

(19)



(11)

EP 3 559 589 B1

(12)

EUROPEAN PATENT SPECIFICATION

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

07.06.2023 Bulletin 2023/23

(51) International Patent Classification (IPC):

F42B 5/02 ^(2006.01) **F42B 12/38** ^(2006.01)
F42B 12/78 ^(2006.01)

(21) Application number: **17886272.8**

(52) Cooperative Patent Classification (CPC):

F42B 12/387; F42B 12/382; F42B 12/78

(22) Date of filing: **19.12.2017**

(86) International application number:

PCT/US2017/067238

(87) International publication number:

WO 2018/125661 (05.07.2018 Gazette 2018/27)

(54) **OPTICALLY TRACKED PROJECTILE**

OPTISCH VERFOLGTES GESCHOSS

PROJECTILE À SUIVI OPTIQUE

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

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(30) Priority: **21.12.2016 US 201615386555**

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(43) Date of publication of application:

30.10.2019 Bulletin 2019/44

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an ammunition projectile that allows for position observation and tracking when illuminated. The projectile may function with a fire control device that tracks the path of a projectile while in ballistic flight toward a given target.

[0002] Tracer technology was developed by the British defense research establishment in the midst of the First World War. The technology continues to be used 100 years later. In machine guns, belts of ammunition are mixed - ball and tracer combinations.

[0003] Unfortunately the 100 year old technology has a number of practical drawbacks: (1) The tracer ammunition's ballistics differ from the trajectory of ball ammunition, (2) handling and inclusion of pyrotechnic tracers in ammunition significantly increases the cost of ammunition, (3) tracers cause unwanted range fires in training, (4) the glow emitted by tracers backlights friendly forces, vehicles, equipment and aircraft and (5) tracers are not optimized for automatic tracking technology.

[0004] The U.S. Patent 2015/308802 A1 discloses a tracer ammunition including a projectile having a body; a chamber in the body having a front end and a rear end, the rear end of the chamber being open; an aperture at a rear end of the body providing an opening to the open end of the chamber; and a tracer material disposed within the chamber, wherein the tracer material is configured to combust when ignited and emit optical energy through the aperture as a result of the combustion process. The tracer material may be configured to include a rear-facing surface having a concave contour to aid in directivity of light output from the tracer material. The tracer material may comprise an exothermic material; and a luminescent material disposed on the exothermic material configured to emit optical energy in response to heat generated by the exothermic material.

[0005] The patent US2016/029188 A discloses a tracer ammunition including a projectile having a body, the body having an exterior-facing, outer metal surface fabricated from a metal that includes reflective, micro-prismatic surfaces.

[0006] Retro-reflection: Use of retro-reflectors is ubiquitous in road signs where the technology was invented in the United Kingdom and introduced in the late 1930s. Retro-reflectors reflect light to the emission source with a minimum of scattering. There are three principal types of retro-reflectors: corner cube reflectors, cat's eyes and phase conjugated mirrors. The coefficient of luminosity returned in the direction of the emission source is high. In addition to their use in road signs, retro-reflectors are used in safety reflectors, high visibility clothing and surveying. NASA has also used this technology in the space program. The Apollo 11, 14 and 15 missions placed retro-reflectors on the moon surface allowing for precise measurements of the moon/earth distance. Today companies

like 3M and Orafal (formerly Reflexite) now dominate the manufacturing of retro-reflective sheathing and tape that are incorporated into a wide variety of products.

[0007] Retro-reflective Materials: Retro-reflective materials are generally categorized as either using glass beads or prismatic technology. The glass bead retro-reflective technology from the 1930's is the oldest; the prismatic technology was developed by Reflexite Americas in the 1960's. Glass bead tapes reflect light back less efficiently than do prismatics, so there are advantages to using prismatic solutions. Prismatic tape exhibits a tighter, more efficient return of light. A brighter, tighter beam extends much further than with glass bead retro-reflectors, giving prismatic tapes an operating range beyond the thousand foot mark. For marine, highway or traffic applications, where long distance conspicuity is important, prismatics are definitely preferred.

[0008] Glass bead retro-reflective materials are produced in tape form as both (1) engineering grade glass bead reflective tape, and (2) high intensity glass bead reflective tape.

[0009] Engineering Grade Glass Bead Reflective Tape: Engineering grade reflective tape starts with a carrier film that is metalized on the top. Glass beads are applied to this layer so that about fifty percent (50%) of the bead is embedded in the metalized layer. This gives the beads their reflective properties. Then a layer of either acrylic or polyester is applied over the top. This layer can either be clear to make white reflective tape or it can be colored to create the different color reflective tapes. A layer of adhesive is then applied to the bottom of the tape and a release liner is applied to that layer. The tape is rolled up, slit to width and then sold. It should be noted that an acrylic layered film will not stretch and a polyester layered film will. Because of the heat used in the manufacturing process, engineering grade films end up being a single layer so they do not delaminate.

[0010] High Intensity Glass Bead Reflective Tape: High intensity reflective tape is made in layers. The first layer has a grid built into the tape, normally using a honeycomb type pattern. This pattern holds the glass beads so that they are in separate cells. The glass beads are bonded to the bottom of this cell, then a layer of acrylic or polyester is applied over the top of the cell leaving a small air space above the beads. A layer of adhesive and a release liner are then applied to the bottom of the tape.

[0011] While the reflective tape industry was originally founded using glass bead technology, micro-prismatic solutions have come of age since the 1970's.

[0012] Non-metalized Micro-prismatic Reflective Tape: The first step in creating non-metalized reflective films utilizes a prism array produced from acrylic or another clear resin. This becomes the top layer of the film. Non-metalized films are more vivid but not necessarily more reflective.

[0013] Retro-reflector Production and Prismatic Tape: Clearly, the easiest and simplest way to produce retro-reflective material involves glass beads that are incorpo-

rated into a film. This glass bead technology was pioneered in the 1930s and has undergone numerous improvements over the decades. Prismatic reflective tapes were invented by Reflexite Americas in the 1960s. Micro-reflective materials were developed in the early 1990's. Following the U.S. Patent 5,171,624, the Reflexite Corporation incorporated micro-reflective materials into polymers that have been widely adopted into sheeting material.

[0014] Today, retro-reflective materials, generally produced as tape or sheeting, are ubiquitous in our lives. However, the glass bead and polymer based micro-prismatics do not lend themselves to direct integration into projectiles that must operate in a high temperature environment.

[0015] Application or Retro-reflection Technology to Ammunition: The U.S. Patent 3,757,623 to Bellinger disclosed the use of retro-reflectors in ammunition. Bellinger proposed incorporating glass bead retro-reflectors or corner cube retro-reflectors, also known as "cat's eyes", on the rear of a munition projectile and using a narrow beam laser to illuminate the target area to observe the projectile when it enters the beam. The gunner is then able to adjust the gun's bearings so that the projectile impacts the target.

[0016] The U.S. Patent 4,015,258 to Smith disclosed incorporating the basic elements of Bellinger's system into an aircraft platform and importantly described the use of a diverging or diffused laser beam. Again, like Bellinger, the target is illuminated coinciding with the travel time associated with a projectile reaching a target.

[0017] Bellinger and Smith disclose the use of typical retro-reflective solutions by attaching glass beads to, or embossing a retro-reflective pattern on, the trailing edge of a projectile. Bellinger's and Smith's patents used the technology of their day, incorporating retro-reflective structure or cat's eyes to the trailing edge of a bullet.

[0018] The published U.S. Patent Application 2016/0209188 to Nugent does not build on Bellinger's or Smith's work. Nugent's publication does, however, propose a means for protecting polymer and glass bead retro-reflective material that could be added to the surface of projectiles. This technique could allow the ammunition reloading community to use commercially available retro-reflective tapes and sheeting coupled with a protective wax to allow for adaption of polymer based retro-reflective technology.

[0019] Laser Induced Fluorescence: The body of information regarding laser induced fluorescence is growing as laboratories throughout the world explore potential applications for this technology. The present application foresees the use of tracer fluorescing material on a projectile or "bullet" which is fired from a weapon. When radiated after barrel exit by a laser co-located with the weapon, it allows an observer or electronic detector to track the projectile. This technology eliminates burning pyrotechnic tracer materials, allowing the trajectory of the projectile to match the trajectory of ball ammunition.

SUMMARY OF THE INVENTION

[0020] The principal object of the present invention is to provide for an observable and trackable projectile that, when coupled to an emitter, allows for the observation and recording of a projectile in flight. Further, when coupled to a fire control system, the recording of actual flight drop, drift and measurement of the time, space and location of a projectile in flight allows for improved precision and accuracy of weapon systems.

[0021] In both embodiments of the invention a bullet's metal jacket is used to form a closure with a metal disk providing a full metal jacket surrounding the bullet's core or cores. One embodiment identifies a disk with micro-prismatic retro-reflectors that are thus incorporated into the trailing edge of the projectile so that reflected light can be viewed and the projectile's position tracked by electro-optical devices in the vicinity of the weapon firing said projectile.

[0022] In particular, according to claim 9 of the invention an ammunition projectile with a full metal jacket configured to be fired from a weapon is provided, said projectile having an elongated circular body with a rear trailing edge that incorporates a thin metal disk, said metal disk being crimped to the rear trailing edge of the projectile, said metal disk having an exterior-facing, outer metal surface fabricated from a metal that includes reflective, micro-prismatic surfaces.

[0023] Alternatively a disk with a phosphor material, on the trailing edge of the projectile, is responsive and re-emits radiation when illuminated by an external electro-optical device. The radiated light emission from the laser emitter may be in the UV, visual, NIR or MWIR spectrum. The light reflected from the retro-reflective material may be in the UV, visual, NIR or MWIR spectrum.

[0024] In particular, according to claim 1 of the invention an ammunition projectile with a full metal jacket configured to be fired from a weapon is provided, said projectile having an elongated circular body with a rear trailing edge that incorporates a thin metal disk with phosphor material, said metal disk being crimped to the rear trailing edge of the projectile, said metal disk having an exterior-facing, rear surface and a photo-luminescent material, disposed on the rear surface that is configured to re-emit radiation when excited by incoming radiation from an external electro-optical radiation source.

[0025] The invention further relates to a cartridge munition according to claim 17, comprising, a cartridge shell having a base; a projectile according to either of the embodiments according to the invention having a rear portion inserted into the shell and mechanically connected thereto, thereby forming a propulsion chamber within the shell, said projectile having a full metal jacket; a pyrotechnic propulsive charge disposed within the propulsion chamber; and a pyrotechnic igniter disposed in the base of the shell by means of which the propulsive charge may be ignited such that propulsive gases of the propulsive charge exert a force on the rear of the projectile when

they burn, causing the projectile to be driven out of the cartridge shell when the munition is chambered in a gun, wherein the projectile has an elongated circular body with a rear-facing trailing surface, adjacent the propellant, that incorporates a retro-reflector.

[0026] Finally, the invention relates to a method according to claim 19 of manufacturing an ammunition projectile according to the invention having a rear surface, said method comprising the steps of first shaping a metal jacket forming an elongated cylindrical body with a rounded nose at a front end and a trailing edge with a circular opening at a rear end, a metal jacket being formed over one or more underlying metallic materials; afterwards inserting a round disk in the circular opening, thereby fully encapsulating the formed underlying metal or metals and closing the opening, said disk having an outer surface facing rearward; and finally crimping the trailing edge of the metal body around the disk to form a substantially impervious seal.

[0027] Simple Deployment and Use: The invention thus provides for a projectile with a special tracer incorporated and crimped into the projectile and closing a metal jacket around the projectile that, when illuminated at the trailing edge, allows electro-optical devices to locate, observe and track a projectile in flight. Full Metal Jacket (FMJ) ammunition is generally preferred for use by military forces for a number of important reasons. Accordingly, this application identifies a useful design to crimp thin metal disks, with certain features, to the trailing edge of the projectile. This design provides distinct benefits over prior art:

(1) Optimized, micro-structured prismatics provide highly efficient reflectance over the projectile's trajectory as the projectile changes attitude and the geometric relationship to the observer changes.

(2) A micro-structure metal retro-reflector incorporated into a disk, allows for manufacture by a specialized forming processor at a manufacturer's facility with equipment to produce microstructures.

(3) A micro-structure metal, especially one using a chrome plate or polished nickel, can survive in the harsh environment of hot propulsion gases.

(4) A micro-structure of ridges forming a prismatic structure is thin, less than a millimeter, which reduces the cost and complexity of stamping prismatic structures with specialized dyes.

(5) Thin disk contraction allows ammunition producers to vary the materials and components incorporated into a projectile's core.

(6) FMJ encapsulating the entire projectile can provide certain optimized terminal effects.

[0028] The small arms propellant industry is continuously modernizing and optimizing propellant mixtures. This proposed solution for special retro-reflective tracers includes preferred use of robust metal combinations such as aluminum, nickel and steel-chrome combinations. The surface and reflectance of these metal combinations are used in gun barrels and are known to remain resilient even after exposure to the high heat propellant burning environment. Additionally, for the purpose of designing and building projectiles with special non energetic tracers, it is understandably useful to use clean burning propellants.

[0029] As an alternative to using special tracers formed from metal disks with micro-prismatic features, tracers with metal disks incorporating a fluorescent material can be used that re-emit light when exposed to a narrow band laser emission source. According to the invention, technology being developed worldwide for applications of laser-induced fluorescence is used to allow electro-optical devices to track projectiles. These designs provide distinct benefits over prior art and also provide an advantageous method for manufacture and assembly of projectiles.

[0030] For a full understanding of the present invention, reference should now be made to the following detailed description of the preferred embodiments of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

Fig. 1A shows the impact location and dispersion for ball ammunition.

Fig. 1B depicts the impact locations and dispersion for normal energetic tracer projectiles.

Fig. 1C depicts the impact locations and dispersion for ball/tracer mix.

Fig. 2A depicts a standard cartridge housing a projectile.

Fig. 2B depicts a standard cartridge housing a projectile in cross-section.

Fig. 2C depicts a standard cartridge in a breach firing a projectile, the projectile having exited the cartridge traveling in a barrel where burning, expanding propellant gases (not depicted) propel the projectile.

Fig. 3A provides a perspective view depicting a projectile tracking device that includes an emitter 18 illuminating a light cone 20 that intersects the ballistic path of a projectile in flight 10.

Figs. 3B and 3C provide views that further illustrate

a methodology to observe and record the projectile's location with a tracking device that illuminates the projectile's path.

Figs. 3A-3C illustrate how an external radiation emission source 18 mounted on the barrel of the weapon emitting light in a cone of illumination 20 intersects with the projectile 10, along the projectile's flight path.

Fig. 4 depicts a external view of a FMJ projectile incorporating a special tracer.

Fig. 5A depicts two views of a special tracer that is in a wafer form.

Fig. 5B depicts a view of a special tracer that is in a wafer form and a magnified view of the surface morphology of the disk.

Fig. 5C depicts a view of a special tracer that is in a wafer with a non-burning phosphorous composition optimized to re-emit laser light.

Fig. 6A is a cut-away view of a projectile with a full metal jacket ("FMJ") and a special tracer.

Fig. 6B depicts the special tracer, crimped to the projectile's trailing edge forming a fully encapsulating metal jacket.

Fig. 6C is a detailed, cross-sectional view of the crimped wafer forming the trailing edge of the projectile providing the projectile with a sealed outer metal body.

Fig. 6D are two perspective views (one in cross-section) of FMJ projectile and a special tracer crimped to the trailing edge.

Fig. 7 depicts one external perspective view and three cross-sectional perspective views of an FMJ projectile, with differing internal configurations, all incorporating a special tracer in the trailing edge.

Fig. 8A depicts a perspective and rear view of a projectile with a special tracer and a magnified view of the wafer's outer surface, the outer surface including micro-prismatic facets and morphology formed into a metal.

Figs. 8B, 8Ca and 8Cb depict variant external morphology of a special retro-reflective tracer with magnified cut-away side views in 8Ca and 8Cb.

Fig. 8D depicts side or cross-sectional views of the metal, magnified pyramid morphology with illustrated path of retro-reflected light.

Fig. 8E shows that the angle of radiation incidence and reflectance are approximately parallel with a micro-prismatic surface.

Fig. 8F depicts a projectile's attitude in flight and a corresponding micro-prismatic surface, in the special tracer, perpendicular to the flight attitude. The figure further depicts the angle of illumination incidence and reflectance that results from the micro-prismatic surface.

Fig. 9 depicts a projectile with a special tracer that includes a fluorescent dye in a medium adhering to the disk, the fluorescent dye being able to re-emit light after illumination by a laser pulse.

Fig. 10 depicts are projectile with a special tracer that incorporates a fluorescent dye in a sub-strata with a protective or ablative coating.

Fig. 11 is a graph response curve (signal return versus time in milliseconds). Incorporating fluorescent phosphorous materials into a special tracer allow the projectile to re-emit light after excitement by laser.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0032] The preferred embodiments of the present invention will now be described with reference to Figures 1-11 of the drawings. Identical elements in various figures are designated with the same reference numerals.

[0033] Figs. 1A-1C respectively show a Monte Carlo simulation of .308 sierra ball, tracer and ball/tracer bullet mix. Tracer bullets are normally fired with a ball to tracer mix. The mean impact point of bullets with and without burning tracers is significant when firing at longer ranges. The comparative tracer and ball comparisons highlight the ballistic drawbacks associated with use of energetic tracers.

[0034] According to the invention, the trackable projectile or "bullet" 10 is fabricated with a full metal jacket ("FMJ") 26 and incorporates a special tracer 28. The special tracer is a not energetic but is provided with special characteristics that are incorporated into a thin metal disk 28. During assembly of the projectile, the disk or wafer 28 is crimped 32 to the trailing edge of the projectile's metal jacket 26 and forming a sealed metal jacket surrounding the bullet's internal material or materials 26A. The special tracer in wafer form either reemits or reflects radiation rearward.

[0035] The special tracers 28 are crimped 32 thus forming a trailing edge of the projectile 30. When illuminated by laser light from the vicinity of a weapon, the special tracer 34 light is reflected, allowing for identification and locating of the projectile in flight. Figures 6A-6D depict a projectile with a special tracer. The special tracer 28 is crimped by the bullet's exterior metal jacket 26 to form a sealed metal jacket 26A surrounding the bullet's

interior metal or components. The special tracer 28 is formed to include micro-prismatic structures 34 in the exterior metal surface as depicted in Figures 8A-8D. With reference to Figures 3A-3C and 8E viewed in combination, the diagrams illustrate how an external device with an emitter 18 and detector 24 illuminate the projectile's flight path 20, and light 72 reaching the disk 34 is reflected in the direction of the incident radiation by the micro-prismatic structures 68, returning the light 74 at an angle of incidence to the external optical detector 24 co-located with the emitter 18. The array of micro-prismatic structures 68 produce a conical reflectance return 74 allowing for the reflected light to be observed by a detector 24. The cone of reflected light produced by the projectile 10 provides for continued tracking of the projectile, through its ballistic flight path 22 and provides for continued tracking where the rotational variation of spin has induced projectile yaw, precession and nutation.

[0036] A partially completed projectile may be assembled with the special tracer 28, fit the rear of the projectile as depicted in Figure 6C, and then crimped 32 to the FMJ 26 by crimping or metal forming, thus completing a fully encapsulating metal jacket 26A and retaining the special tracer 28 within the finished projectile 10.

[0037] After completing manufacture of the projectile 10, the projectile is then loaded into a cartridge case 04 that is filled with propellant 08 forming a completed projectile 02 (Figures 2B and 2C). The product may benefit from use of a propellant 08 with an optimized stoichiometric balance, as such propellants are known to burn and minimize residue from propellant combustion. Thus, a clean burning propellant in combination with special tracers is useful in precluding the unwanted deposition of carbonaceous residue on a special tracer's surface.

[0038] In a second embodiment the wafer includes a fluorescent material (e.g., a dye) that is responsive and re-emits light when radiated with a laser. The light re-emission 46 returns a light signal to an optical detector or 24 tracking device. When illuminated by a light from the vicinity of a weapon 18, light is re-emitted from the projectile's trailing edge 30 in the direction of the weapon. Figures 6A-D depict projectiles with a special tracer. The special tracer 28 is crimped by the bullet's exterior metal jacket 28 to form a sealed metal jacket 28A surrounding the bullet's interior metal or components. The special tracer disk 28, 36 includes fluorescent dyes responsive to laser emission that include phosphorous. Figure 5C depicts a special tracer that exhibits a special light response (reemission) that is crimped to a FMJ projectile 58 that, when excited by laser light, reemits radiation as identified in Figure 11. A cartridge with this type of special tracer in the trailing edge may incorporate an ablative or protective material 36B that burns or otherwise vaporizes after cartridge ignition.

REFERENCE NUMBERS

[0039]

02	Cartridge.
04	Cartridge Case with primer.
06	Primer.
08	Propellant.
5 10	Trackable Projectile (or Bullet) with a Special Tracer.
11	Barrel of a Weapon.
12	Weapon.
14	Breach (in a barrel).
10 16	Projectile attitude (in a flight path).
18	Emitter (Laser or LED).
20	Light Emission Cone (from an emitter near the weapon).
22	Projectile Flight Path.
15 24	Detector.
26	Full Metal Jacket (FMJ) of a projectile.
26A	Fully encapsulating metal jacket composed of a FMJ and crimped metal tracer disk.
28	Special Tracer (prior to crimping).
20 28B	Special Tracer Wafer with Laser Re-emitting phosphor prior to crimping.
30	Special Tracer Crimped into the Projectile by the outer metal jacket forming the surface of a projectile's trailing edge.
25 32	Crimp of projectile's metal jacket to position Special Tracer Wafer within the projectile.
34	Special Tracer Wafer of metal with formed with micro-prismatic surface (seen under magnification).
30 36A	Special Tracer Wafer with a Laser Re-emitting phosphor in a sub-straight crimped into a projectile.
36B	Protective Coating for a Laser Re-emitting phosphor Tracer Wafer fit the rear of a projectile.
35 46	Light Return from a Special Tracer.
52	Projectile with a Special Tracer and a conventional metal core.
54	Projectile with a Special Tracer and a penetrator and core (Type 1).
40 56	Projectile with a Special Tracer and a penetrator core (Type 2).
58	Projectile with a Special Tracer incorporating a re-emitting phosphor responsive to laser illumination.
45 59	Projectile with a Special Tracer with a micro-prismatic surface.
60	Micro-prismatic Retro-reflective surface morphology.
62A	Top view of a 3 sided micro-prismatic pyramid.
50 62B	Side view of a 3 sided micro-prismatic pyramid.
64	An array of 3 sided micro-prismatic pyramids.
66	A side or cut-away view (with magnification) of the special tracer wafer's microprismatic exterior surface.
55 68	An alternate design cut-away view (with magnification) of the special tracer wafer's micro-prismatic exterior surface.
70	Coincident Light Fall and Reflectance Incident

- Angle.
 72 Incoming light falling onto the special tracer.
 74 Reflected light returning to the angle of incidence.
 76 Rearward conical emission dispersion producing
 a return reflection over a preponderance of a pro-
 jectiles trajectory.
 78 Rearward Special Tracer's surface is perpendic-
 ular to the projectile's flight position.

Claims

1. An ammunition projectile (10, 52, 54, 56, 58) with a full metal jacket (26) configured to be fired from a weapon (12), said projectile (10, 52, 54, 56, 58) having an elongated circular body with a rear trailing edge that incorporates a thin metal disk (28, 30, 36) with a phosphor material, said metal disk (28, 30, 36) being crimped to the rear trailing edge of the projectile (10, 52, 54, 56, 58), said metal disk (28, 30, 36) having an exterior-facing, rear surface and a photo-luminescent material, disposed on the rear surface, that is configured to re-emit radiation when excited by incoming radiation from an external electro-optical radiation source.
2. The ammunition projectile defined in claim 1, wherein said photo-luminescent material is additionally disposed on a side surface of the projectile body.
3. The ammunition projectile defined in claim 1, wherein said photo-luminescent material is a fluorescent dye.
4. The ammunition projectile defined in claim 3, wherein said fluorescent dye responds to excitation in one of the UV, visual and IR spectral bands.
5. The ammunition projectile defined in claim 3, wherein said fluorescent dye responds preferentially to the laser light illumination in a narrow frequency range.
6. The ammunition projectile defined in claims 2 and 3, wherein the fluorescent dye forms a coating on the projectile body.
7. The ammunition projectile defined in claim 3, wherein said projectile (10, 52, 54, 56, 58) includes a protective ablative material disposed on the projectile body to protect said fluorescent dye during cartridge ignition.
8. The ammunition projectile defined in claim 7, wherein said fluorescent dye forms a coating on an inside surface of a transparent material.
9. An ammunition projectile (10, 52, 54, 56, 59) with a full metal jacket (26) configured to be fired from a

weapon (12), said projectile (10, 52, 54, 56, 59) having an elongated circular body with a rear trailing edge that incorporates a thin metal disk (28, 30, 34), said metal disk (28, 30, 34) being crimped to the rear trailing edge of the projectile (10, 52, 54, 56, 59), said metal disk (28, 30, 34) having an exterior-facing, outer metal surface fabricated from a metal that includes reflective, micro-prismatic surfaces.

10. The ammunition projectile defined in claim 9, wherein said metal disk (28, 30, 34) is fabricated from a reflective nickel alloy.
11. The ammunition projectile defined in claim 9, wherein said metal disk (28, 30, 34) is fabricated from a highly polished aluminum alloy.
12. The ammunition projectile defined in claim 9, wherein said metal disk (28, 30, 34) is coated with a reflective chrome finish.
13. The ammunition projectile defined in claim 9, wherein said metal disk (28, 30, 34) is fabricated by at least one of stamping, etching, and forming with a die that produces prismatic features.
14. The ammunition projectile defined in claim 9, wherein the outer surface of said metal disk (28, 30, 34) includes a thin metal surface layer adhering to an underlying polymer sheet with prismatic features.
15. The ammunition projectile defined in claim 9, wherein said metal disk (28, 30, 34) is crimped to the metal jacket (26) at the rear trailing edge of the projectile (10, 52, 54, 56, 59).
16. The ammunition projectile defined in claim 15, wherein said metal disk (28, 30, 34) is optimized for rearward reflectance of reflected light over a flight path (22) of the projectile (10, 52, 54, 56, 59).
17. A cartridge munition comprising, in combination:
 - a cartridge shell (02) having a base;
 - a projectile (10, 52, 54, 56, 58, 59) according to claim 1 or 9 having a rear portion inserted into the shell and mechanically connected thereto, thereby forming a propulsion chamber within the shell, said projectile (10, 52, 54, 56, 58, 59) having a full metal jacket (26),
 - a pyrotechnic propulsive charge (08) disposed within the propulsion chamber; and
 - a pyrotechnic igniter (06) disposed in the base of the shell by means of which the propulsive charge (08) may be ignited such that propulsive gases of the propulsive charge (08) exert a force on the rear of the projectile (10, 52, 54, 56, 58, 59) when they burn, causing the projectile (10,

- 52, 54, 56, 58, 59) to be driven out of the cartridge shell (02) when the munition is chambered in a gun (12), wherein the projectile (10, 52, 54, 56, 58, 59) has an elongated circular body with a rear-facing trailing surface, adjacent the propellant (08), that incorporates a retro-reflector (28, 30, 34, 36).
18. The cartridge munition of claim 17, wherein the pyrotechnic propulsive charge (08) comprises a composition with a balanced stoichiometric combustion producing minimal combustion residue, thereby to avoid dimming the retro-reflector.
19. A method of manufacturing an ammunition projectile (10, 52, 54, 56, 58, 59) according to claim 1 or 9 having a rear surface, said method comprising the steps of:
- (a) shaping a metal jacket (26) forming an elongated cylindrical body with a rounded nose at a front end and a trailing edge with a circular opening at a rear end, a metal jacket (26) being formed over one or more underlying metallic materials;
 - (b) inserting a round disk (28, 30, 34, 36) in the circular opening, thereby fully encapsulating the formed underlying metal or metals and closing the opening, said disk (28, 30, 34, 36) having an outer surface facing rearward; and
 - (c) crimping the trailing edge of the metal body around the disk (28, 30, 34, 36) to form a substantially impervious seal.
20. The method defined in claim 19, wherein the rear-facing outer surface of the disk (28, 30, 34) includes reflective, micro-prismatic surfaces (60) forming a retro-reflector.
21. The method defined in claim 19, wherein the rear-facing outer surface of the disk (28, 30, 36) is coated with a fluorescent material.
- Patentansprüche**
1. Waffengeschoss (10, 52, 54, 56, 58) mit einem Vollmetallmantel (26), das ausgestaltet ist, von einer Waffe (12) abgefeuert zu werden, wobei das Geschoss (10, 52, 54, 56, 58) einen länglichen kreisförmigen Körper mit einer hinteren Endkante aufweist, die eine dünne Metallscheibe (28, 30, 36) mit einem Phosphormaterial beinhaltet, wobei die Metallscheibe (28, 30, 36) an die hintere Endkante des Geschosses (10, 52, 54, 56, 58) gecrimpt ist, wobei die Metallscheibe (28, 30, 36) eine nach außen weisende, hintere Oberfläche und ein auf der hinteren Oberfläche angebrachtes photolumineszierendes
- Material aufweist, das ausgestaltet ist, Strahlung zu reemittieren, wenn es durch eintreffende Strahlung von einer externen elektrooptischen Strahlungsquelle erregt wird.
2. Waffengeschoss nach Anspruch 1, wobei das photolumineszierende Material zusätzlich auf einer Seitenoberfläche des Geschosskörpers angebracht ist.
3. Waffengeschoss nach Anspruch 1, wobei das photolumineszierende Material ein Fluoreszenzfarbstoff ist.
4. Waffengeschoss nach Anspruch 3, wobei der Fluoreszenzfarbstoff auf eine Erregung in einem der Spektralbereiche, UV-Spektralbereich, sichtbaren Spektralbereich und IR-Spektralbereich, reagiert.
5. Waffengeschoss nach Anspruch 3, wobei der Fluoreszenzfarbstoff vorzugsweise auf die Laserlichtbeleuchtung in einem schmalen Frequenzbereich reagiert.
6. Waffengeschoss nach Anspruch 2 und 3, wobei der Fluoreszenzfarbstoff eine Ummantelung auf dem Geschosskörper bildet.
7. Waffengeschoss nach Anspruch 3, wobei das Geschoss (10, 52, 54, 56, 58) ein schützendes Ablationsmaterial umfasst, das auf dem Waffenkörper angebracht ist, den Fluoreszenzfarbstoff während der Patronenzündung zu schützen.
8. Waffengeschoss nach Anspruch 7, wobei der Fluoreszenzfarbstoff eine Ummantelung auf einer Innenoberfläche eines transparenten Materials bildet.
9. Waffengeschoss (10, 52, 54, 56, 59) mit einem Vollmetallmantel (26), das ausgestaltet ist, von einer Waffe (12) abgefeuert zu werden, wobei das Geschoss (10, 52, 54, 56, 59) einen länglichen kreisförmigen Körper mit einer hinteren Endkante aufweist, die eine dünne Metallscheibe (28, 30, 34) beinhaltet, wobei die Metallscheibe (28, 30, 34) an die hintere Endkante des Geschosses (10, 52, 54, 56, 59) gecrimpt ist, wobei die Metallscheibe (28, 30, 34) eine nach außen weisende, äußere Metalloberfläche aufweist, die aus einem Metall hergestellt ist, das reflektierende, mikrop Prismatische Oberflächen umfasst.
10. Waffengeschoss nach Anspruch 9, wobei die Metallscheibe (28, 30, 34) aus einer reflektierenden Nickellegierung hergestellt ist.
11. Waffengeschoss nach Anspruch 9, wobei die Metallscheibe (28, 30, 34) aus einer hochglanzpolierten Aluminiumlegierung hergestellt ist.

12. Waffengeschoß nach Anspruch 9, wobei die Metallscheibe (28, 30, 34) mit einer reflektierenden Chromschicht ummantelt ist.

13. Waffengeschoß nach Anspruch 9, wobei die Metallscheibe (28, 30, 34) mittels mindestens einem, Stanzen, Ätzen und/oder Formen mit einer Matrize, hergestellt ist, sodass prismatische Merkmale entstehen.

14. Waffengeschoß nach Anspruch 9, wobei die Außenoberfläche der Metallscheibe (28, 30, 34) eine dünne metallische Oberflächenschicht umfasst, die an einer darunterliegenden Polymerfolie mit prismatischen Merkmalen haftet.

15. Waffengeschoß nach Anspruch 9, wobei die Metallscheibe (28, 30, 34) an der hinteren Endkante des Geschosses (10, 52, 54, 56, 59) auf den Vollmetallmantel (26) gecrimpt ist.

16. Waffengeschoß nach Anspruch 15, wobei die Metallscheibe (28, 30, 34) für die Rückwärtsreflexion des reflektierten Lichts über einer Flugbahn (22) des Geschosses (10, 52, 54, 56, 59) optimiert ist.

17. Patronenmunition, die in Kombination Folgendes umfasst:

eine Patronenhülse (02), die eine Basis aufweist;

ein Geschoss (10, 52, 54, 56, 58, 59) nach Anspruch 1 oder 9, das einen in die Hülse eingeführten und mechanisch damit verbundenen hinteren Abschnitt aufweist, wodurch eine Treibkammer innerhalb der Hülse gebildet wird, wobei das Geschoss (10, 52, 54, 56, 58, 59) einen Vollmetallmantel (26) aufweist,

eine pyrotechnische Treibladung (08), die innerhalb der Treibkammer angebracht ist; und

einen pyrotechnischen Zünder (06), der in der Basis der Hülse angebracht ist und mittels dessen die Treibladung (08) gezündet werden kann, sodass die Treibgase der Treibladung (08), wenn sie verbrennen, eine Kraft an der Rückseite des Geschosses (10, 52, 54, 56, 58, 59) ausüben, die bewirkt, dass das Geschoss (10, 52, 54, 56, 58, 59) aus der Patronenhülse (02) herausgetrieben wird, wenn die Munition in einer Waffe (12) gelagert ist,

wobei das Geschoss (10, 52, 54, 56, 58, 59) einen länglichen kreisförmigen Körper mit einer nach hinten gerichteten, an das Treibmittel (08) angrenzenden Rückoberfläche aufweist, die einen Retro-Reflektor (28, 30, 34, 36) beinhaltet.

18. Patronenmunition nach Anspruch 17, wobei die pyrotechnische Treibladung (08) eine Zusammensetzung

aus einer ausgewogenen stöchiometrischen Verbrennung umfasst, die minimale Verbrennungsrückstände erzeugt, um so eine Verdunkelung des Retro-Reflektors zu vermeiden.

19. Verfahren zur Herstellung eines Waffengeschoßes (10, 52, 54, 56, 58, 59) nach Anspruch 1 oder 9, das eine hintere Oberfläche aufweist, wobei das Verfahren die folgenden Schritte umfasst:

(a) Formen eines Vollmetallmantels (26), das einen länglichen zylindrischen Körper mit einer abgerundeten Nase an einem vorderen Ende und einer Endkante mit einer kreisförmigen Öffnung an einem hinteren Ende bildet, wobei ein Vollmetallmantel (26) über einem oder mehreren darunter liegenden metallischen Materialien geformt wird;

(b) Einsetzen einer runden Scheibe (28, 30, 34, 36) in die kreisförmige Öffnung, wodurch das geformte darunterliegende Metall oder die Metalle vollständig eingekapselt wird/werden und die Öffnung verschlossen wird, wobei die Scheibe (28, 30, 34, 36) eine nach hinten gerichtete Außenoberfläche aufweist; und

(c) Crimpen der Endkante des Metallkörpers um die Scheibe (28, 30, 34, 36), um eine im Wesentlichen undurchlässige Dichtung zu bilden.

20. Verfahren nach Anspruch 19, wobei die nach hinten gerichtete Außenoberfläche der Scheibe (28, 30, 34) reflektierende, mikro-prismatische Oberflächen (60) umfasst, die einen Retro-Reflektor bilden.

21. Verfahren nach Anspruch 19, wobei die nach hinten gerichtete Außenoberfläche der Scheibe (28, 30, 36) mit einem fluoreszierenden Material ummantelt ist.

Revendications

1. Projectile (10, 52, 54, 56, 58) de munition avec une enveloppe métallique (26) conçu pour être tiré à partir d'une arme (12), ledit projectile (10, 52, 54, 56, 58) ayant un corps circulaire allongé avec un bord de fuite arrière qui incorpore un disque métallique (28, 30, 36) fin avec un matériau de phosphore, ledit disque métallique (28, 30, 36) étant serti sur le bord de fuite arrière du projectile (10, 52, 54, 56, 58), ledit disque métallique (28, 30, 36) ayant une surface arrière, faisant face vers l'extérieur, et un matériau photoluminescent, disposé sur la surface arrière, qui est conçu pour réémettre un rayonnement lorsqu'il est excité par un rayonnement entrant provenant d'une source de rayonnement électro-optique externe.

2. Projectile de munition selon la revendication 1, dans

- lequel ledit matériau photoluminescent est en outre disposé sur une surface latérale du corps de projectile.
3. Projectile de munition selon la revendication 1, dans lequel ledit matériau photoluminescent est une teinte fluorescente. 5
 4. Projectile de munition selon la revendication 3, dans lequel ladite teinte fluorescente répond à l'excitation dans une bande spectrale parmi une bande spectrale UV, une bande spectrale visuelle et une bande spectrale IR. 10
 5. Projectile de munition selon la revendication 3, dans lequel ladite teinte fluorescente répond de préférence à l'éclairage de lumière laser dans une plage de fréquences étroite. 15
 6. Projectile de munition selon les revendications 2 et 3, dans lequel la teinte fluorescente forme un revêtement sur le corps de projectile. 20
 7. Projectile de munition selon la revendication 3, dans lequel ledit projectile (10, 52, 54, 56, 58) inclut un matériau ablatif de protection disposé sur le corps de projectile pour protéger ladite teinte fluorescente pendant l'allumage de la cartouche. 25
 8. Projectile de munition selon la revendication 7, dans lequel ladite teinte fluorescente forme un revêtement sur une surface interne d'un matériau transparent. 30
 9. Projectile (10, 52, 54, 56, 59) de munition avec une enveloppe métallique (26) conçu pour être tiré à partir d'une arme (12), ledit projectile (10, 52, 54, 56, 59) ayant un corps circulaire allongé avec un bord de fuite arrière qui incorpore un disque métallique (28, 30, 34) fin, ledit disque métallique (28, 30, 34) étant serti sur le bord de fuite arrière du projectile (10, 52, 54, 56, 59), ledit disque métallique (28, 30, 34) ayant une surface métallique externe, faisant face vers l'extérieur, fabriquée à partir d'un métal qui inclut des surfaces micro-prismatiques réfléchissantes. 35 40 45
 10. Projectile de munition selon la revendication 9, dans lequel ledit disque métallique (28, 30, 34) est fabriqué à partir d'un alliage de nickel réfléchissant. 50
 11. Projectile de munition selon la revendication 9, dans lequel ledit disque métallique (28, 30, 34) est fabriqué à partir d'un alliage d'aluminium hautement poli. 55
 12. Projectile de munition selon la revendication 9, dans lequel ledit disque métallique (28, 30, 34) est revêtu d'une finition de chrome réfléchissante.
 13. Projectile de munition selon la revendication 9, dans lequel ledit disque métallique (28, 30, 34) est fabriqué par au moins une opération parmi l'emboutissage, le décapage et le formage avec une matrice qui produit des caractéristiques prismatiques.
 14. Projectile de munition selon la revendication 9, dans lequel la surface externe dudit disque métallique (28, 30, 34) inclut une couche de surface métallique fine adhérent à une feuille polymère sous-jacente avec des caractéristiques prismatiques.
 15. Projectile de munition selon la revendication 9, dans lequel ledit disque métallique (28, 30, 34) est serti sur l'enveloppe métallique (26) au niveau du bord de fuite arrière du projectile (10, 52, 54, 56, 59).
 16. Projectile de munition selon la revendication 15, dans lequel ledit disque métallique (28, 30, 34) est optimisé pour une réflectance vers l'arrière de la lumière réfléchi sur une trajectoire de vol (22) du projectile (10, 52, 54, 56, 59).
 17. Munition de cartouche comportant, en combinaison :
 - une chemise de cartouche (02) ayant une base ;
 - un projectile (10, 52, 54, 56, 58, 59) selon la revendication 1 ou 9 ayant une portion arrière insérée dans la chemise et reliée mécaniquement à celle-ci, formant ainsi une chambre de propulsion au sein de la chemise, ledit projectile (10, 52, 54, 56, 58, 59) ayant une enveloppe métallique (26),
 - une charge de propulsion pyrotechnique (08) disposée au sein de la chambre de propulsion ;
 - et
 - un système d'allumage pyrotechnique (06) disposé dans la base de la chemise au moyen duquel la charge de propulsion (08) peut être allumée, de sorte que des gaz de propulsion de la charge de propulsion (08) exercent une force sur l'arrière du projectile (10, 52, 54, 56, 58, 59) lorsqu'ils brûlent, amenant le projectile (10, 52, 54, 56, 58, 59) à être entraîné hors de la chemise de cartouche (02) lorsque la munition est chargée dans un pistolet (12),
 - dans lequel le projectile (10, 52, 54, 56, 58, 59) a un corps circulaire allongé avec une surface de fuite faisant face vers l'arrière, adjacente au propulseur (08), qui incorpore un rétroreflécteur (28, 30, 34, 36).
 18. Munition de cartouche selon la revendication 17, dans laquelle la charge de propulsion (08) pyrotechnique comporte une composition avec une combustion stoechiométrique équilibrée produisant des résidus de combustion minimum, ce qui permet d'éviter d'atténuer le rétroreflécteur.

19. Procédé de fabrication d'un projectile (10, 52, 54, 56, 58, 59) de munition selon la revendication 1 ou 9 ayant une surface arrière, ledit procédé comportant les étapes de :

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(a) façonnage d'une enveloppe métallique (26) formant un corps cylindrique allongé avec un nez arrondi à une extrémité avant et un bord de fuite avec une ouverture circulaire à une extrémité arrière, une enveloppe métallique (26) étant formée sur un ou plusieurs matériaux métalliques sous-jacents ;

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(b) insertion d'un disque rond (28, 30, 34, 36) dans l'ouverture circulaire, ce qui permet d'encapsuler pleinement le métal ou les métaux sous-jacents formés et de fermer l'ouverture, ledit disque (28, 30, 34, 36) ayant une surface externe faisant face vers l'arrière ; et

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(c) sertissage du bord de fuite du corps métallique autour du disque (28, 30, 34, 36) pour former un joint sensiblement imperméable.

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20. Procédé selon la revendication 19, dans lequel la surface externe faisant face vers l'arrière du disque (28, 30, 34) inclut des surfaces micro-prismatiques réfléchissantes (60) formant un rétroreflecteur.

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21. Procédé selon la revendication 19, dans lequel la surface externe faisant face vers l'arrière du disque (28, 30, 36) est revêtue d'un matériau fluorescent.

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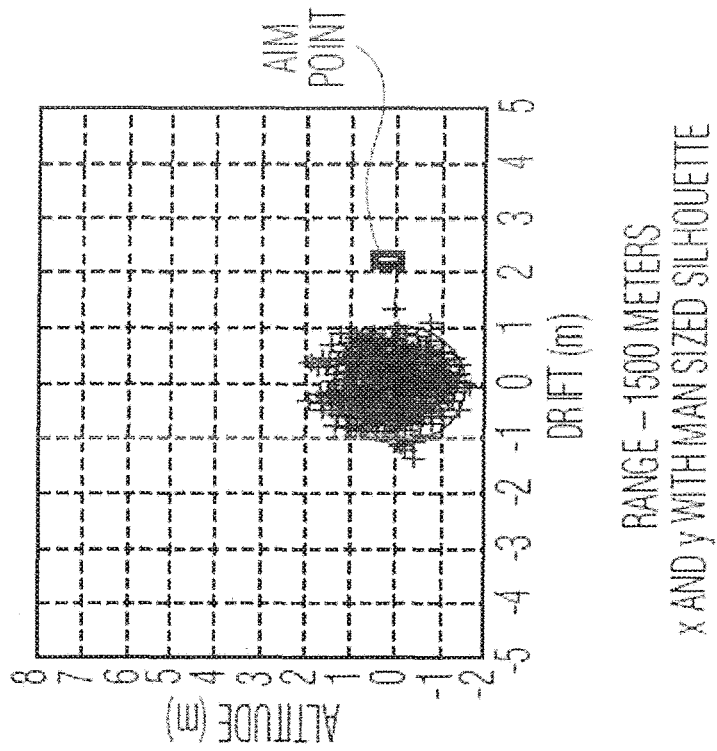


Figure 1A

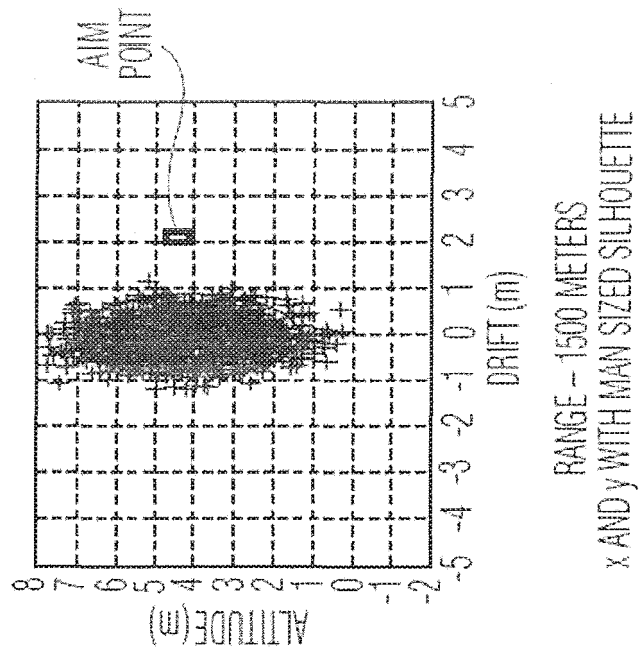
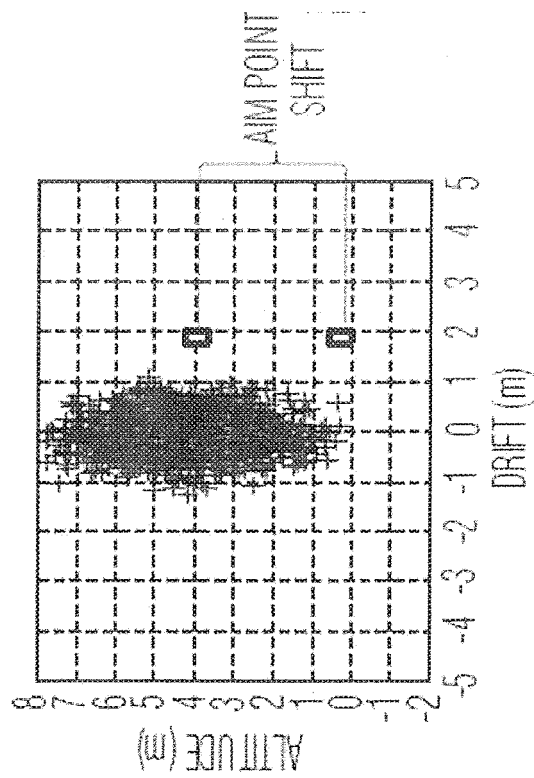


Figure 1B



RANGE -- 1500 METERS
X AND Y WITH MAN SIZED SILHOUETTE

Figure 1C

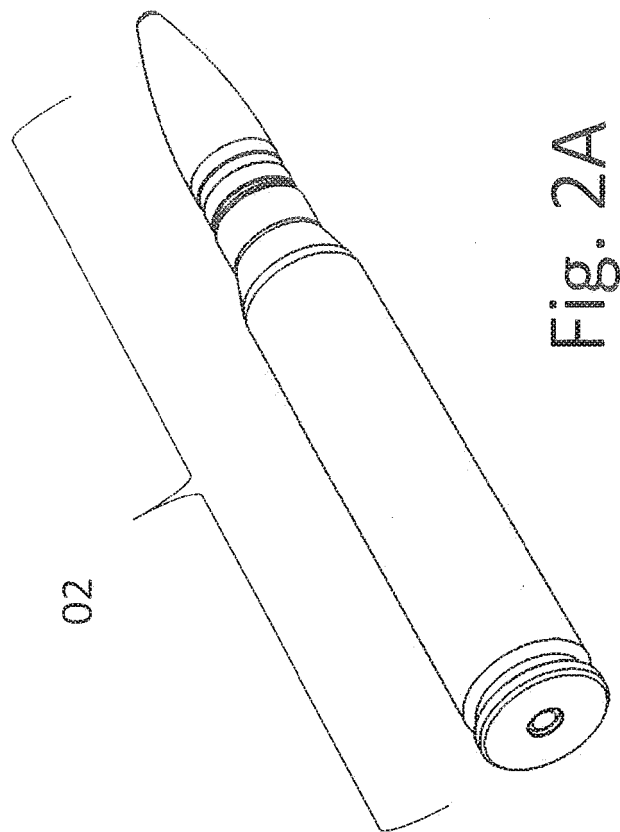


Fig. 2A

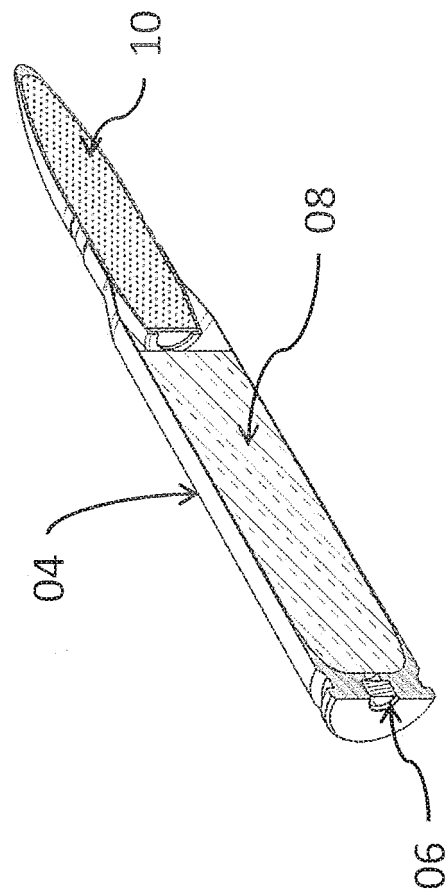


Fig. 2B

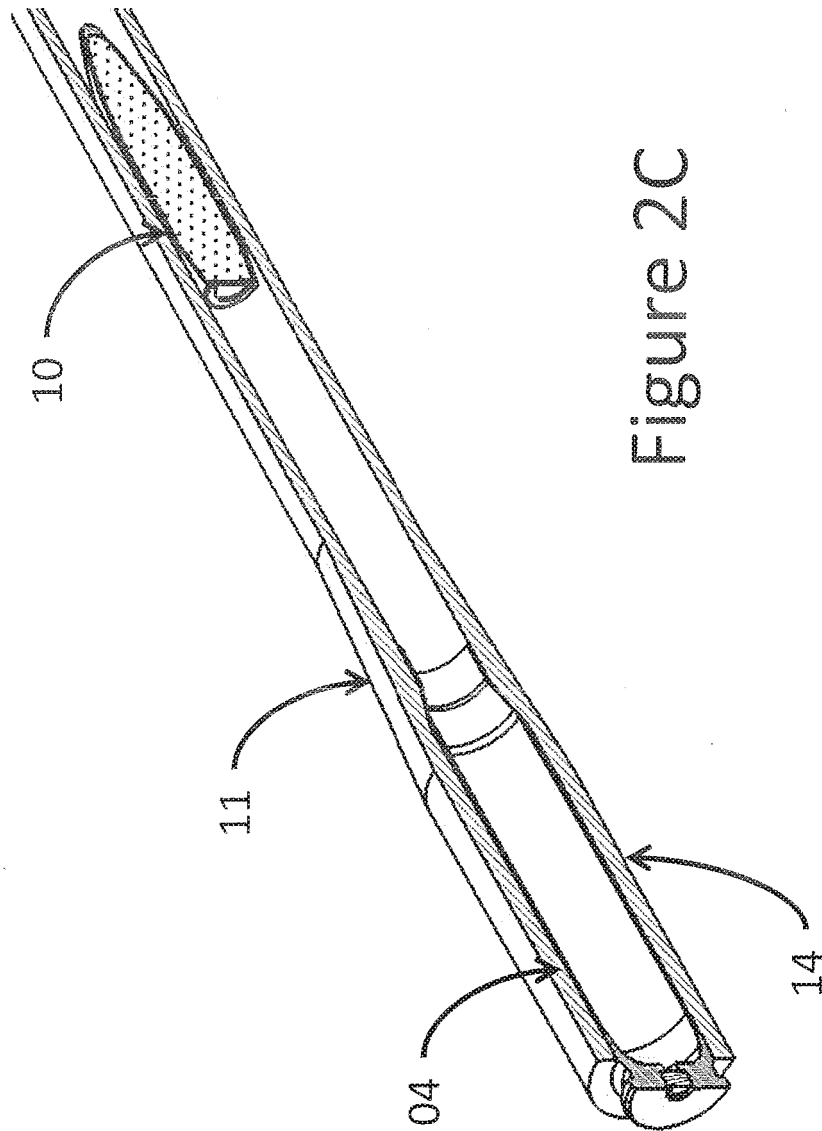


Figure 2C

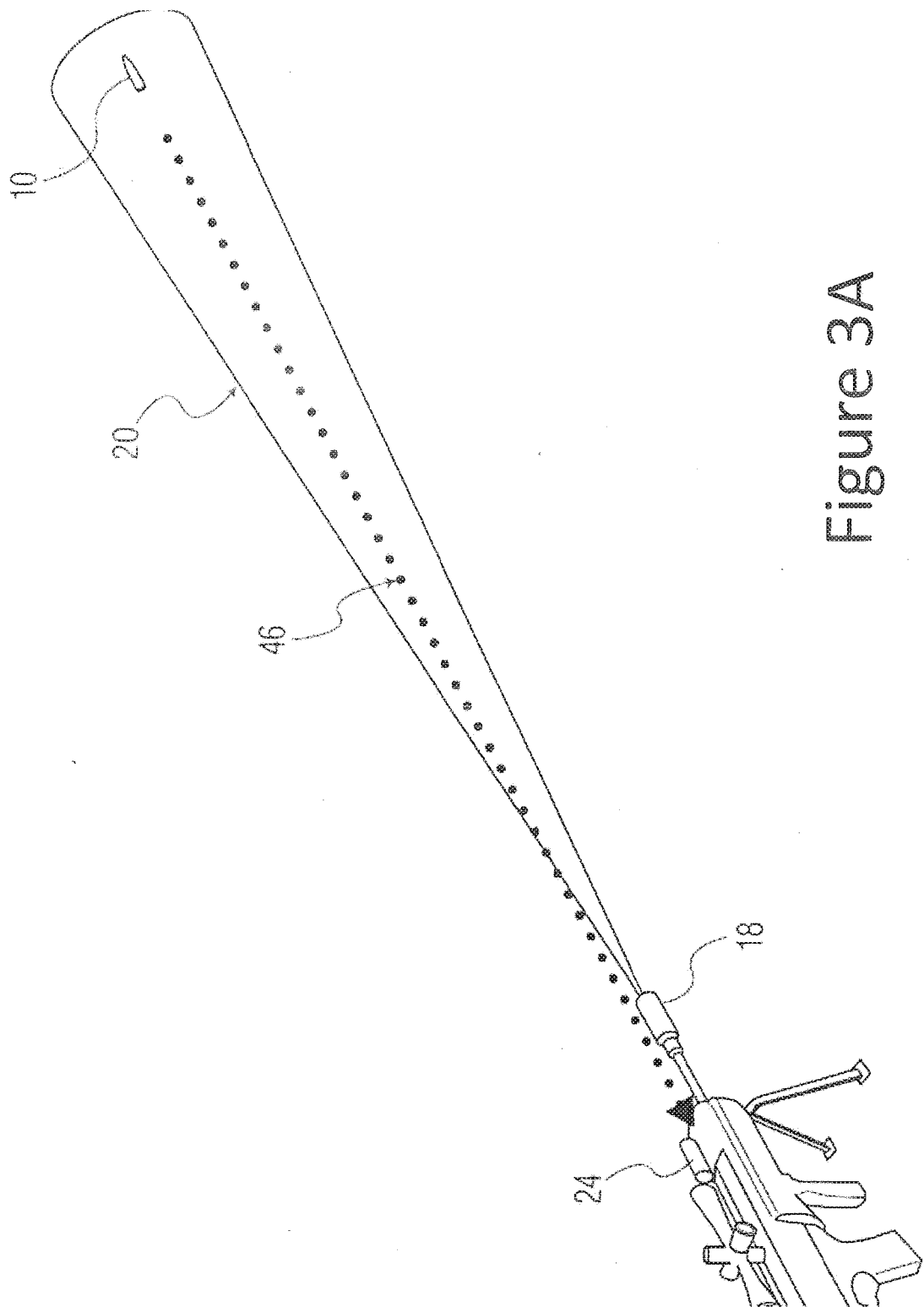


Figure 3A

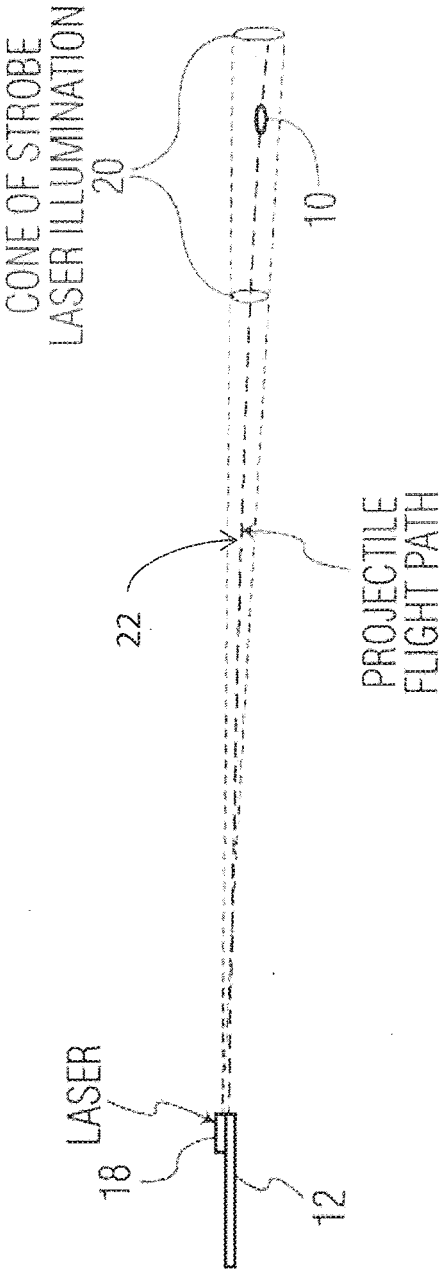


Figure 3B

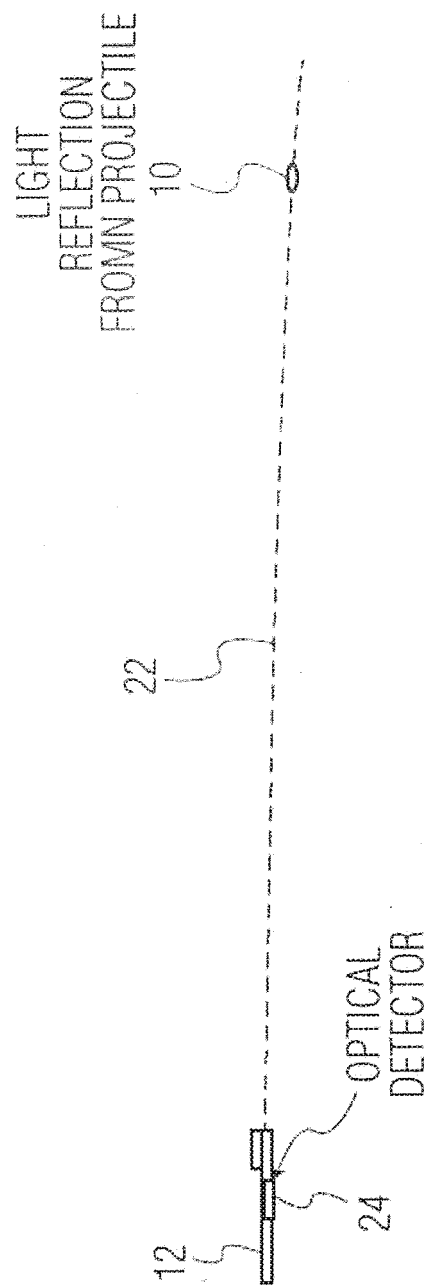


Figure 3C

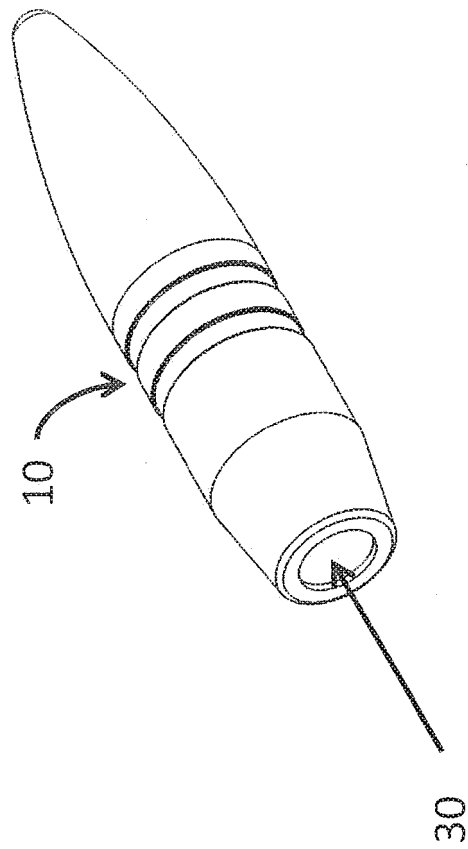


Figure 4

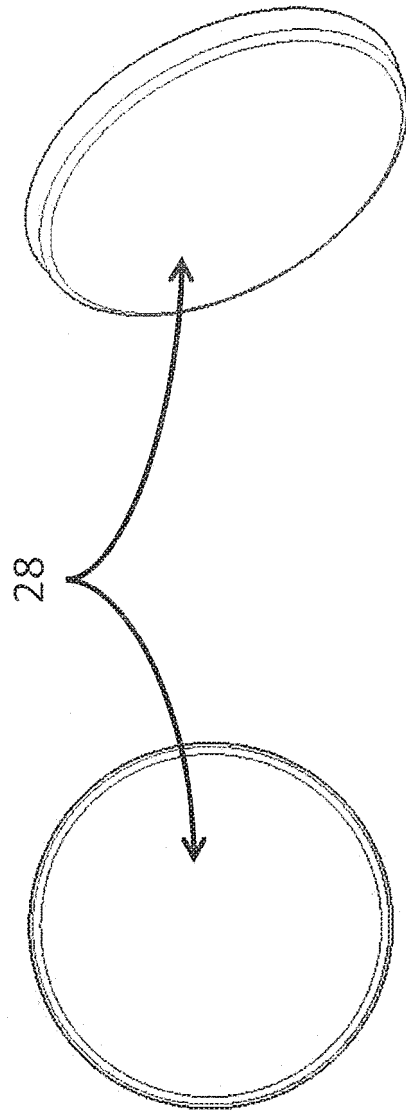


Figure 5A

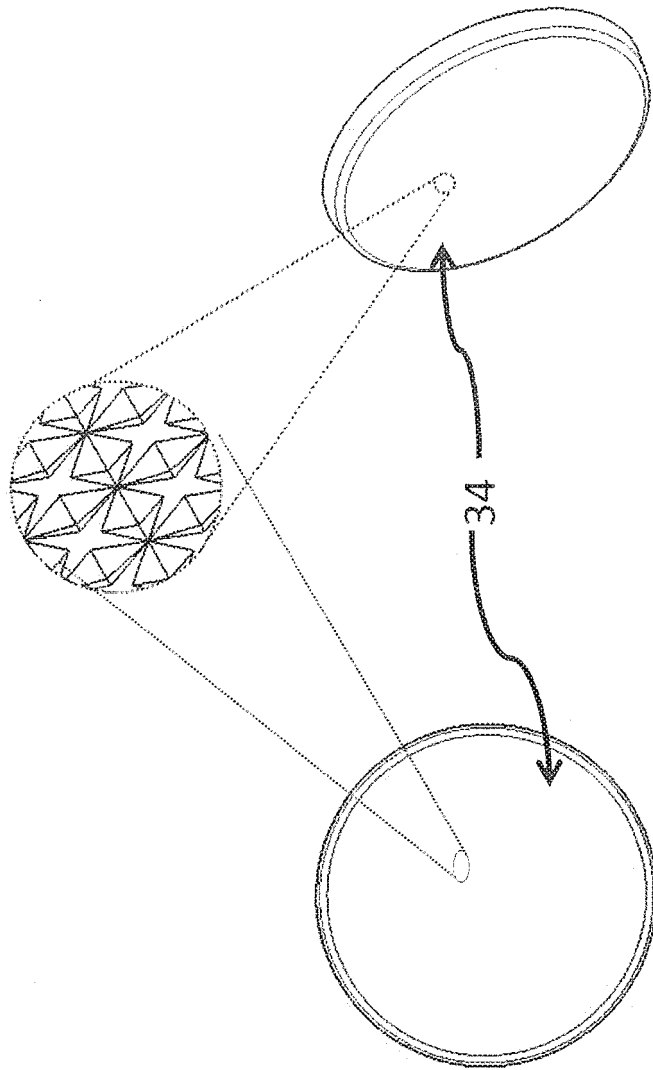


Figure 5B

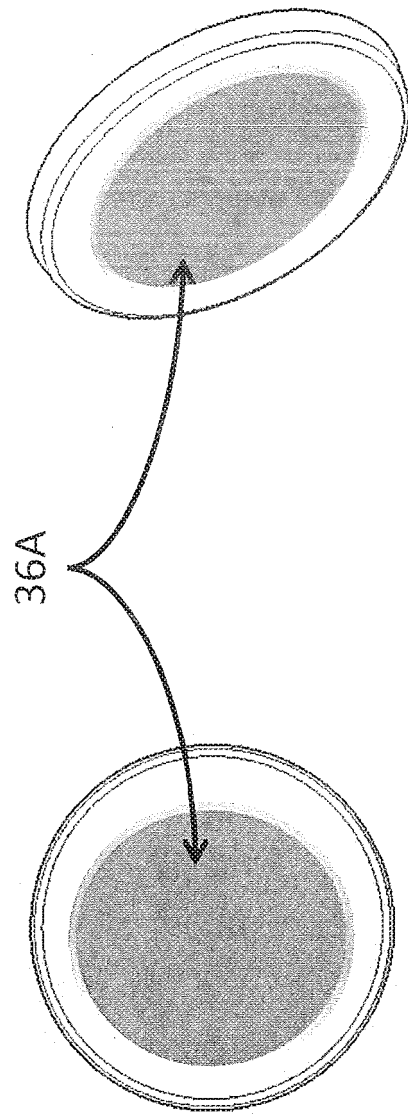


Figure 5C

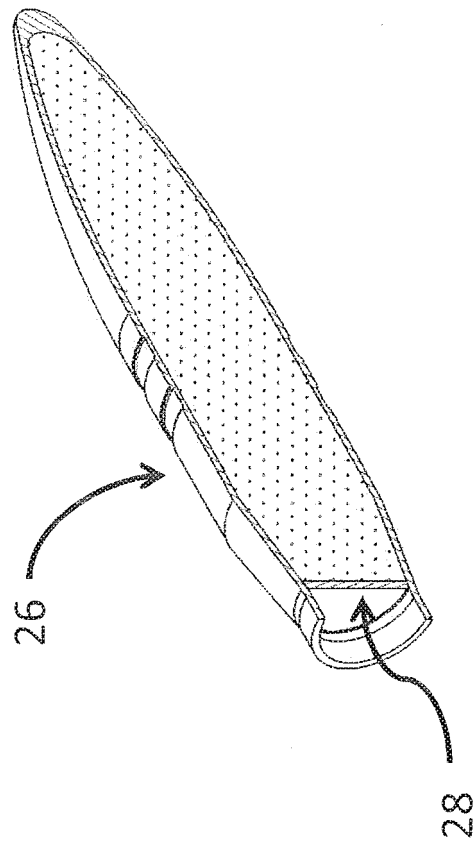


Figure 6A

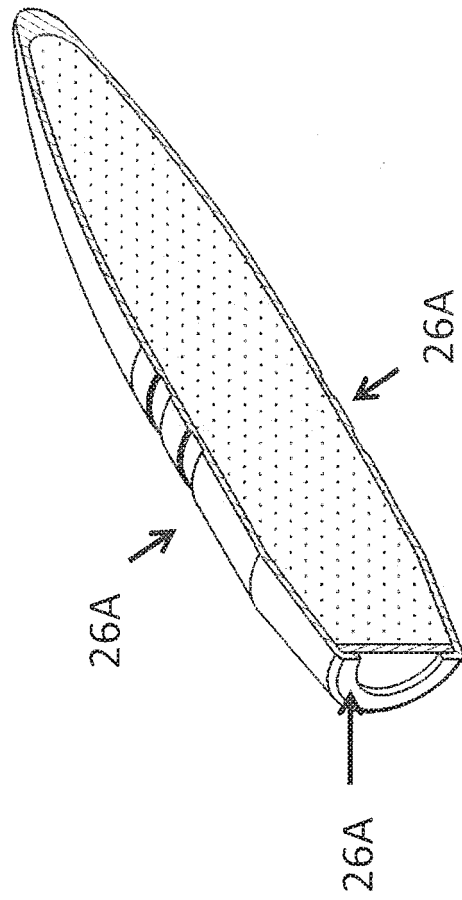


Figure 6B

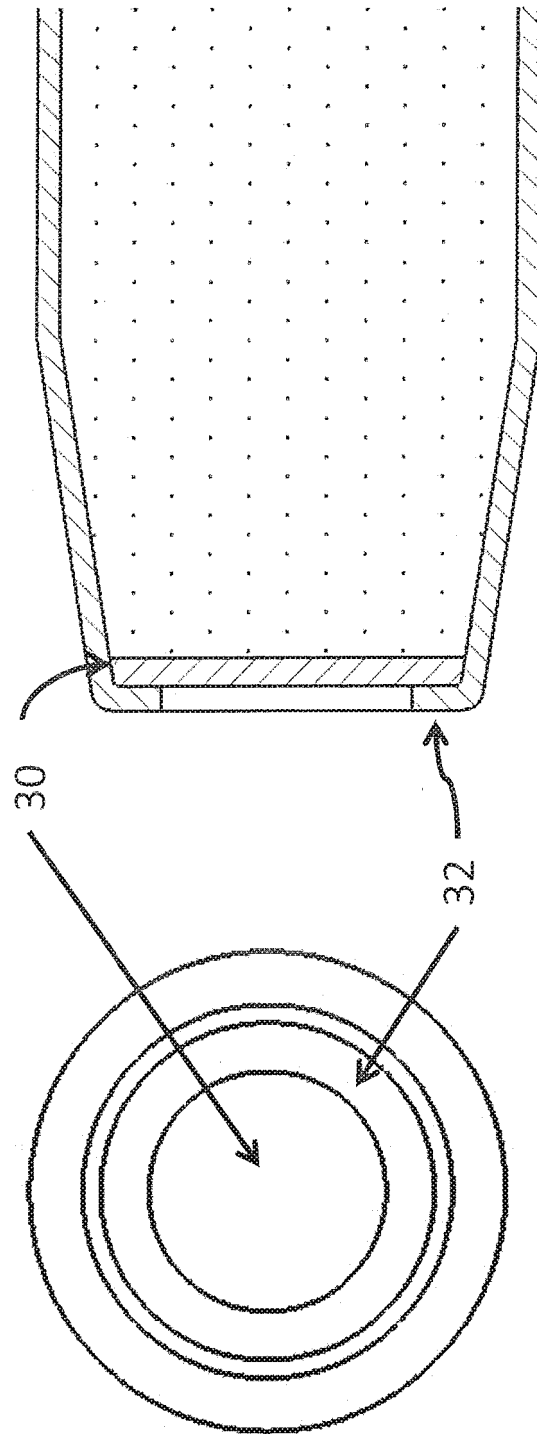


Figure 6C

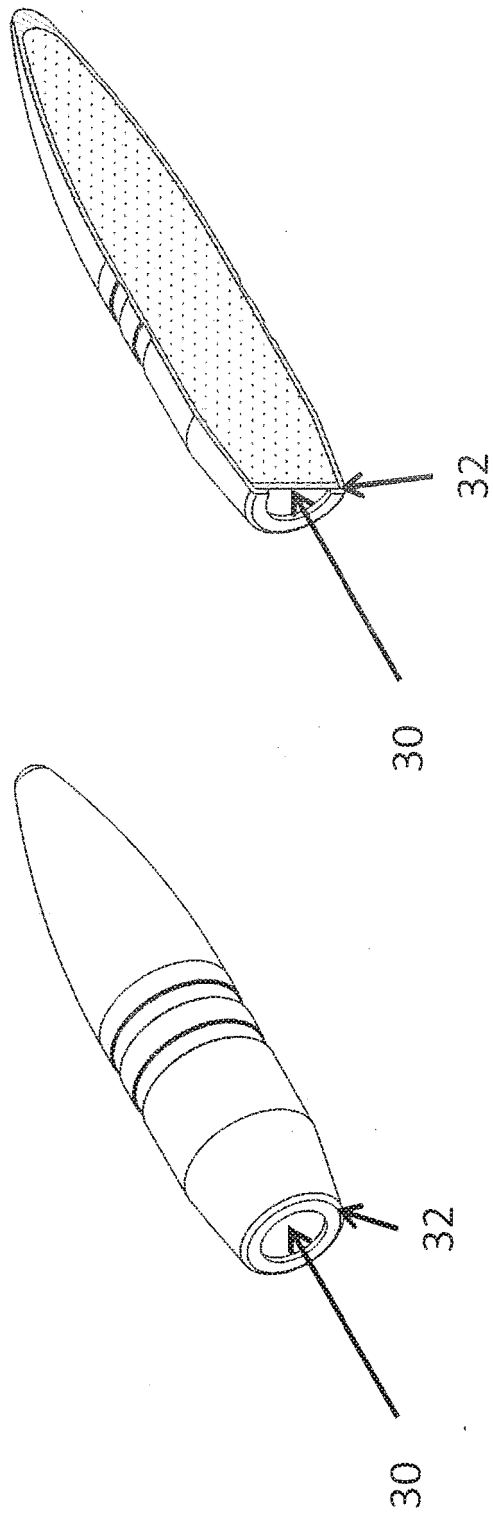


Figure 6D

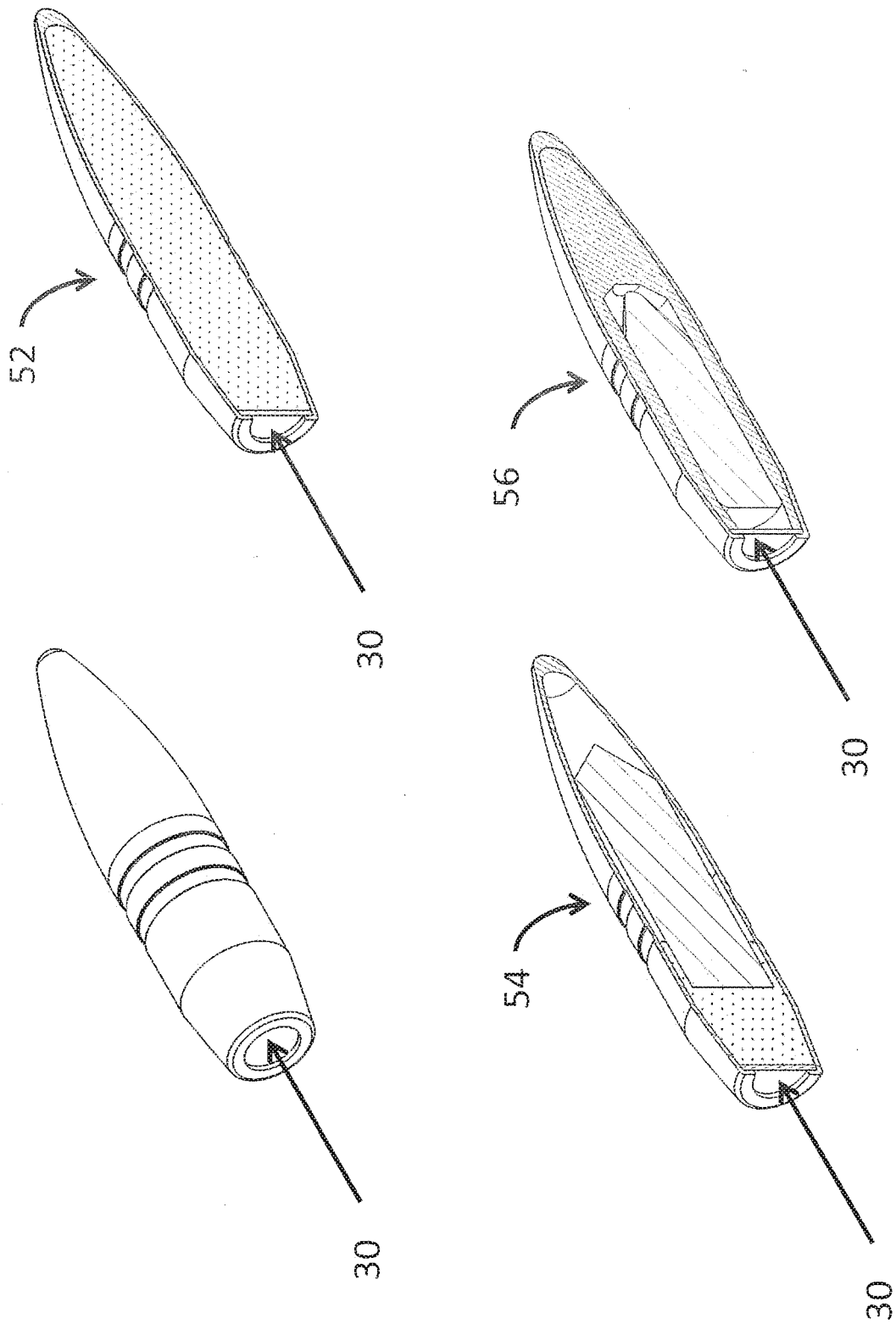


Figure 7

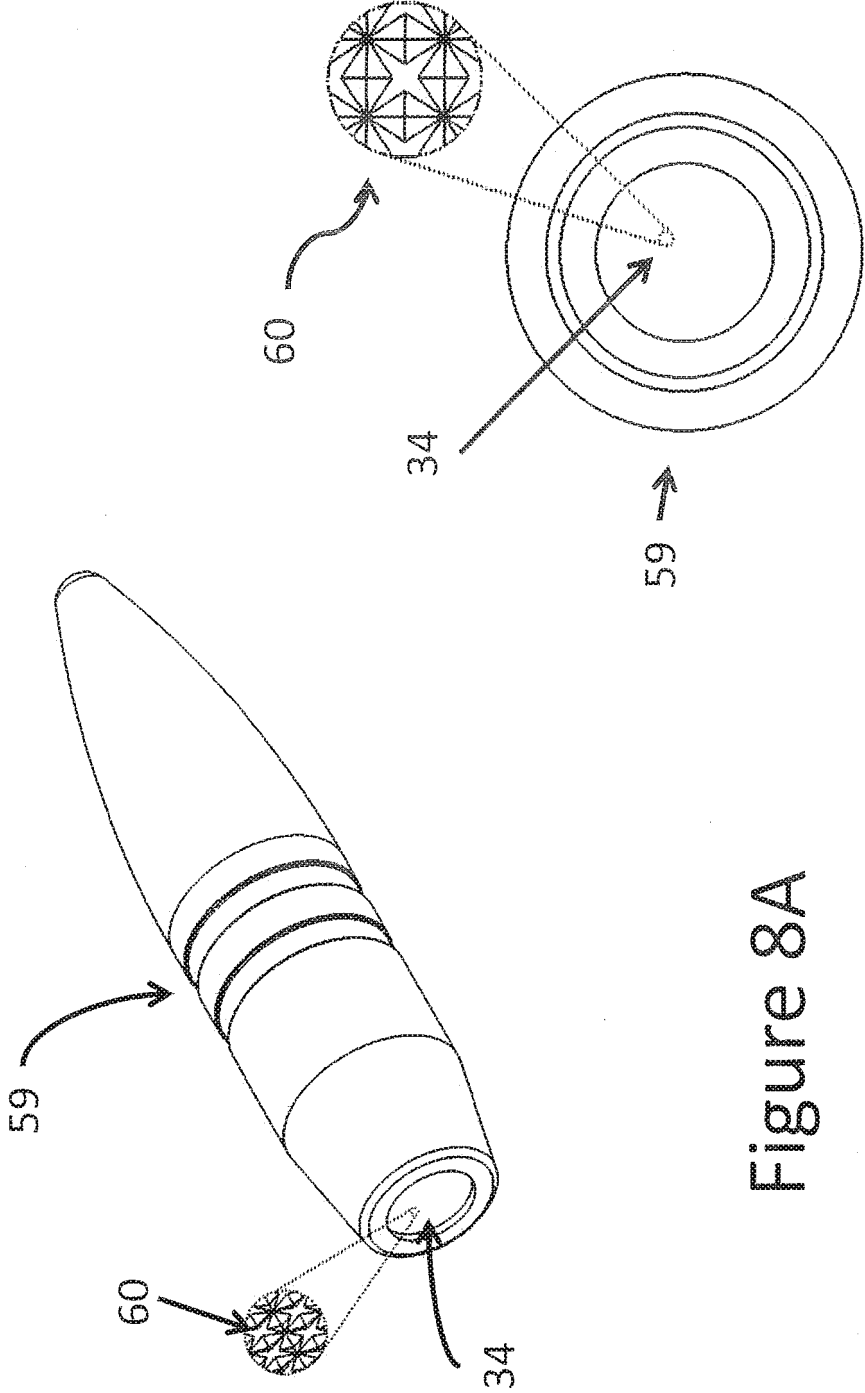


Figure 8A

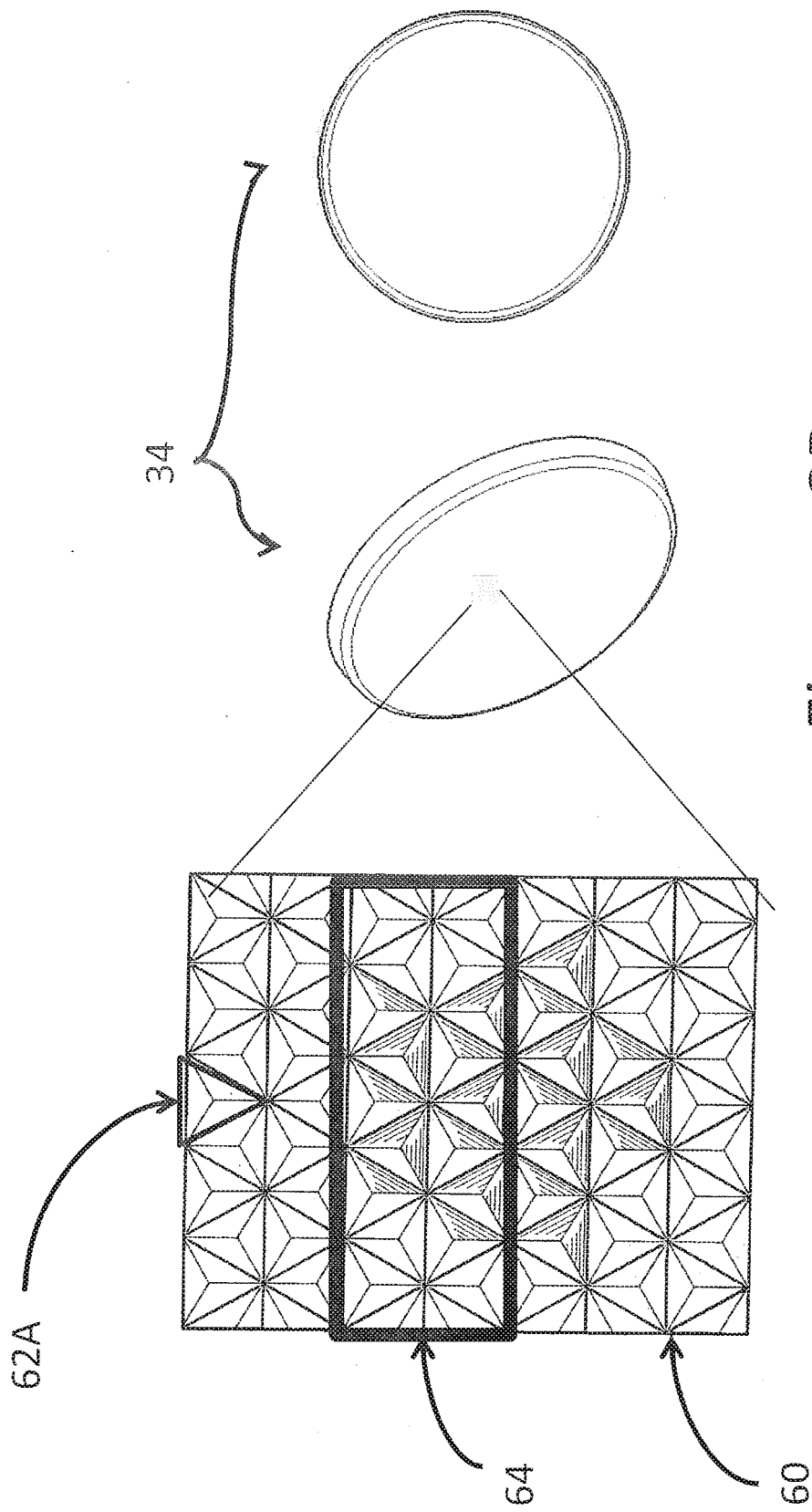


Figure 8B

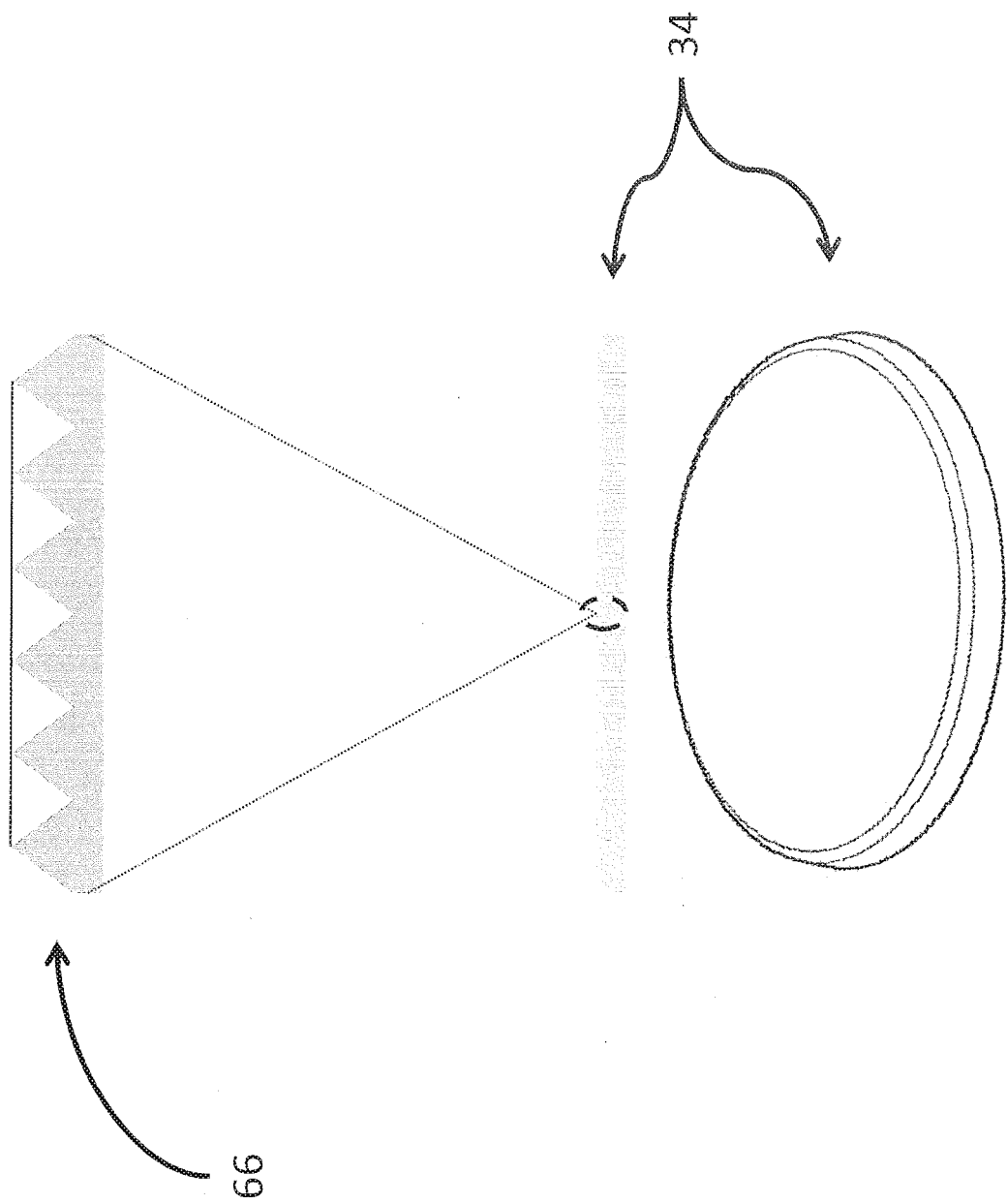


Figure 8C a

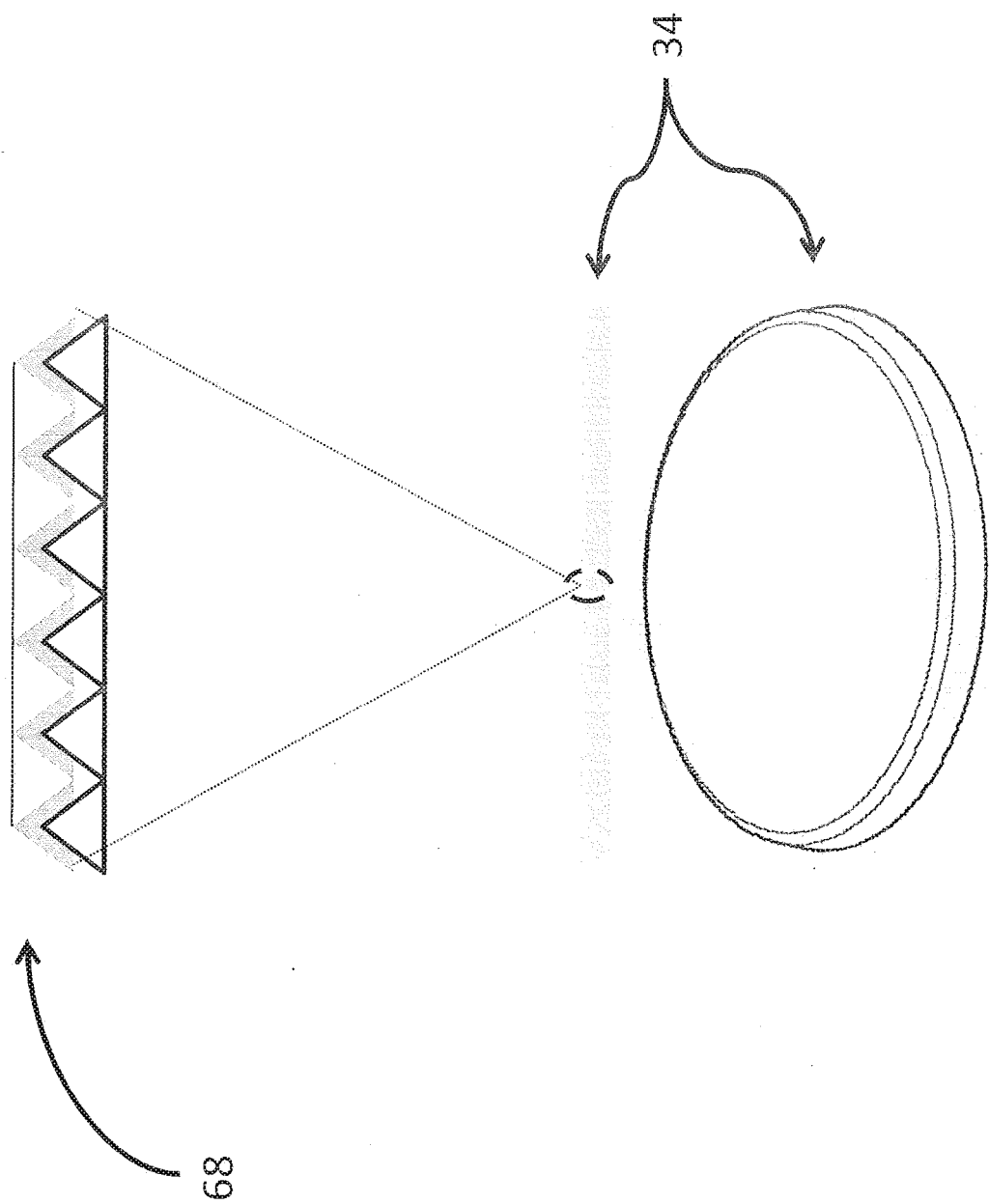


Figure 8C b

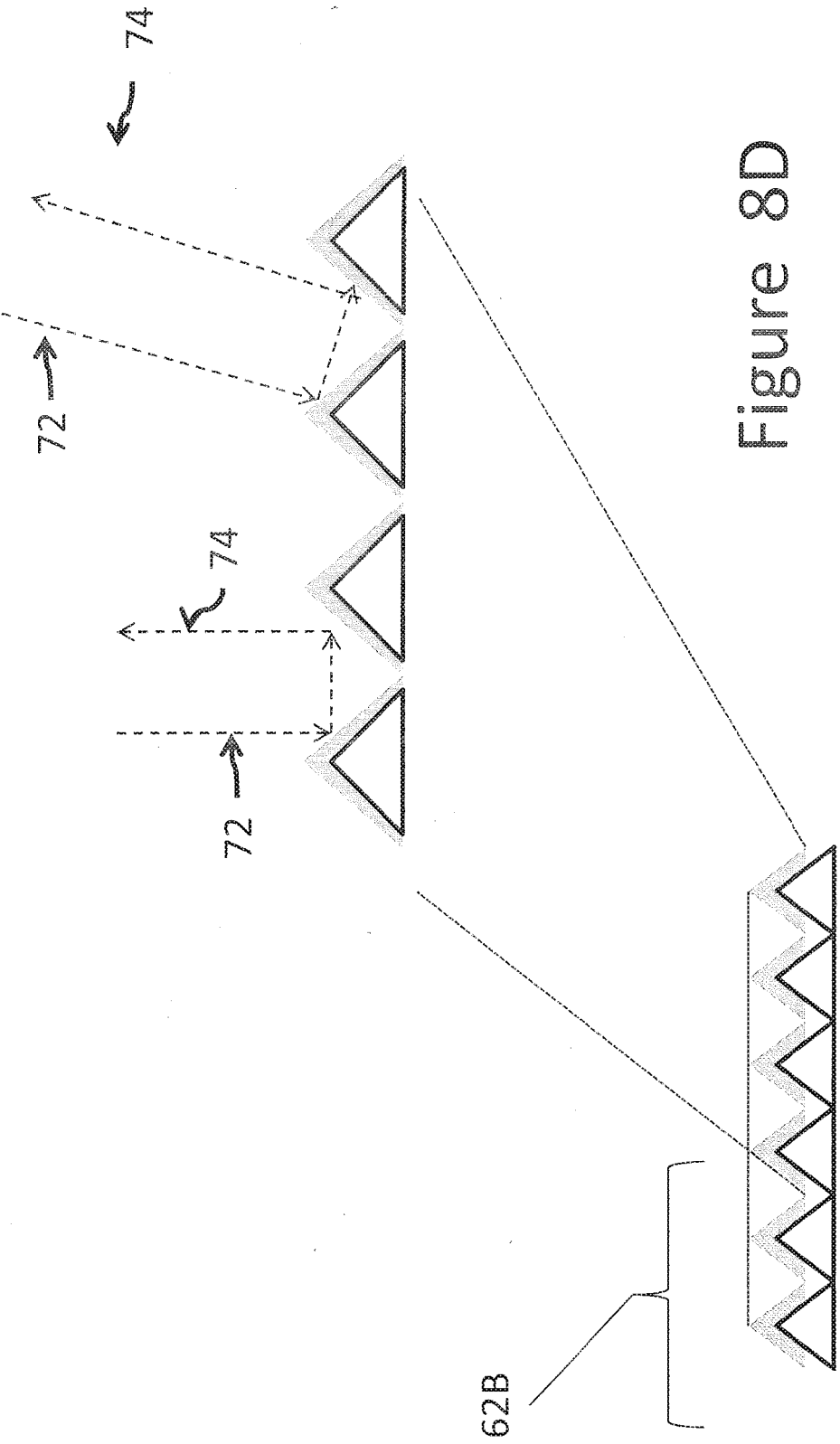


Figure 8D

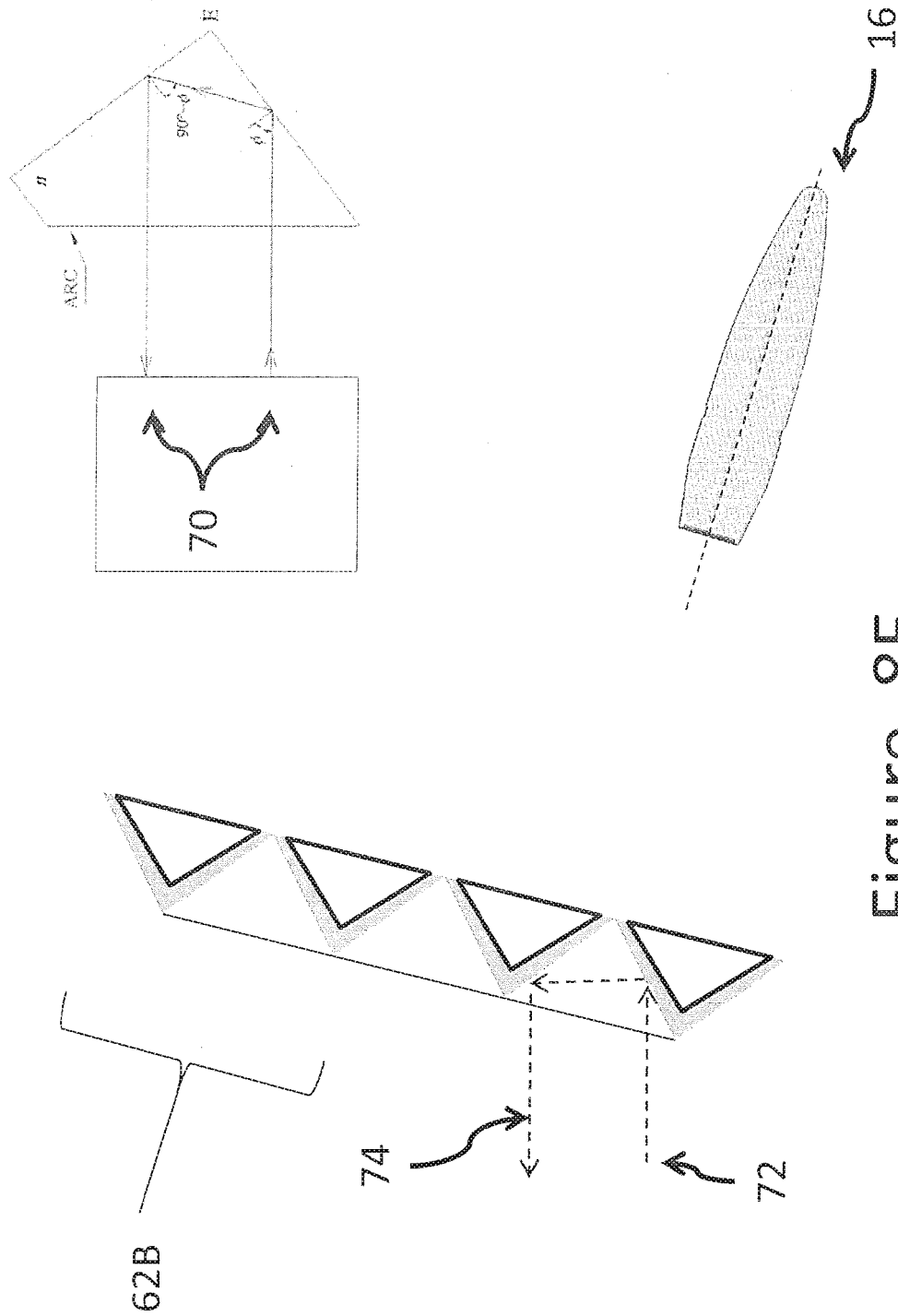


Figure 8E

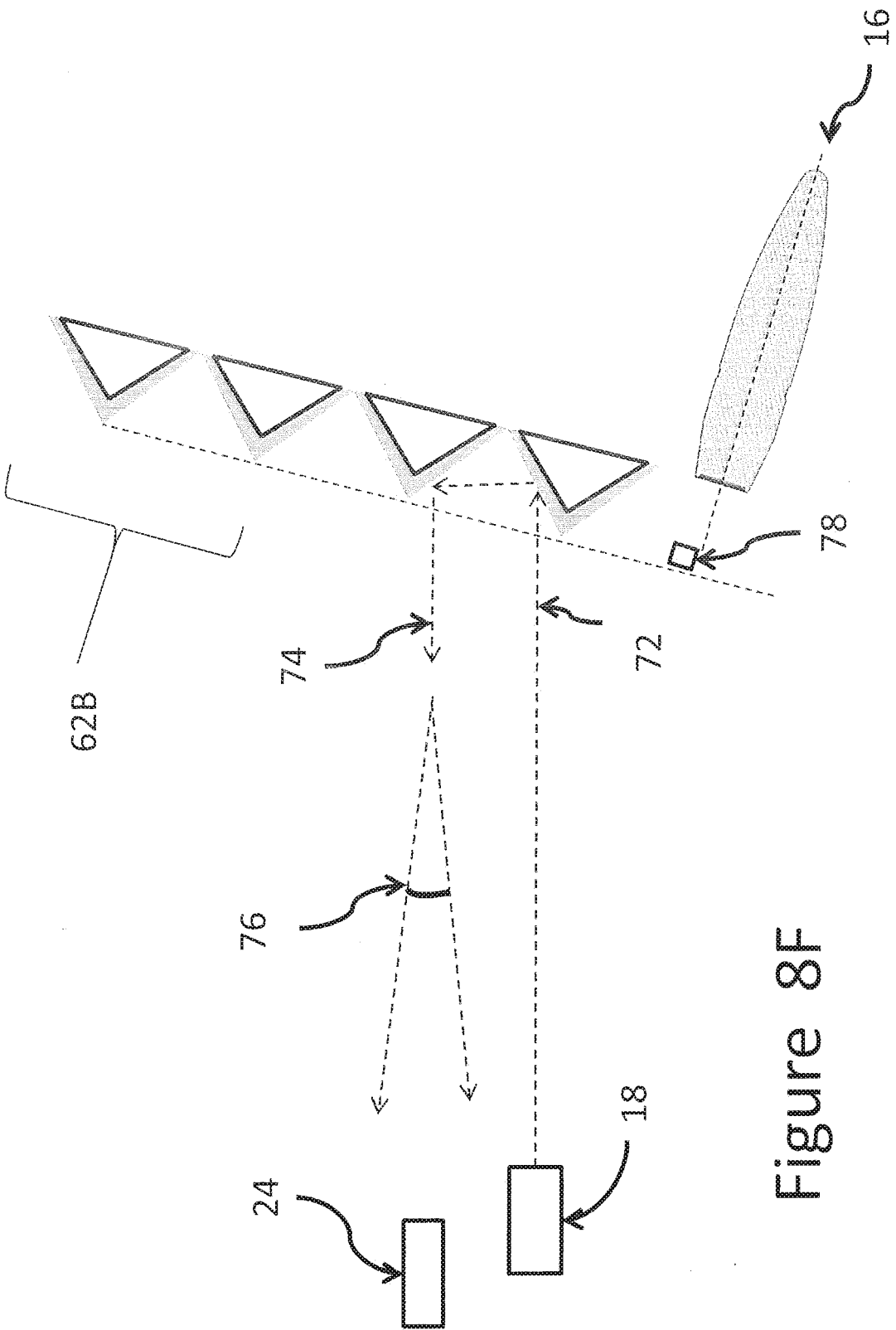


Figure 8F

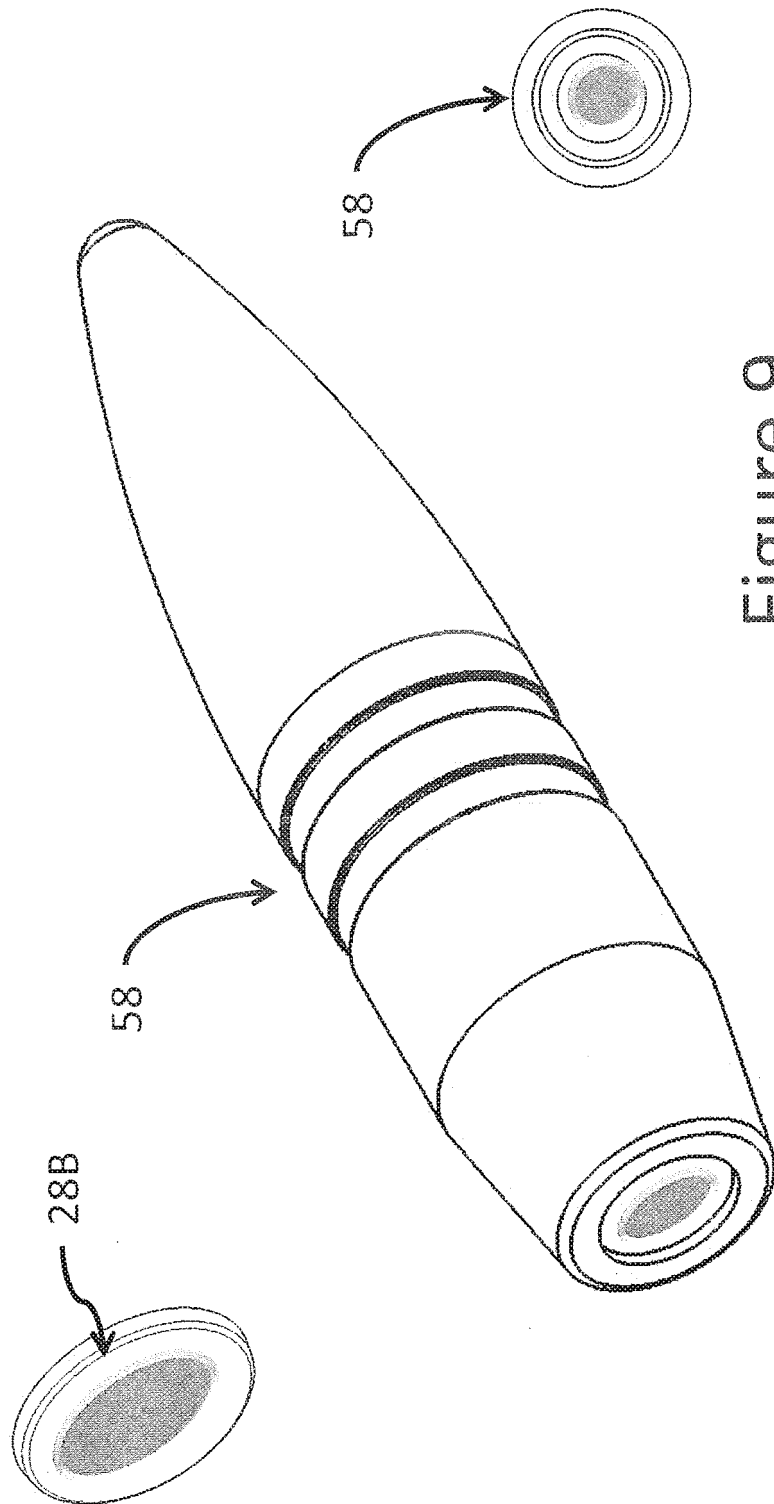


Figure 9

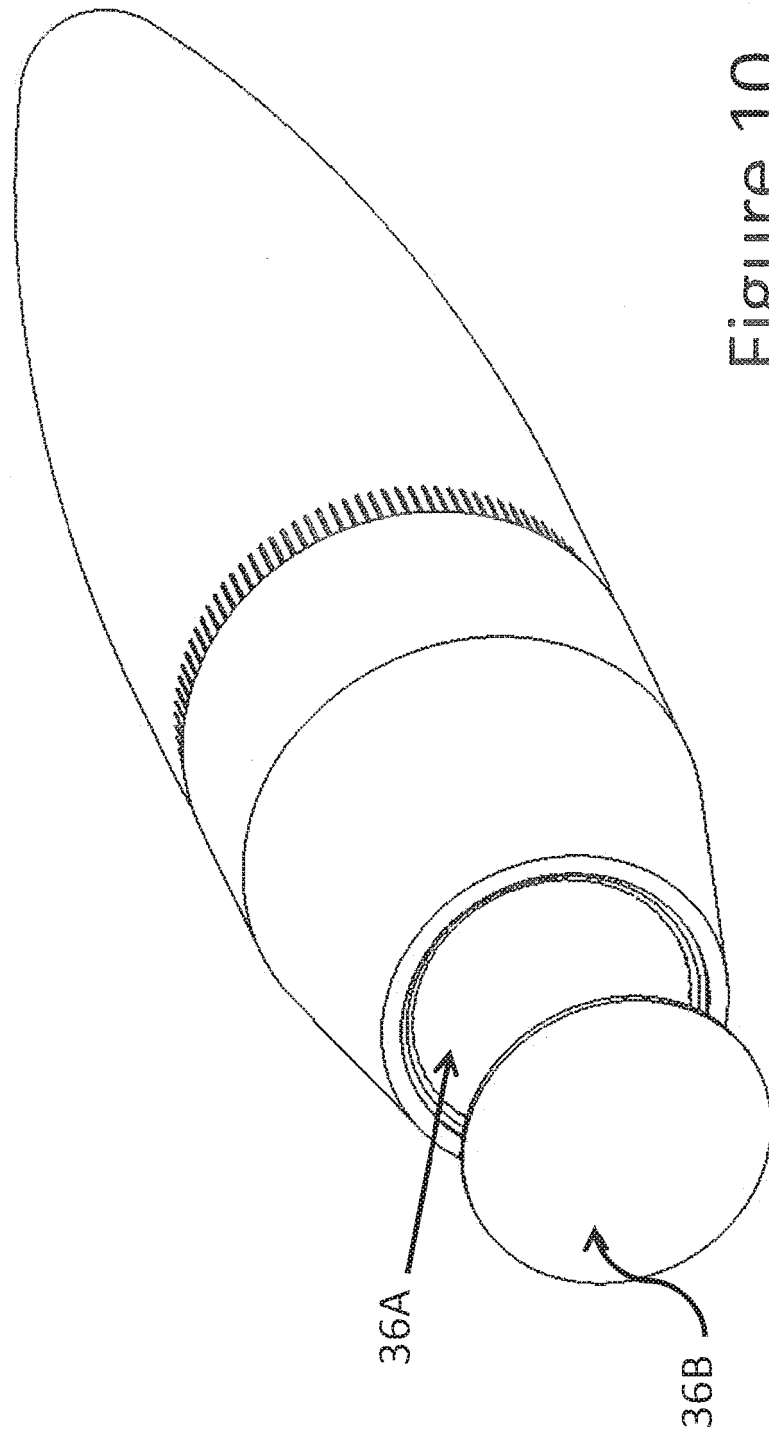


Figure 10

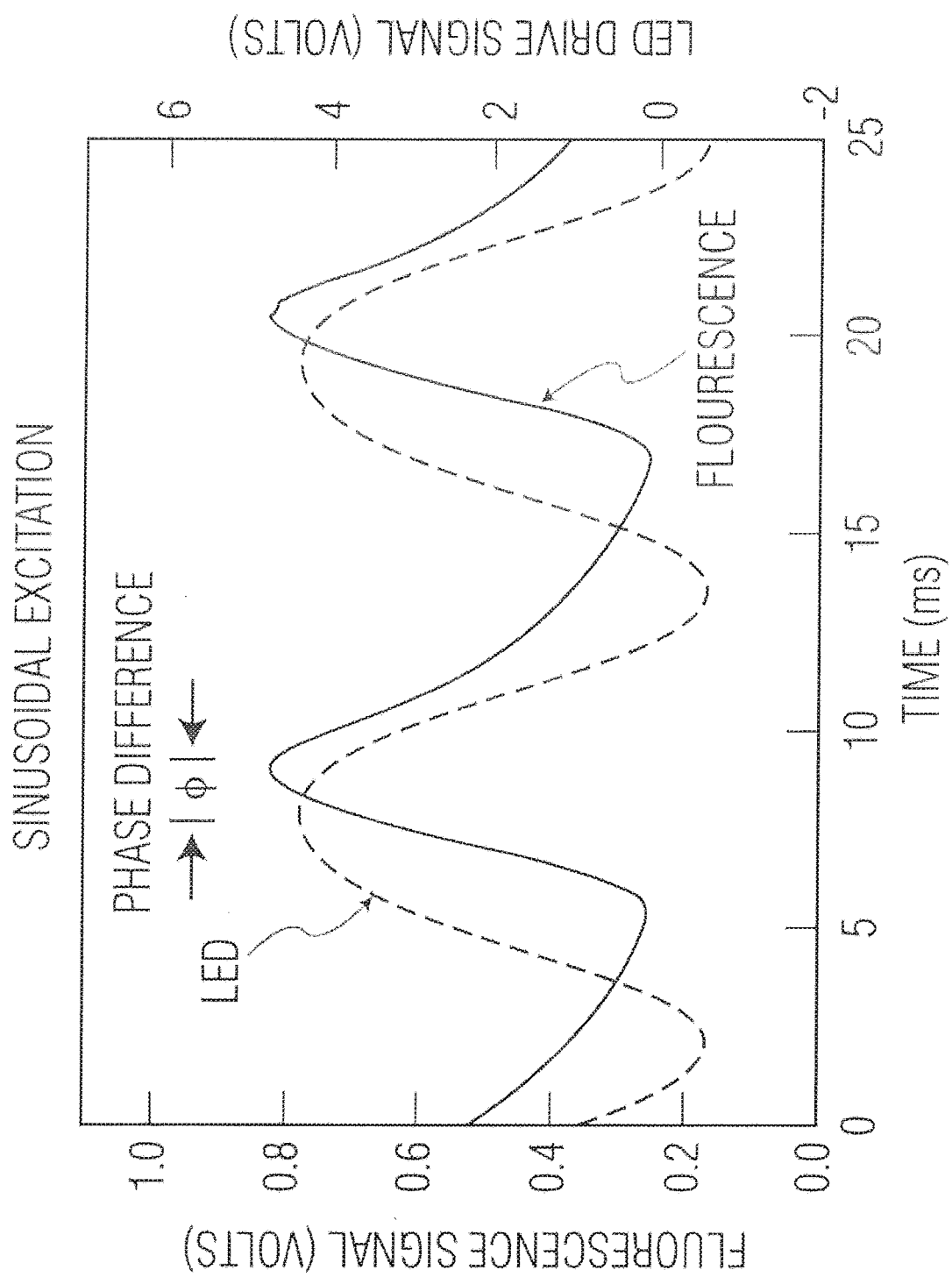


Figure 11

REFERENCES CITED IN THE DESCRIPTION

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