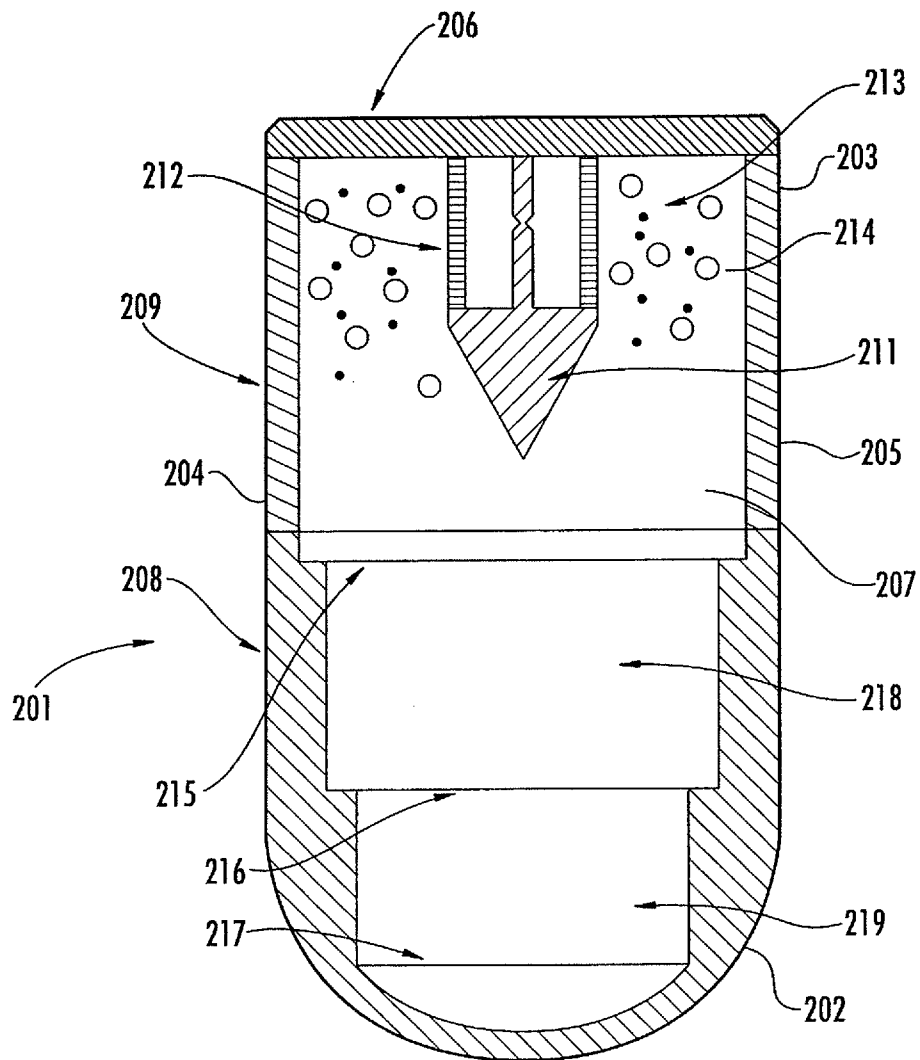
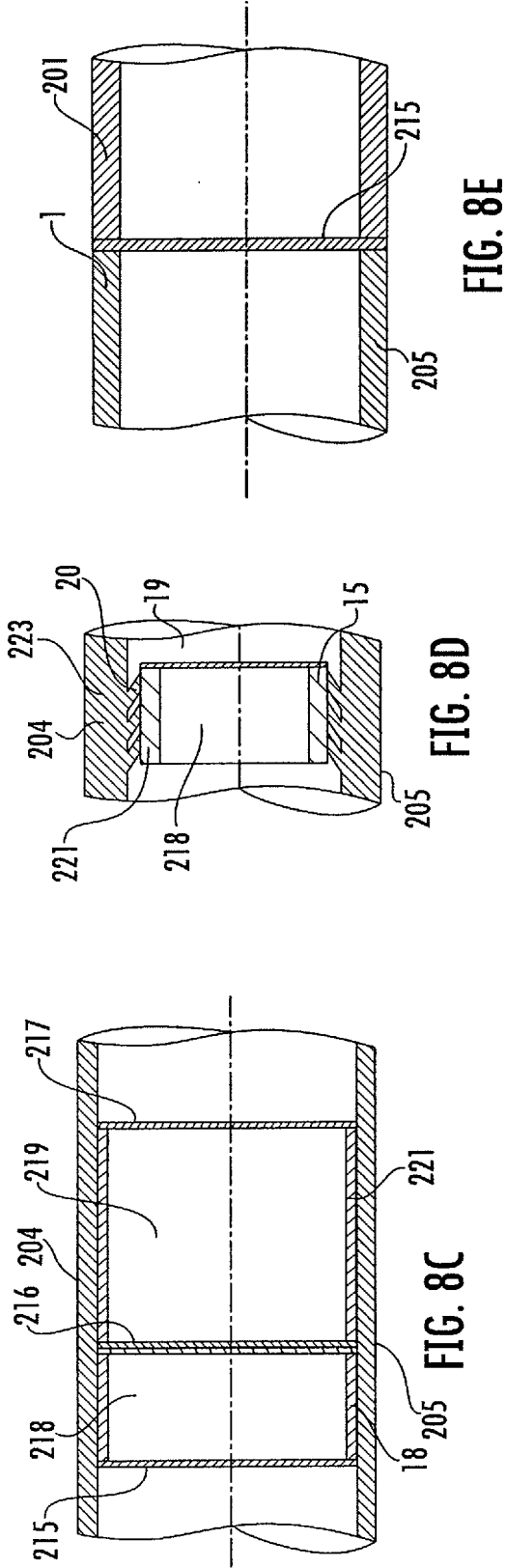
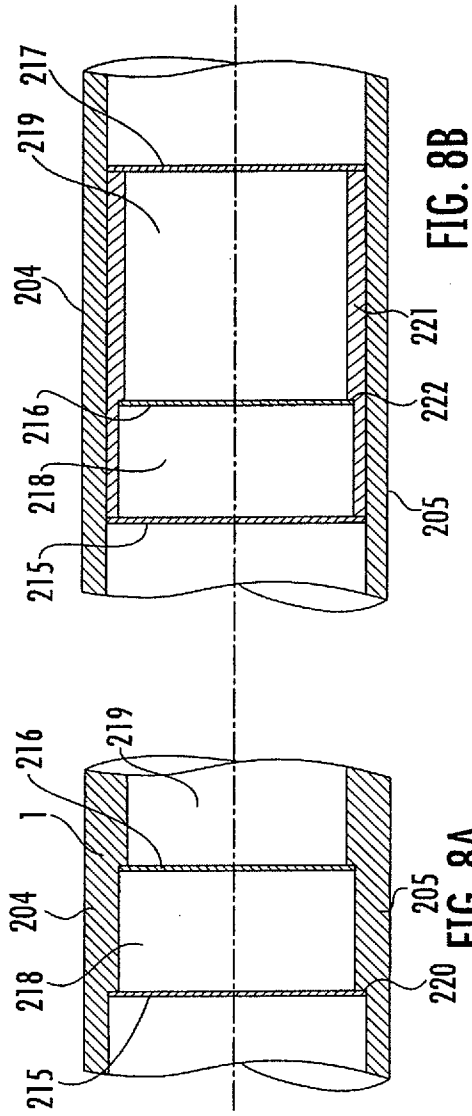


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No

PCT/US2011/043869

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F42B12/40
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 F42B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/107215 A1 (CONTINENTAL STRUCTURES SPRL [BE]; LADYJENSKY JACQUES [BE]) 12 September 2008 (2008-09-12)	1-8, 14-17
Y	page 7, line 26 - page 8, line 16 page 8, line 20 - line 23 page 9, line 7 - line 15 figures 1a,1b,2	9-13, 18-20
Y	----- US 2008/229964 A1 (CRANOR EARL [US]) 25 September 2008 (2008-09-25)	9,10
A	paragraphs [0046], [0048]; figures 1,3 -----	1
Y	DE 10 2005 053491 A1 (RHEINMETALL WAFFE MUNITION [DE]) 10 May 2007 (2007-05-10)	11-13, 18-20
A	paragraphs [0018], [0021], [0023]; figure 1 -----	1



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

28 September 2011

Date of mailing of the international search report

07/10/2011

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Authorized officer

Seide, Stephan

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2011/043869

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2008107215 A1	12-09-2008	EP 2115383 A1 US 2010175577 A1	11-11-2009 15-07-2010
US 2008229964 A1	25-09-2008	EP 2132519 A2 WO 2008127769 A2	16-12-2009 23-10-2008
DE 102005053491 A1	10-05-2007	WO 2007054077 A1 US 2007119329 A1	18-05-2007 31-05-2007