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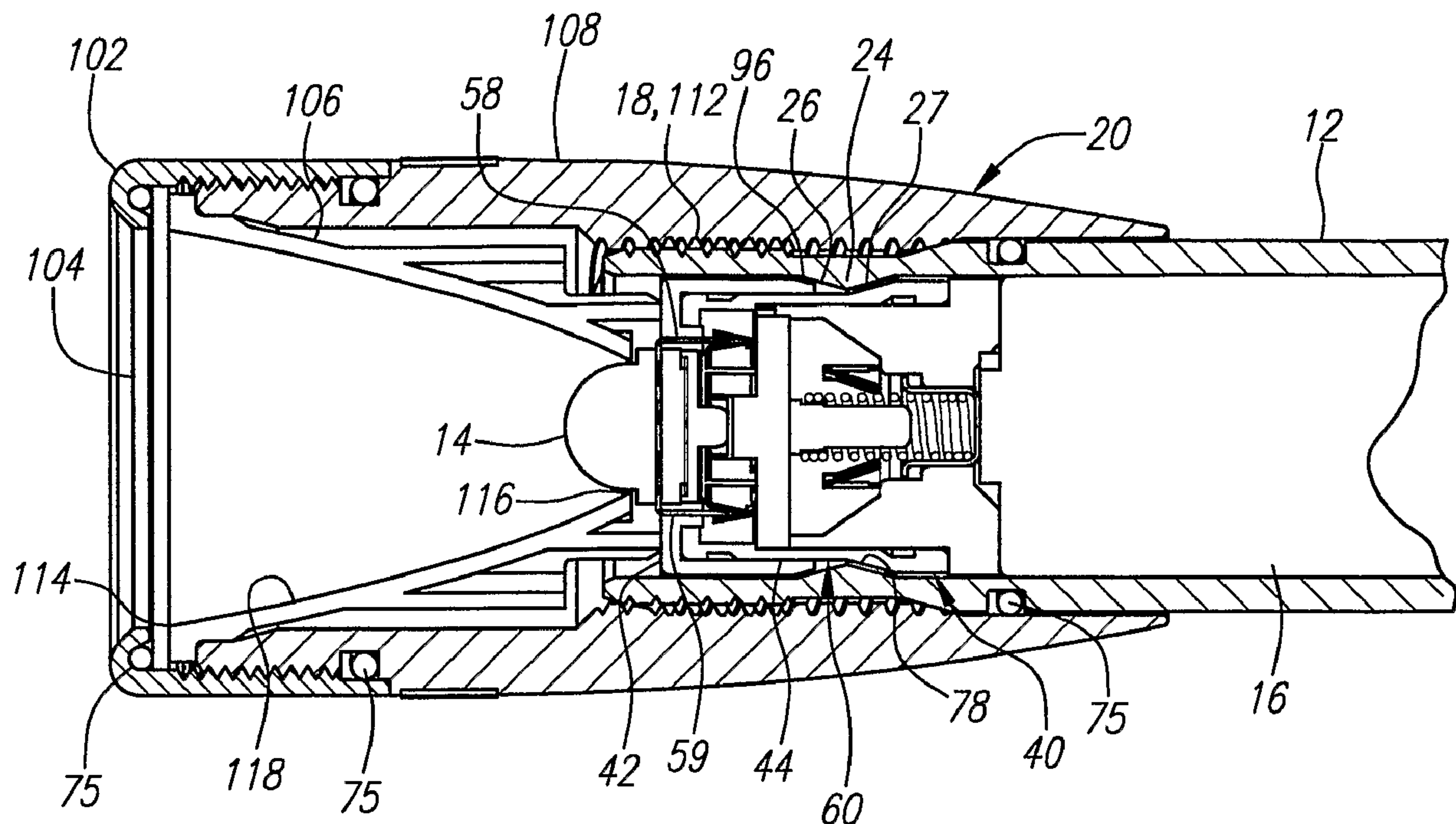
(71) Demandeur/Applicant:
MAG INSTRUMENT, INC., US

(72) Inventeurs/Inventors:
MAGLICA, ANTHONY, US;
WEST, STACEY H., US;
O'FARRELL, JOHN K., US

(74) Agent: GOWLING LAFLEUR HENDERSON LLP

(54) Titre : LAMPE DE POCHE A DIODES ELECTROLUMINESCENTES AMELIOREE

(54) Title: IMPROVED LED FLASHLIGHT



(57) Abrégé/Abstract:

A lighting device with improved optical performance and efficiency is provided. The lighting device includes a source of energy, a light source, a reflector and a holder. The reflector has a first open end, a second end, and a parabolic profile extending between the first open end and second end. The focus of the parabolic profile is located outside of the profile. The reflector may also be movable relative to the light source. The lighting device may include a circuit that delivers a pulsed or thermally compensated pulsed current to the light source. The light device may also include a heat sink housing.

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(71) Applicant (for all designated States except US): **MAG INSTRUMENT, INC.** [US/US]; 1635 South Sacramento Avenue, Ontario, CA 91761 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **MAGLICA, Anthony** [US/US]; 1635 South Sacramento Avenue, Ontario, CA 91761 (US). **WEST, Stacey, H.** [US/US]; 1417 Innisbrook Circle, Upland, CA 91784 (US). **O'FARRELL, John, K.** [US/US]; 5062 E. Mark Lane, Cave Creek, AZ 85331 (US).

(74) Agent: **WONG, Charles, C.**; Jones Day, 555 South Flower Street, Fiftieth Floor, Los Angeles, CA 90071 (US).

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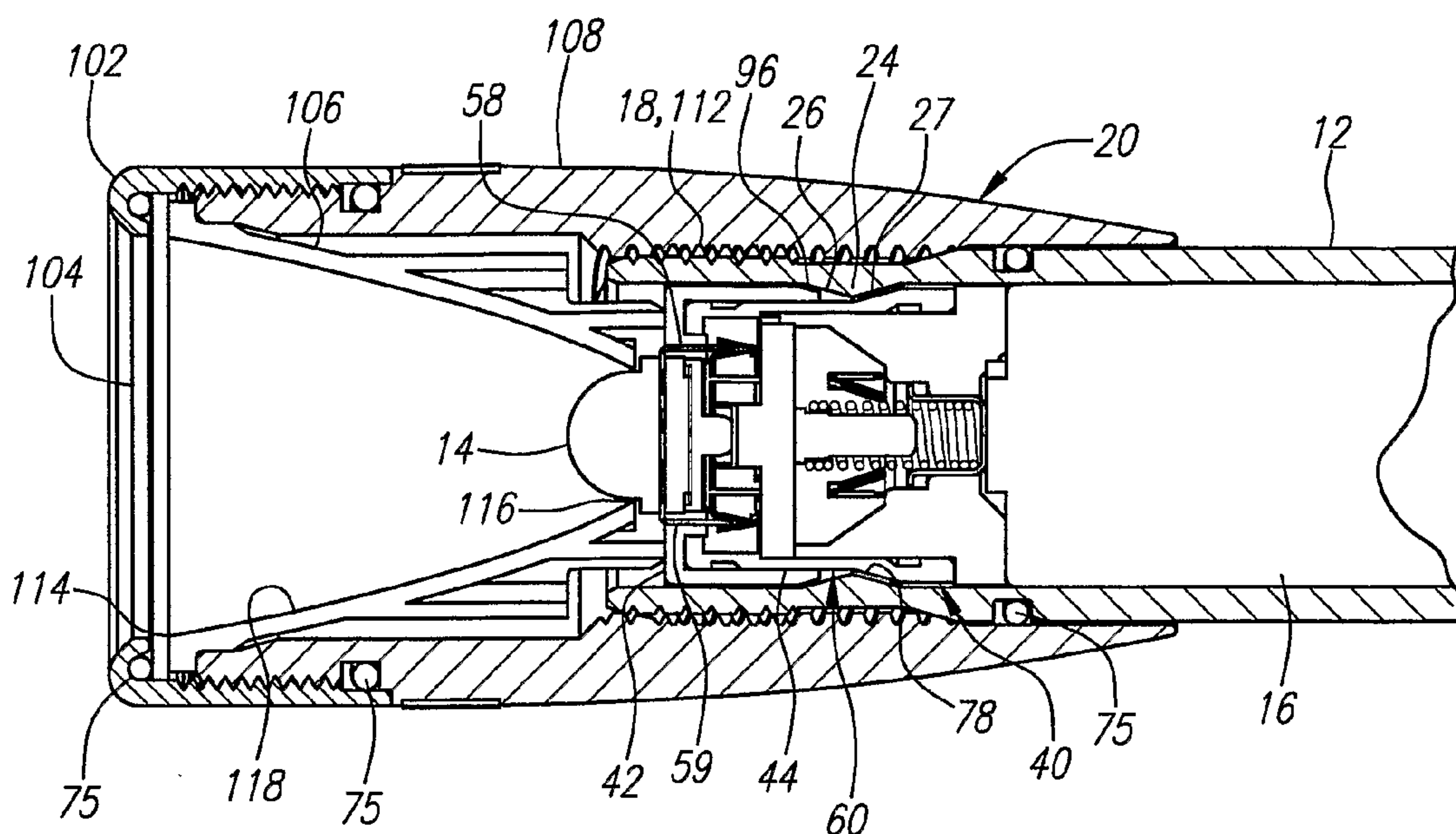
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(54) Title: IMPROVED LED FLASHLIGHT



(57) Abstract: A lighting device with improved optical performance and efficiency is provided. The lighting device includes a source of energy, a light source, a reflector and a holder. The reflector has a first open end, a second end, and a parabolic profile extending between the first open end and second end. The focus of the parabolic profile is located outside of the profile. The reflector may also be movable relative to the light source. The lighting device may include a circuit that delivers a pulsed or thermally compensated pulsed current to the light source. The light device may also include a heat sink housing.

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DESCRIPTION

Improved LED Flashlight

Field of the Invention

The field of the present invention relates to hand-held or portable lighting
5 devices, including flashlights and flashlight components.

Background of the Invention

Light emitting diodes ("LEDs") have been used in various applications
including illuminating watches, transmitting information from remote controls, and
forming images on jumbo television screens. More recently, LEDs have been
10 used in portable lighting devices, such as flashlights, because, among other
things, LEDs can last longer and can be more durable than incandescent lamps
commonly used in conventional flashlights.

Notwithstanding the desirable characteristics LEDs may have over
incandescent lamps, improvements can be made over existing lighting devices
15 that use an LED as its primary source of light. For example, current LED
flashlights typically fail to produce a quality light beam that projects for any
appreciable distance. A reason for this is that available LED lamps substantially
radiate light in a pattern over an angle less than 180° relative to the position of the
LED. Figure 1 illustrates the brightness or radiation pattern of a typical LED lamp.
20 A typical LED lamp includes a LED and a lens arranged over the LED. The light
rays that emanate from the typical LED lamp is generally conical - the brightness
(indicated in percentages) is generally concentrated about the center axis 11 and
reduces non-linearly as the spherical angle θ increases. Existing LED flashlights
have not provided a reflector/lamp combination that effectively captures the
25 brighter light rays that are concentrated about the center axis. Accordingly,
although available LED lighting devices may be suitable to illuminate the
immediate surrounding area, the distance that the light beam is able to project has
been limited.

To try to overcome this deficiency, some devices have used multiple LEDs
30 or a combination of LED lamps and incandescent lamps. However, such devices
involve greater complexity, consume more energy, and cost more to
manufacture. Accordingly, the present invention provides an energy efficient LED
lighting device that has improved optical performance and that projects a quality
light beam.

Also, as improvements are made to light sources, such as LEDs, another problem challenging the operation of portable lighting devices is effectively dissipating the increased heat that is generated by the light source. Accordingly, the present invention provides a combination that effectively dissipates heat from the light source of a portable lighting device. The present invention also provides a means to reduce the amount of heat generated by the light source and to use less energy to illuminate the light source.

Summary of the Invention

The present invention involves a portable lighting device having an improved optical performance. The present invention also provides for improving the efficiency of a portable lighting device.

In one embodiment, the lighting device includes a source of energy, a light source, a reflector and a holder. The reflector has a first open end, a second open end, and a parabolic profile extending between the open ends. The reflector also has its focus located outside the parabolic profile, which, among other things, facilitate more effectively collimating the brighter light rays that radiate from the light source. The holder holds the light source relative to the reflector such that light generated by the light source is reflected by the reflector. The relative position of the light source and the reflector may be variable. In one embodiment of the invention, a unique energy source assembly is provided to hold batteries in a side-by-side arrangement.

Optionally, the parabolic profile of the reflector may substantially conform to a profile according to the equation $r^2 = 4fz$, wherein the focal length, i.e., the distance between the vertex and the focus, is between 0.020-.050 or .035 inch. Alternatively, the ratio between the distance from the vertex to the smaller opening and the focal length is greater than 1.5:1, less than 6.5:1, between 1.5:1 to 6.5:1, 3.0:1 to 3.4:1, or 3.2:1. The light source may also be a lamp comprising an LED. The lighting device may also include a heat sink housing thermally coupled to the light source and a main housing. The lighting device may also include a current modulating circuit to deliver a pulsed current or a thermally compensated pulsed current to the light source.

In a flashlight, the invention includes a portable source of power, a light source, and a movable curved shaped reflector. The light source includes an LED and a lens, and light radiates substantially from the light source at an angle less than 180° relative to the LED position. The movable reflector includes a parabolic profile and a focus located outside the parabolic profile. Also, the reflector may be

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movable in a direction parallel to the principal axis of the parabola. The flashlight may also include a heat sink thermally coupled to the light source.

In another aspect of the invention, the flashlight includes a portable source of energy, an LED lamp, and an electrical circuit that includes a heat sink housing that electrically couples a first lead of the LED lamp and the portable source of energy. The heat sink housing is also thermally coupled to the LED lamp to substantially dissipate heat that is generated from the LED lamp.

In still another aspect of the invention, an improved energy source assembly includes batteries held in a side-by-side arrangement.

10 Description of the Figures

Figure 1 is a plan view of a brightness or radiation pattern of a typical LED lamp.

Figure 2 is a perspective view of a flashlight in accordance with the present invention.

15 Figure 3 is a cross-sectional side view of the flashlight of figure 2 as taken through the plane indicated by 3-3.

Figure 4 is an enlarged cross-sectional side view of the front end of the flashlight of figure 2 as taken through the plane indicated by 3-3 where the flashlight is shown in the OFF position.

20 Figure 5 is an enlarged cross-sectional side view of the back end of the flashlight of figure 2 as taken through the plane indicated by 3-3.

Figure 6 is a perspective view of a tail cap contact.

Figure 7 is a cross-sectional view of the switch assembly in isolation.

Figure 8A is a block diagram of a current modulating circuit.

25 Figure 8B is a schematic of one embodiment of a current modulating circuit.

Figure 9 is a cross-sectional view of a heat sink housing.

Figure 10 is a cross-sectional view of a reflector.

30 Figure 11 is a cross-sectional view of the switch assembly of figure 7 rotated to show lock tabs.

Figure 12 is a cross-sectional view of the switch assembly of figure 7 rotated to show locking tabs.

Figure 13 is a perspective view of another embodiment of a flashlight in accordance with the present invention.

35 Figure 14 is a cross-sectional side view of the flashlight of figure 13 as taken through the plane indicated by 14-14.

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Figure 15 is an enlarged cross-sectional side view of the front end of the flashlight of figure 13 as taken through the plane indicated by 14-14.

Figure 16A is a front perspective view of an energy source assembly in isolation.

5 Figure 16B is a back perspective view of an energy source assembly in isolation.

Detailed Description Of The Preferred Embodiments

Referring to figures 2 and 13, a portable lighting device in the form of flashlights 10 and 200, each an embodiment of the present invention, are
10 illustrated in perspective. Each of flashlight 10 and flashlight 200 incorporates various features of the present invention. These features are described in detail below and illustrated in the accompanying figures for the purpose of illustrating the preferred embodiment of the invention. It is to be expressly understood, however, that the present invention is not restricted to the flashlights described herein.
15 Rather, the present invention includes lighting devices that incorporate one or more of the various features of the invention. It is also to be understood that the present invention is directed to each of the inventive features of the lighting devices described below.

Referring to figures 2 and 3, the flashlight 10 includes a head assembly 20,
20 a barrel 12, a light source 14 and a tail cap assembly 30. The head assembly 20 and the light source 14 are disposed about the forward end of the barrel 12. The tail cap assembly 30 encloses the aft end of the barrel 12.

Referring to figures 3 and 4, the barrel 12 is a hollow structure suitable for housing at least one source of energy, such as for example, a battery 16. In the
25 illustrative embodiment, the barrel 12 includes forward threads 18 formed on the outer diameter of its front end, and aft threads 22 formed on the inside diameter of its aft end. The barrel 12 also includes a reduced diameter region 24 that includes a front taper 26 and an aft taper 27. In the illustrative embodiment, preferably three batteries 16 are disposed in the barrel 12 in a series arrangement. It will be
30 appreciated by those skilled in the art, however, that barrel 12 may also be configured to include a single battery, two batteries, a plurality of more than three batteries, or other suitable portable source of energy in either a series or a side-by-side parallel arrangement. In a preferred embodiment, the batteries 16 are alkaline type dry cell batteries.

35 Referring to figures 3 and 5, the tail cap assembly 30 includes a tail cap 28, a conductive spring member 32 and a tail cap contact 38. The tail cap 28 preferably includes a region of external threads 34 for engaging the matching aft

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threads 22 formed on the interior of the barrel 12. Those skilled in the art should recognize that other suitable means may be employed for attaching the tail cap 28 to the barrel 12.

5 A sealing element 36 may be provided at the interface between the tail cap 28 and the barrel 12 to provide a watertight seal. The sealing element 36 may be an O-ring or other suitable sealing devices. In a preferred embodiment, the sealing element 36 is a one-way valve that is orientated so as to prevent flow from the outside into the interior of the flashlight 10, while simultaneously allowing overpressure within the flashlight to escape or vent to the atmosphere. Radial
10 spines 35 may be disposed at the interface between the tail cap 28 and the barrel 12 to ensure that the end of the barrel 12 does not provide a gas tight seal against the adjacent flange of the tail cap 28, thereby impeding the flow of overpressure gases from the interior of the flashlight.

The design and use of one-way valves in flashlights are more fully
15 described in U.S. Patent Nos. 5,003,440; 5,113,326; 5,207,502; 5,349,506; and 5,485,360, all issued to Anthony Maglica, which are hereby incorporated by reference.

Referring to figure 5, the tail cap contact 38 is disposed between the conductive spring member 32 and the tail cap 28. The conductive spring member
20 32 is electrically coupled to the tail cap contact 38 and the case electrode of the battery 16. The tail cap contact 38 is electrically coupled to the conductive spring member 32 and the barrel 12.

Referring to figure 6, the tail cap contact 38 includes a ring 39 and two extensions 41. The two extensions 41 are generally positioned 180° apart and
25 extend substantially perpendicular from the outer perimeter of the ring 39. Each of the extensions 41 also includes a profile 43 that extends radially outward from the outer perimeter of the ring 39. Because of the profile 43, the extensions 41 frictionally engage and electrically couple with the inside diameter of the barrel 12 when the tail cap assembly 30 is assembled with the barrel 12. In this way, the
30 illustrative embodiment discloses one way of providing an electrical connection between the battery 16 and the barrel 12 without the tail cap 28 conducting any electricity. Accordingly, if desired, the tail cap 28 may be fabricated from a non-conductor, such as plastic or rubber.

In an alternate embodiment, a tail cap insert may be used to provide an
35 electrical connection between the battery 16 and the barrel 12. Such an insert is shown or described in U.S. Patent Nos. 4,819,141; 4,823,242; 4,864,474; 5,003,440; 5,008,785; 5,113,326; 5,121,308; 5,193,898; 5,207,502; 5,267,130;

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5,349,506; 5,455,752; 5,485,360; 5,528,472; 5,722,765; 5,836,672; and 6,086,219, which are hereby incorporated by reference.

In an alternate embodiment, a conductive sleeve within the barrel can engage the extensions 41 of the tail cap contact 38 to provide an electrical path. Such a sleeve is described in U.S. Patent Nos. 4,656,565 and 4,851,974 to Anthony Maglica, which are hereby incorporated by reference. In an alternate embodiment, a conductive strip within the barrel can engage the extensions 41 to provide an electrical path. Such a strip is shown in U.S. Patent No. 6,585,391. Such a sleeve or strip will permit the barrel to be fabricated from a non-conductor, such as plastic or rubber.

In another alternate embodiment, the tail cap assembly 30 may be configured without a tail cap contact 38 and the tail cap 28 is used as an electrical conductor. In this alternate embodiment, when the tail cap assembly 30 is installed onto the barrel 12, the spring member 32 forms an electrical path between the case electrode of the battery 16 and the tail cap 28. An electrical path is further formed between the tail cap 28 and the barrel 12 through, for example, their interface and/or the mating threads. To facilitate the flow of electricity, any existing surface treatments, such as by anodizing, disposed at the tail cap/barrel contact is removed. Accordingly, in this alternate embodiment, the tail cap 28 is a conductor, such as aluminum.

Referring to figure 3, regardless of the tail cap assembly embodiment employed, the conductive spring member 32 urges the batteries 16 toward the front of the flashlight 10. As a result, the center electrode of the rear battery is in electrical contact with the case electrode of the battery forward thereof. In this way, the batteries 16 contained in the barrel 12 are electrically coupled. Referring to figure 4, the center electrode of the forward-most battery 16 is urged into contact with a switch assembly 40.

Referring to figure 4, the switch assembly 40 is disposed about the forward end of the barrel 12 and, among other things, holds the light source 14 relative to a reflector. The light source 14 includes a first electrode 58 and a second electrode 59.

The light source 14 may be any suitable device that generates light. For example, the light source 14 may be an LED lamp, an incandescent lamp, or an arc lamp. In the illustrative embodiment, the light source 14 is preferably an LED lamp that substantially radiates light at a spherical angle of less than 180°. A suitable light source 14 is an LED emitter LXHL-PWO1, manufactured by Lumileds Lighting, San Jose, California.

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The switch assembly 40 includes features to hold the light source 14. Also, among other things, the switch assembly 40 includes features that facilitate closing and interrupting an electrical circuit to the light source 14. The switch assembly 40 also includes features that effectively dissipates heat generated by the light source 14.

Referring to figure 7, the switch assembly 40 includes an upper insulator 42 and a switch subassembly 60. The switch subassembly 60 includes a heat sink housing 44, a circuit assembly 50, an upper conductive spring member 52, a source contact 54 and a lower insulator 56.

The circuit assembly 50, among other things, preferably controls the energy that flows to the light source 14. In an illustrative embodiment, the circuit assembly 50 includes a circuit board 62, a contact plug 64, a first contact 46 and a second contact 48.

The circuit board 62 includes a current modulating circuit suitable for controlling the current that is delivered to the light source 14. Preferably, the current modulating circuit modulates the DC current from the batteries 16 to a pulsed current. Also preferably, the duty cycle of the pulsed current delivered to the light source 14 is automatically adjusted, if necessary, according to the heat that is generated by the light source 14.

Referring to figure 8A, an illustrative embodiment of a current modulating circuit 15 is illustrated in block form. When the flashlight is turned ON and electrical energy is delivered to the current modulating circuit 15, the pulse generator 21 controls the power switch 23 to regulate the current that is delivered to the light source 14. In a preferred embodiment, the power switch 23 is a metal-oxide semiconductor field effect transistor ("MOSFET") with the pulse generator 21 coupled to its gate. The power switch 23 may be other suitable devices such as, for example, a transistor or a bi-polar junction transistor. Also, in a preferred embodiment, the pulse generator 21 is a circuit comprising a comparator and a system of diodes and resistors.

The current modulating circuit 15 further includes a temperature responsive resistor 25 that detects the heat generated by the light source 14. In a preferred embodiment, the temperature responsive resistor 25 is a thermistor. The thermistor may be disposed such that the heat generated by the light source 14 may be detected. The thermistor may be coupled to the pulse generator 21 to adjust the duty cycle of the pulsed current that is delivered to the light source. For example, when the thermistor detects that the light source's temperature is too high, the duty cycle of the pulsed current is reduced to avoid overheating the light source. Also, if the thermistor detects that the light source's temperature is too

low, the duty cycle of the pulsed signal is increased to ensure that the light source 14 produces light having adequate luminous intensity and consistent color. Figure 8B, illustrates a schematic of one embodiment of a current modulating circuit 15 according to the present invention, wherein the thermistor is indicated as T1.

Powering the light source 14 by a thermally compensated pulsed current signal has several advantages over powering by a DC signal. Among others, a pulsed current signal reduces the amount of heat generated by the light source 14 thereby extending the life of the light source. Also, a pulsed current signal expends less energy over time thereby extending the life of the batteries. Further, a pulsed current signal allows higher peak current to be supplied to the light source thereby improving the brightness that the light source may generate. By adjusting the energy delivered to the light source according to the heat generated by the light source 14, heat damage to the light source may be prevented.

Also, although the power circuit disclosed herein makes use of a MOSFET, a pulse generator, and a thermistor, the present invention is not limited to a circuit including the combination of electronic components disclosed herein. Those skilled in the art will recognize that other circuit designs, such as a circuit that includes a microprocessor and a look-up table, may also be used to deliver a pulsed current signal or a temperature adjusted pulsed current signal to the light source.

Referring back to figure 7, the electrical connection from the current modulating circuit 15 on the circuit board 62 and the light source 14 is facilitated by the first contact 46 and the second contact 48. The first and second contacts are preferably selectively soldered onto the circuit board 62. The first and second contacts are also disposed to receive the electrodes 58, 59 of the light source 14.

The first contact 46 is configured to frictionally receive the first electrode 58 of the light source 14. In the illustrative embodiment, the first contact 46 includes a pair of flexible angled surfaces 66 to receive the first electrode 58. Other suitable methods or configurations for establishing an electrical connection between conductors may also be used. For example, the first electrode 58 may be electrically connected to the first contact 46 by soldering.

The second contact 48 is configured to frictionally receive the second electrode 59 of the light source and to electrically couple with the heat sink housing 44. In the illustrative embodiment, the second contact 48 includes a pair of flexible angled surfaces 67 and a connecting member 68 electrically connected to the angled surfaces 67. The pair of flexible angled surfaces 67 receive the second electrode 59. Other suitable methods or configurations for establishing an

electrical connection between conductors may also be used. For example, the second electrode 59 may be electrically connected to the second contact 48 by soldering.

5 The connecting member 68 of the second contact 48 electrically couples the second contact 48 to the heat sink housing 44. In the illustrative embodiment, the connecting member 68 frictionally engages with a heat sink plug 72 of the heat sink housing 44. Other suitable methods or configurations for establishing an electrical connection between conductors may also be used.

10 The first contact 46 and the second contact 48 may be made from a sheet of a conductor material that is formed to the desired configuration. To facilitate the shaping/forming of the sheet of conductor material, relief cuts in the conductor sheet may be employed. In a preferred embodiment, the first and second contacts are made from a sheet of copper alloy.

15 Still referring to figure 7, the contact plug 64 of the circuit assembly 50 is disposed on the circuit board 62 on the side opposite to where the first contact 46 and the second contact 48 are located. The contact plug 64, among other things, facilitates electrically coupling the batteries 16 to the current modulating circuit 15. In the illustrative embodiment, the contact plug 64 is selectively electrically coupled to the current modulating circuit 15. The contact plug 64 is also
20 configured to receive the upper conductive spring member 52.

The circuit assembly 50 is disposed in the heat sink housing 44. Referring to figure 9, in one embodiment, the heat sink housing 44 is generally a hollow cylinder with a closed end. The heat sink housing 44, among other things, thermally couples the light source 14 and the barrel 12, and electrically couples
25 the second electrode 59 of the light source 14 to the barrel 12. By utilizing the heat sink housing 44 and the barrel 12 to absorb and/or dissipate heat that is generated by the light source 14, the flashlight 10 more effectively protects the light source 14 from being damaged due to heat. Preferably, the heat sink housing 44 is a conductor, such as aluminum.

30 Referring to figures 7, 9, 11 and 12, the heat sink housing 44 includes the heat sink plug 72, a front face 71, a pair of openings 74, an inside shoulder 76, an outer taper 78, a front snap-in groove 82, and an aft snap-in groove 87. The two openings 74 extend through the front face 71 and are sized to provide access for the electrodes of the light source 14 to couple with the first and second contacts
35 46, 48 of the circuit assembly 50. The front snap-in groove 82 includes a shoulder 91 that is generally perpendicular to the axis of the heat sink housing 44. The front snap-in groove 82 serves to receive locking tabs 84 of the upper insulator 42. The aft snap-in groove 87 includes a shoulder 93 that is generally perpendicular to

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the axis of the heat sink housing 44. The aft snap-in groove 87 serves to receive lock tabs 79 of the lower insulator 56.

The inside shoulder 76 of the heat sink housing 44 is sized and positioned to receive the circuit assembly 50. The outer taper 78 of the heat sink housing 44 is preferably tapered at an angle substantially equal to the angle of the aft taper 27 of the barrel 12 (shown in figure 4). The outer taper 78 of the heat sink housing 44 is also sized so that once disposed in the barrel 12, the axial movement of the heat sink housing 44, and consequently, the switch assembly 40, will be limited by the aft taper 27 of the barrel 12.

Referring to figure 7, the upper spring member 52 electrically couples the contact plug 64 and the source contact 54. In the illustrative embodiment, the upper spring member 52 is a coil spring that has an inside diameter sized to fit over the contact plug 64. The aft end of the upper spring member 52 is received by the source contact 54.

The source contact 54 electrically couples the upper spring member 52 and the battery 16. In the illustrative embodiment, the source contact 54 is an open-ended receptacle with a flange 81 depending from the open end of the receptacle. In a preferred embodiment, the source contact 54 is a conductor such as, for example, copper alloy.

Referring to figures 7 and 11, the lower insulator 56, among other things, contains the circuit assembly 50, the upper conductive spring member 52, and the source contact 54 in the heat sink housing 44. The lower insulator 56 includes lock tabs 79, a back face 88, a recess 89, a through hole 83 and a counterbore shoulder 85. Figure 7 shows the source contact flange 81 lifted off the lower insulator shoulder 85. Figure 11 shows the source contact flange 81 in contact with the lower insulator shoulder 81. In a preferred embodiment, the lower insulator is a non-conductor such as, for example, plastic.

Referring to figure 11, the lower insulator 56 is secured to the heat sink housing 44 by the lock tabs 79 fitting into the aft snap-in groove 87 and being confined by the shoulder 93. The circuit assembly 50 is received in the inside shoulder 76 of the heat sink housing 44. The front end of the upper spring member 52 fits over the contact plug 64 of the circuit assembly 50. The aft end of the upper spring member 52 is received by the source contact 54. The source contact 54 is slidably disposed in the through hole 83 of the lower insulator 56. The flange 81 of the source contact 54 rests against the counterbore shoulder 85 which limits the axial displacement of the source contact 54 in the aft direction. Assembled this way, the upper spring member 52 biases the circuit assembly 50 forward against the inside shoulder 76 of the heat sink housing 44. The upper

spring member 52 also biases the source contact 54 in the aft direction against the counterbore shoulder 85 of the lower insulator 56.

Preferably, the axial length of the source contact 54 is sized so that its closed end is always forward of the back face 88 and remains within the envelope defined by the recess 89 of the lower insulator 56. In the illustrated embodiment, the recess 89 is a frustoconical cavity with the base facing the back of flashlight 10. The recess 89 is dimensioned to be deeper than the height of the battery's center electrode that extends beyond the battery casing.

Arranged this way, when the battery 16 is urged forward against the back face 88 of the lower insulator 56, the center electrode of the battery 16 engages with the source contact 54 and lifts its flange 81 off the lower insulator's counterbore shoulder 85 as shown in figure 7. Concurrently, the upper spring member 52 urges the source contact 54 in the rearward direction against the battery's center electrode to achieve a spring biased electrical connection with the battery 16. In this way, the switch subassembly 60 provides a simple configuration that enhances the electrical coupling between components even when the flashlight is jarred or dropped, which may cause the battery or batteries 16 to suddenly displace axially within the barrel 12. Further, because the upper spring member 52 may absorb impact stresses due to, for example, mishandling, the battery's center electrode and the flashlight components, for example the circuit assembly 50, are better protected.

Also, because the closed end of the source contact 54 is forward of the back face 88, if a battery or batteries 16 are inserted backwards into the barrel 12 so that their case electrodes are directed forward, no coupling with the source contact 54 is formed. When the batteries are inserted correctly, the center electrode of the forwardmost battery is urged into contact with the source contact 54 and compresses the upper spring member 52. Such an arrangement serves to immediately notify the user of improper battery installation, and may further protect the flashlight's electronics from being affected or damaged by reverse current flow. In another embodiment for protecting the flashlight's electronics from reverse current flow, a diode may be selectively arranged in an electrical circuit. Figure 8B, illustrates a schematic of one embodiment of such a circuit wherein diode D102-C prevents reverse current flow should the batteries be installed improperly.

Thus, the structure and the assembly of the switch subassembly 60 has now been described. Referring to figures 3 and 4, the switch subassembly 60 is disposed generally on the forward end of the barrel 12. Absent further assembly, the switch subassembly 60 is urged forward by the action of the conductive spring

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member 32 until the outer taper 78 of the heat sink housing 44 comes into contact with the aft taper 27 of the barrel 12.

Referring to figures 4 and 12, the upper insulator 42 attaches to the switch subassembly 60 and, among other things, limits axial movement of the switch subassembly 60 in the rearward direction beyond a predetermined distance. The upper insulator 42 attaches to the switch subassembly 60 at the front snap-in groove 82 of the heat sink housing 44.

Referring to figures 7 and 12, the upper insulator 42 includes locking tabs 84, a center clearance 92 and a taper 96. The center clearance 92 is sized to provide the light source 14 and its electrodes 58, 59 clearance to be secured onto the heat sink housing 44. The taper 96 corresponds to the front taper 26 of the barrel 12. Referring to figure 12, each of the locking tabs 84 is sized to fit into the front snap-in groove 82 and be confined by the shoulder 91 in the forward direction. Referring to figure 4, by securing the upper insulator 42 to the switch subassembly 60, which is disposed in the barrel 12, the upper insulator 42 keeps the switch subassembly 60 from falling to the rear of barrel 12, and potentially out the back end of the flashlight, in the absence of batteries 16 being installed in the flashlight 10. In a preferred embodiment, the upper insulator 42 is a nonconductor such as, for example, plastic.

Referring to figure 7, the light source 14 is thermally coupled to the heat sink housing 44 and electrically coupled to the circuit assembly 50. In the illustrative embodiment, the light source 14 includes the first electrode 58, the second electrode 59, a lamp 95, and a slug 98. The slug 98 of the light source 14 secures to the heat sink housing 44 to facilitate transfer of heat generated by the light source 14 to the heat sink housing 44. Preferably, a layer of thermally conductive adhesive is applied between the slug 98 and the heat sink housing 44. Also, because the slug 98 may not be electrically neutral, the thermally conductive adhesive is preferably an electrical insulator. The first and second electrodes 58, 59 frictionally engage with the first and second contacts 46, 48, respectively.

Referring to figure 4, the head assembly 20 is disposed on the forward end of barrel 12. The head assembly 20 includes a face cap 102, a lens 104, a reflector 106, and a sleeve 108. The reflector 106 and the lens 104 are rigidly held in place by the face cap 102 which is threadedly coupled with the sleeve 108. The sleeve 108 includes threads 112 formed on its inside diameter that engages with the forward threads 18 of the barrel 12. Arranged this way, the reflector 106 may displace in the axial direction of the flashlight 10 by rotating the head assembly 20 relative to the barrel 12.

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Reflectors have been used with portable lighting devices to redirect light and to increase the distance that the light is able to project. The reflector has a highly reflective surface that is intended to reflect the light rays from a light source and form a beam. A parabolic profiled reflector is preferred because a parabola
5 has the optical characteristic of collecting light rays emanating from its focus or focal point and reflecting them as a collimated beam, parallel to the principal axis of the parabola. By collimating the light rays, the otherwise dispersed light rays are arranged to form a light beam that can be projected an appreciable distance.

Despite the utilization of a reflector, LED lighting devices, in particular,
10 continue to be limited in the distance that the light beam is able to project. This is because an effective combination of properly configured parts is needed to effectively capture the light produced by available LED lamps that substantially radiates spherically over an angle less than 180°. Although some LED lamps claim to have a radiation pattern that is substantially greater than 180°, many LED
15 lamps have little (less than 10% of the maximum light intensity) or no light radiation beyond 180° or, referring to figure 1, little or no light radiation for $\theta > 90^\circ$.

Referring to figures 4 and 10, the reflector 106 has a first end 114, a second end 116, a profile 118, and a support 122. In the illustrative embodiment, the first end 114 is suitable for emitting a beam of light, and the second end 116 is
20 an opening that defines the end of the profile 118. In a preferred embodiment, the profile 118 is a segment of a parabola having a reflective surface that is axisymmetrical about its principal axis 121.

Referring to figure 10, the second end 116 is located such that the focal point 94 of the parabola is disposed outside the reflective surface of the profile
25 118. The profile 118 preferably conforms to a parabolic shape according to the equation $r^2 = 4fz$, wherein "r" is the radius of the parabolic profile normal to the axis 121, "f" is the focal length, or the distance from the vertex of the parabola to the focus or the focal point, and "z" is the distance along the axis 121.

In a preferred embodiment, dimension "f" is less than .080 inch, 0.020 -
30 0.050 inch, or 0.035 inch. Also, in a preferred embodiment, the distance between the vertex and the second end 116 (see "s" shown in figure 10) is 0.080 - 0.130 inch, 0.109-0.115 inch, or 0.112 inch; the first open end 114 has a diameter of 0.7-0.8 inch or 0.741-0.743 inch; and the second open end 116 has a diameter of 0.2-0.3 inch or 0.247-0.253 inch. Further in the preferred embodiment, the ratio
35 between the distance of the second end from the vertex and dimension "f" is greater than 1.5:1, less than 6.5:1, between the range of 1.5:1 to 6.5:1, 3.0:1 to 3.4:1, or 3.2:1. Moreover, in the preferred embodiment, the ratio between the

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distance of the first end from the vertex and dimension "f" is greater than 20:1, less than 40:1, between the range of 25:1 to 30:1, or 28:1.

The illustrative reflector 106, among other things, more effectively collects light rays that radiate in a generally conical form or that has brightness intensity that is generally centrally concentrated such as that produced by a conventional LED lamp. By defining the focal length and configuring the reflector as described herein, a narrower or a deeper parabolic profile is achieved that facilitates capturing more light radiating from the light source. A parabolic profile collimates light most effectively, when the light radiates from a theoretical point positioned at the focus. The deeper parabolic profile also serves to make the light source appear more like a point to the reflective surface. The disclosed reflector facilitates collecting and reflecting light rays that do not substantially radiate uniformly spherically. In these ways, the reflector 106 advantageously produces an improved and collimated light beam that projects for distance.

The illustrative flashlight 10 described above is also one embodiment for axially moving the light source 14 relative to the reflector 106. By rotating the head assembly 20 relative to the barrel 12, the head assembly 20 travels along the forward threads 18 of the barrel 12 and causes the reflector 106 to axially displace relative to the light source 14. By varying the axial position of the light source 14 with respect to the reflector, the flashlight 10 advantageously varies the dispersion of light produced by the light source. In this way, the flashlight 10 can produce spot lighting, i.e., a collimated light beam, as well as flood lighting, i.e., a wide dispersion of light. Although the embodiment described above uses mating threads to effectuate relative axial displacement between the reflector and the light source, other suitable means, such as for example, a cam or guide may be utilized.

In a preferred implementation of the illustrative embodiment, the tail cap 28, the barrel 12, the face cap 102 and the sleeve 108, generally forming the external surfaces of the flashlight 10 are manufactured from aircraft quality, heat treated aluminum, which may be selectively anodized. The non-conductive components are preferably made from polyester plastic or other suitable material for insulation and heat resistance. The reflective profile 118 of the reflector 106 is preferably a segment of a computer-generated parabola that is metallized to ensure high precision optics. Optionally, the reflective profile 118 may include an electroformed nickel substrate for heat resistance.

Although the embodiment disclosed herein illustrates a substantially planar lens 104, the flashlight 10 may instead be combined with lens that include curved surfaces to further improve the optical performance of the flashlight 10. For

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example, the lens may include a biconvex profile or a plano-convex profile in the whole or part of the lens surface.

A sealing element, such as an O-ring 75, may also be incorporated at the interface between the face cap 102 and the lens 104, the face cap 102 and the sleeve 108, and the sleeve 108 and the barrel 12 to provide a watertight seal.

The electrical circuit of flashlight 10 will now be described. Referring to figures 3, 4, 5 and 7, the electrical circuit of flashlight 10 is shown in the open or OFF position. The electrical circuit closes, or is in the ON position, when the head assembly 20 is rotated to sufficiently translate the switch assembly 40 in the forward direction so that the outer taper 78 of the heat sink housing 44 electrically couples with the aft taper 27 of the barrel 12. Once the circuit is closed, electrical energy is conducted from the rear battery through its center contact which is in connection with the case electrode of the battery disposed forward thereof. Electrical energy is then conducted from the forwardmost battery to the source contact 54 of the circuit assembly 50. The electrical energy then selectively conducts through the electronics of the circuit assembly 50 and the to the first electrode 58 of the light source 14. After passing through the light source 14, the electrical energy emerges through the second electrode 59 which is coupled to the second contact 48 of the circuit assembly 50. The second contact 48 is electrically coupled to the heat sink housing 44, which is electrically coupled to the barrel's aft taper 27. The barrel 12 is coupled to the tail cap contact 38, which is in electrical contact with the conductive spring member 32. Finally, the conductive spring member 32 of the tail cap assembly 30 completes the circuit by electrically coupling with the case electrode of the rearmost battery. In this manner, an electrical circuit is formed to provide electrical energy to illuminate the light source.

Referring to figure 4, to open the electrical circuit of flashlight 10, the user rotates the head assembly 20 to translate the switch assembly 40 in the aft direction until the outer taper 78 of the heat sink housing 44 separates from the aft taper 27 of the barrel 12.

Although a rotating type switch that opens and closes the electrical circuit at the barrel/heat sink housing taper interface has been described, the electrical circuit may be closed or opened at other locations. Moreover, although a rotating type switch has been described, the various aspects of the invention as described herein is not limited by the type of switching scheme employed. Other suitable switch device, such as a push-button switch or an electronic switch may be employed.

Turning to figures 13 and 14, flashlight 200 is an alternate embodiment of the present invention. Flashlight 200 includes several components that are

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functionally equivalent to the components described above for flashlight 10. Flashlight 200 includes a head assembly 220, a barrel 212 and a tail cap assembly 230. The head assembly 220 includes a head 202, a lens 204 and a reflector 206. The tail cap assembly 230 includes a tail cap 208, and a spring member 214. The head assembly 220 and tail cap assembly 230 are each threadably engaged to the barrel 212.

Referring to figure 15, the reflector 206 includes a flexible tab 216, and the head 202 includes a locking groove 217. The reflector 206 is secured to the head 202 by inserting the flexible tab 216 into the locking groove 217 with the lens 204 interposed between the reflector 206 and a front flange of the head 202. The flashlight 200 also includes a switch assembly 240 that includes an upper insulator 242 and a switch subassembly 260. The switch subassembly 260 includes a heat sink housing 244, a circuit assembly 250, an upper conductive spring member 252, a source contact 254, and a lower insulator 256. The switch assembly 240 is assembled employing snap-fit features as described above. The switch assembly 240 is disposed on the forward end of the barrel 212. The light source 211 is received by the heat sink housing 244 and thermally coupled thereto and to the barrel 212. The electrodes of the light source 211 are selectively electrically coupled to the circuit assembly 250.

Referring to figure 14, the flashlight 200 also includes an energy source assembly 210 for illuminating the light source 211. In a preferred embodiment, the energy source assembly 210 holds a plurality of energy sources in a side-by-side arrangement. Referring to figures 16A and 16B, the energy source assembly 210 includes a housing 219, conductors 227, a forward contact 221, radial contacts 223 and sources of energy, such as for example batteries 225. The housing 219 includes receptacles 229 to receive the batteries 225. The conductors 227 are selectively disposed in the housing 219 to electrically couple the batteries 225 in either a series or parallel circuit arrangement. In the preferred embodiment, the batteries 225 are electrically coupled in a series circuit arrangement. The terminals of the series circuit are coupled to the forward contact 221 and the radial contacts 223.

Referring to figures 14, 16A and 16B, the energy source assembly 210 is sized to be disposed in the barrel 212. The forward contact 221 couples with the source contact 254. The radial contacts 223 are disposed about the outer feature of the housing 219 and extend radially outward therefrom. Configured this way, when the energy source assembly 210 is installed in the barrel 212, the radial contacts 223 engage and electrically couple with the barrel 212. Although the illustrative embodiment includes three radial contacts 223, the present invention is

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not limited by the number of radial contacts. For example, the energy source assembly 210 may include a single radial contact. Also, although the radial contacts 223 are illustrated disposed generally in the aft end of the energy source assembly 210, the radial contacts 223 may be disposed at other locations for establishing an electrical connection between the batteries 225 and the barrel 212.

Because the energy source assembly 210 directly couples the batteries 225 to the barrel 212, the tail cap assembly 230 is not used to conduct electricity. Accordingly, if desired, the tail cap assembly 230, including the tail cap 228 and the spring member 214 may be fabricated from a non-conductor or a poor conductor.

Referring to figures 14 and 15, the electrical circuit of flashlight 200 is opened and closed by rotating the head assembly 220. The electrical circuit is closed when the switch assembly 240 is translated and the heat sink housing 244 is caused to electrically couple with a taper 227 of the barrel 212. Once the circuit is closed, electrical energy is conducted from the energy source assembly 210 to the source contact 254 and to the circuit assembly 250. Electrical energy then flows through the light source 211, the heat sink housing 244 and to the barrel 212. The barrel is electrically coupled to the radial contact 223 of the energy source assembly 210 to complete the circuit. In this manner, an electrical circuit is formed to provide electrical energy to illuminate the light source 211.

To open the electrical circuit of flashlight 200, the user rotates the head assembly 220 to translate the switch assembly 240 in the aft direction until the heat sink housing 244 separates from the taper 227 of the barrel 212.

Thus, a novel portable light emitting combination and device has been shown and described. While preferred embodiments of the herein invention have been described, numerous modifications, alterations, alternate embodiments, and alternate materials may be contemplated by those skilled in the art and may be utilized in accomplishing the various aspects of the present invention. It is envisioned that all such alternate embodiments are considered to be within the scope of the present invention as described by the appended claims.

Claims:

1. A lighting device comprising:
a source of energy;
a light source coupled to said source of energy;
5 a reflector that reflects light including a first open end, a second end, and a parabolic profile extending between said first open end and said second end, wherein the focus of said parabolic profile is located outside said parabolic profile;
a holder that holds said light source relative to said reflector such that light generated by said light source is reflected by said reflector.
- 10 2. A lighting device of claim 1, wherein the relative position of said light source and said reflector is variable.
3. A lighting device of claim 1, wherein said first open end is larger than said second end, wherein the ratio between the distance of the second end from the vertex of said parabolic profile and the distance of the focus from the vertex of
15 said parabolic profile is greater than 1.5:1.
4. A lighting device of claim 1, wherein said first open end is larger than said second end, wherein the ratio between the distance of the second end from the vertex of said parabolic profile and the distance of the focus from the vertex of said parabolic profile is less than 6.5:1.
- 20 5. A lighting device of claim 1, wherein said first open end is larger than said second end, wherein the ratio between the distance of the second end from the vertex of said parabolic profile and the distance of the focus from the vertex of said parabolic profile is between 3.0:1 and 3.4:1.
6. A lighting device of claim 1, wherein said first open end is larger than
25 said second end, wherein the ratio between the distance of the second end from the vertex of said parabolic profile and the distance of the focus from the vertex of said parabolic profile is 3.2:1.
7. A lighting device of claim 1, wherein said parabolic profile substantially conforms to a profile according to the equation $r^2 = 4fz$, wherein "r" is
30 the radius of the parabolic profile normal to the axis of the reflector, "f" is the

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distance between the focus and the vertex of said parabolic profile set at 0.035 inch, and "z" is the distance in the reflector axis direction.

8. A lighting device of claim 1, wherein said light source is an LED lamp.

5 9. A lighting device of claim 8, wherein said LED lamp substantially radiates light at an angle of less than 180°.

10 10. A lighting device of claim 1 further including a head assembly coupled to a main housing, wherein said reflector is mounted to said head assembly, wherein said main housing contains said source of energy, and wherein rotating said head assembly relative to said main housing opens or closes an electrical path between said source of energy and said light source.

15 11. A lighting device of claim 1 further including a main housing and an electrical circuit, wherein said electrical circuit includes a heat sink housing, wherein said heat sink housing receives said light source and thermally couples said light source to said main housing.

12. A lighting device of claim 11, wherein said heat sink housing electrically couples said light source to said main housing.

20 13. A lighting device of claim 1 further including a current modulating circuit coupled to said source of energy, wherein said current modulating circuit delivers a pulsed current to said light source.

14. A lighting device of claim 13, wherein said current modulating circuit includes a pulse generator, a power switch and a temperature responsive resistor, wherein said current modulating circuit delivers a thermally compensated pulsed current to said light source.

25 15. A lighting device of claim 1 further including a current modulating circuit coupled to said source of energy, wherein said current modulating circuit delivers a thermally compensated current to said light source.

16. A lighting device of claim 1 further including means for delivering a thermally compensated pulsed current signal to said light source.

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17. A lighting device of claim 1 further including a tail cap, a main housing and an energy source assembly, wherein said tail cap attaches to said main housing, wherein said main housing receives said energy source assembly, wherein said energy source assembly receives said source of energy and electrically couples said source of energy to said main housing without conducting electricity through said tail cap.

18. A flashlight comprising:
a portable source of energy;
an LED lamp that substantially radiates light spherically over an angle less than 180° coupled to the portable source of energy; and
a parabolic reflector that reflects light radiated by said LED lamp, said reflector including a first open end, a second open end and an axis extending between said ends, wherein the focus of said parabolic reflector is not located between said first open end and said second open end, wherein the focal length is between .020-.050 inch.

19. A flashlight of claim 18, wherein said reflector is movable in a direction parallel to the principal axis of said parabolic reflector.

20. A flashlight comprising:
a portable source of power;
a light source coupled to said portable source of power including an LED and a lens, wherein said lens is arranged over the LED such that light substantially radiates from said light source at an angle less than 180° relative to the LED position; and
a movable parabola shaped reflector for reflecting light radiating from said light source including a first open end, a second open end, and a parabolic profile extending between the first open end and the second open end, wherein the focus of the parabola is located outside the parabolic profile.

21. A flashlight of claim 20, wherein the reflector is movable in a direction parallel to the principal axis of the parabola.

22. A flashlight of claim 20 further including a heat sink thermally coupled to said light source.

23. A flashlight comprising:

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a source of energy;

a light source coupled to said source of energy;

a reflector for reflecting light from said light source including a first open end, a second open end, and a parabolic profile extending between said first open end and said second open end, said first open end adapted to emit a light beam, wherein the focus of said parabolic profile is not located between the first open end and the second open end; and

a current modulating circuit coupled to said light source, wherein said current modulating circuit delivers a pulsed current to said light source.

10 24. A flashlight of claim 23, wherein said current modulating circuit includes pulse generator and a power switch.

25. A flashlight of claim 24, wherein said pulse generator includes a comparator.

26. A flashlight of claim 24, wherein said power switch is a transistor.

15 27. A flashlight of claim 23, wherein said current modulating circuit modulates said pulsed current according to heat generated by said light source.

28. A flashlight of claim 23, wherein said current modulating circuit adjusts the duty cycle of said pulsed signal depending on the temperature of said light source.

20 29. A flashlight of claim 23, wherein said current modulating circuit includes a temperature responsive resistor that detects the heat generated by said light source.

30. A flashlight of claim 29, wherein said temperature responsive resistor is a thermistor.

25 31. A flashlight comprising:
a portable source of energy;
an LED lamp that substantially radiates light spherically over an angle less than 180° coupled to said portable source of energy; and
a reflector that reflects light radiated by said LED lamp including a first
30 open end, a second open end, and a parabolic profile extending between said first

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open end and said second open end, said parabolic profile conforming to a profile according to the equation $r^2 = 4fz$, wherein "r" is the radius of the parabolic profile normal to the axis of the reflector, "f" is the distance between the focal point and the vertex of said parabolic profile set at between 0.020-0.050 inch, and "z" is the distance in the reflector axis direction;

wherein said first open end has a diameter larger than said second open end, wherein said second open end has a diameter between 0.20-0.30 inch.

32. A lighting device of claim 31, wherein said first open end is larger than said second end, wherein the ratio between the distance of the second end from the vertex of said parabolic profile and the distance of the focus from the vertex of said parabolic profile is greater than 1.5:1.

33. A flashlight of claim 31, wherein said first end has a diameter of 0.70-0.80 inch.

34. A flashlight comprising:
a portable source of energy;
an LED lamp including a first lead and a second lead; and
an electrical circuit including a heat sink housing that electrically couples said first lead and said portable source of energy, wherein said heat sink housing is thermally coupled to said LED lamp to substantially dissipate heat generated therefrom.

35. A flashlight of claim 34 further including a main housing adapted to contain said portable source of energy, wherein said heat sink housing is thermally coupled to said main housing.

36. An energy source assembly comprising:
a plurality of energy sources; and
a housing adapted to receive said plurality of energy sources, said housing including a plurality of conductors, a first electrode, a second electrode and an outer feature;

wherein said plurality of conductors are selectively disposed to electrically couple said plurality of energy sources in an electrical circuit arrangement, wherein said electrical circuit arrangement includes a first terminal and a second terminal, wherein said first terminal is coupled to said first electrode, wherein said

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second terminal is coupled to said second electrode, and wherein said second electrode is disposed about the outer feature of said housing.

37. An energy source assembly of claim 36, wherein said housing includes receptacles arranged to hold said plurality of energy sources in a side-by-side arrangement.

38. An energy source assembly of claim 37, wherein said plurality of energy sources is a plurality of batteries.

39. An energy source assembly of claim 36, wherein said electrical circuit arrangement is a series circuit.

40. An energy source assembly of claim 36, wherein said electrical circuit arrangement is a parallel circuit.

41. An energy source assembly of claim 36, wherein said plurality of energy sources is a plurality of batteries.

42. A lighting device comprising:
an energy source assembly including a plurality of energy sources and a housing, said housing adapted to receive said plurality of energy sources, said housing having a plurality of conductors, a first electrode, a second electrode and an outer feature, wherein said plurality of conductors are selectively disposed to electrically couple said plurality of energy sources in an electrical circuit arrangement, wherein said electrical circuit arrangement includes a first terminal and a second terminal, wherein said first terminal is coupled to said first electrode, wherein said second terminal is coupled to said second electrode, and wherein said second electrode is disposed about the outer feature of said housing;
a light source coupled to said plurality of energy sources; and
a barrel configured to receive said energy source assembly, wherein said barrel is suitable to conduct electricity;
wherein said second electrode of said energy source assembly electrically contacts said barrel.

43. A lighting device of claim 42, wherein said barrel includes an inner feature that generally corresponds to said outer feature of said energy source

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assembly, wherein said second electrode of said energy source assembly frictionally engages to said inner feature.

5 44. A lighting device of claim 42 further including a reflector that reflects light generated by said light source, said reflector having a first open end, a second end, and a parabolic profile extending between said first open end and said second end, wherein the focal point of said parabolic profile is located outside said parabolic profile.

10 45. A lighting device of claim 42, wherein said housing of said energy source assembly includes receptacles arranged to hold said plurality of energy sources in a side-by-side arrangement.

46. A lighting device of claim 42, wherein said electrical circuit arrangement of said energy source assembly is a series circuit.

47. A lighting device of claim 42, wherein said electrical circuit arrangement of said energy source assembly is a parallel circuit.

15 48. A lighting device of claim 42, wherein said plurality of energy sources is a plurality of batteries.

49. A lighting device comprising:
a source of energy;
a light source coupled to said source of energy;
20 a temperature responsive resistor disposed to detect the temperature of said light source;
a current modulating circuit coupled to said temperature responsive resistor, wherein said current modulating circuit delivers a thermally compensated pulsed current to said light source.

25 50. A lighting device of claim 49, wherein the pulsed current is thermally compensated by adjusting the duty cycle of the pulsed current based on the temperature of said light source detected by said temperature responsive resistor.

51. A lighting device of claim 50, wherein the duty cycle of the pulsed current reduces if the temperature of said light source increases.

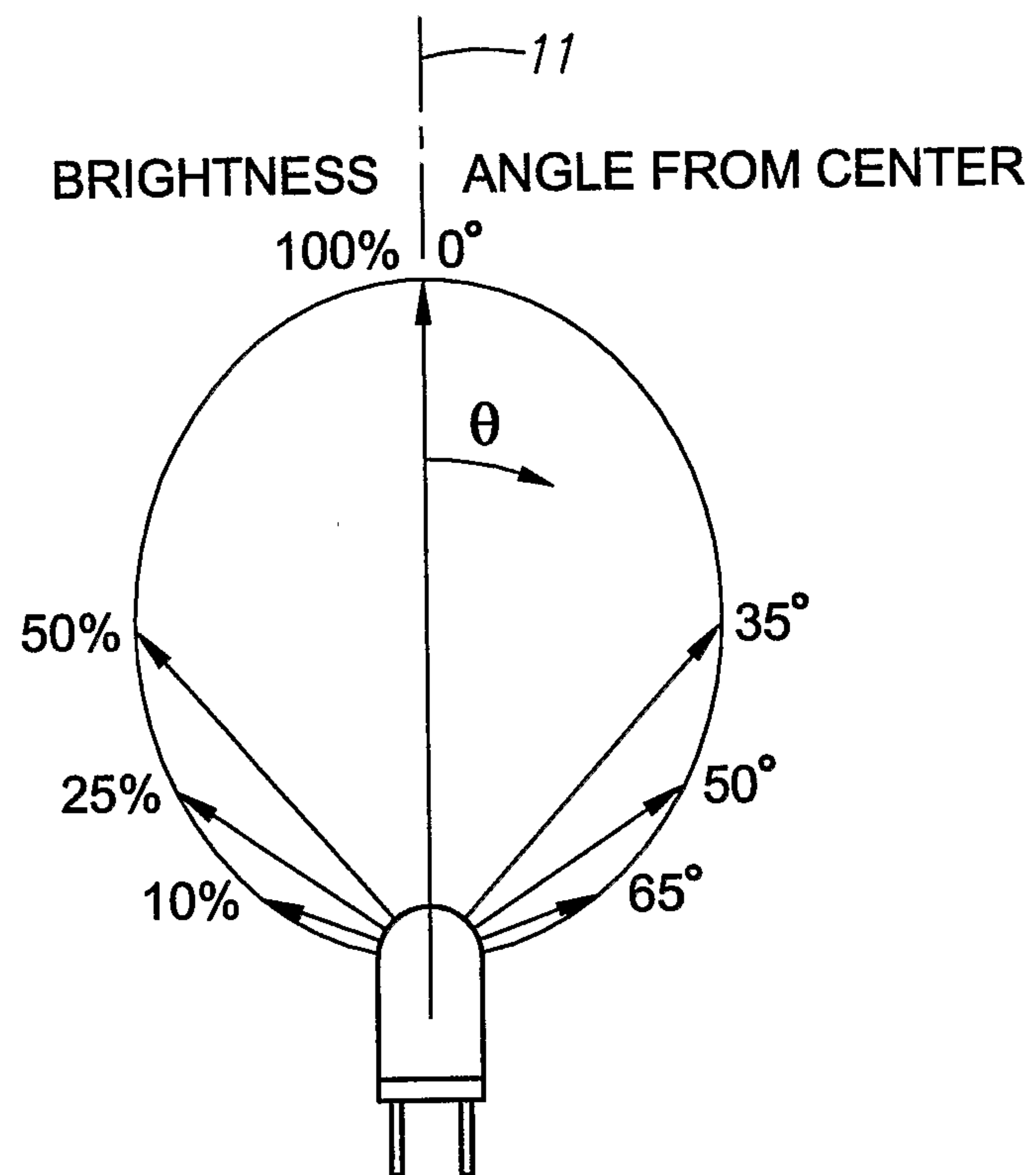
25

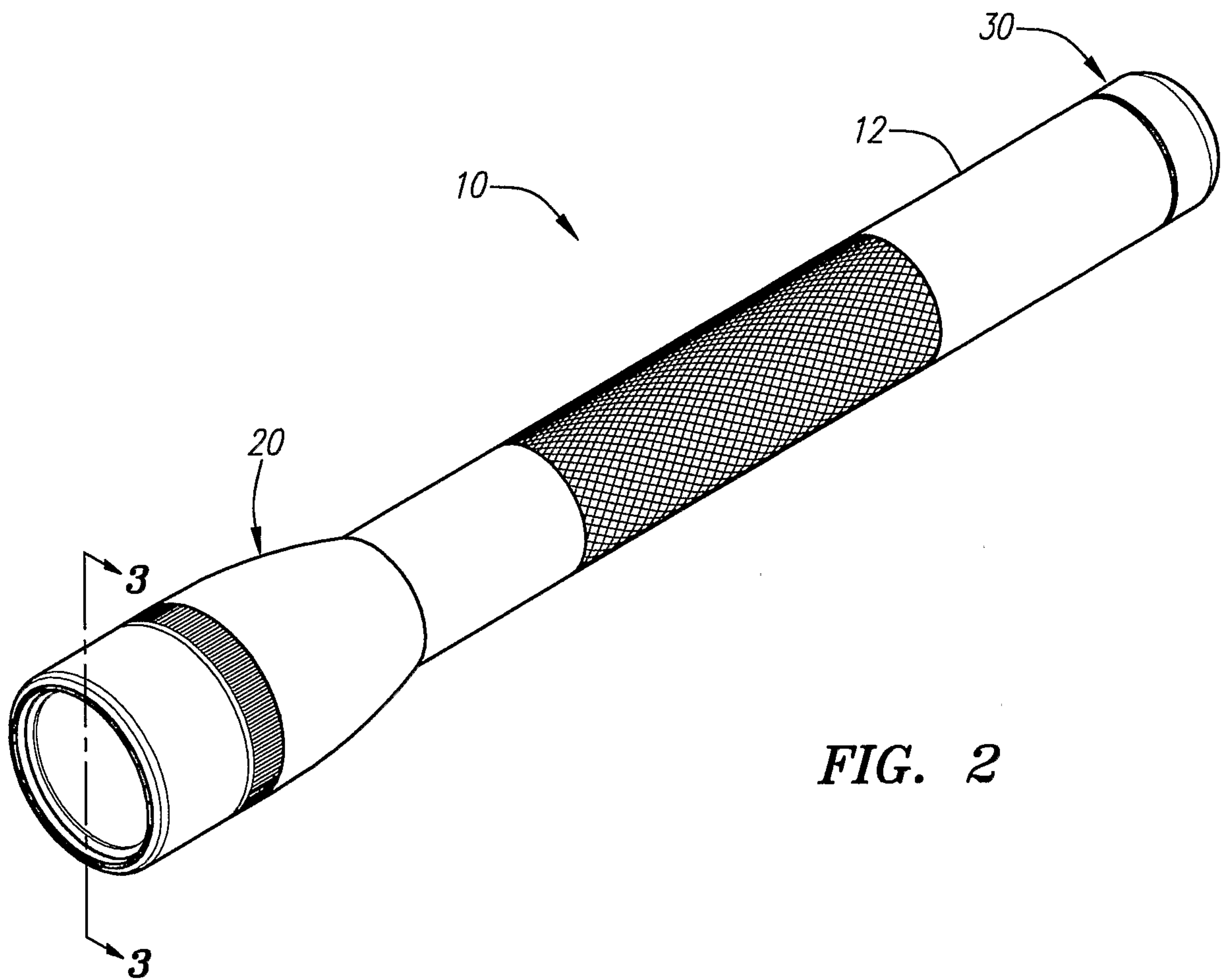
52. A lighting device of claim 50, wherein the duty cycle of the pulsed current increases if the temperature of the light source decreases.

53. A lighting device of claim 50, wherein said light source is an LED.

54. A lighting device of claim 49, wherein said temperature responsive
5 resistor is a thermistor.

55. A lighting device of claim 49 further including a diode electrically coupled to said current modulating circuit, wherein said diode prevents current flow should said source of energy be reversely installed.

*FIG. 1*

**FIG. 2**

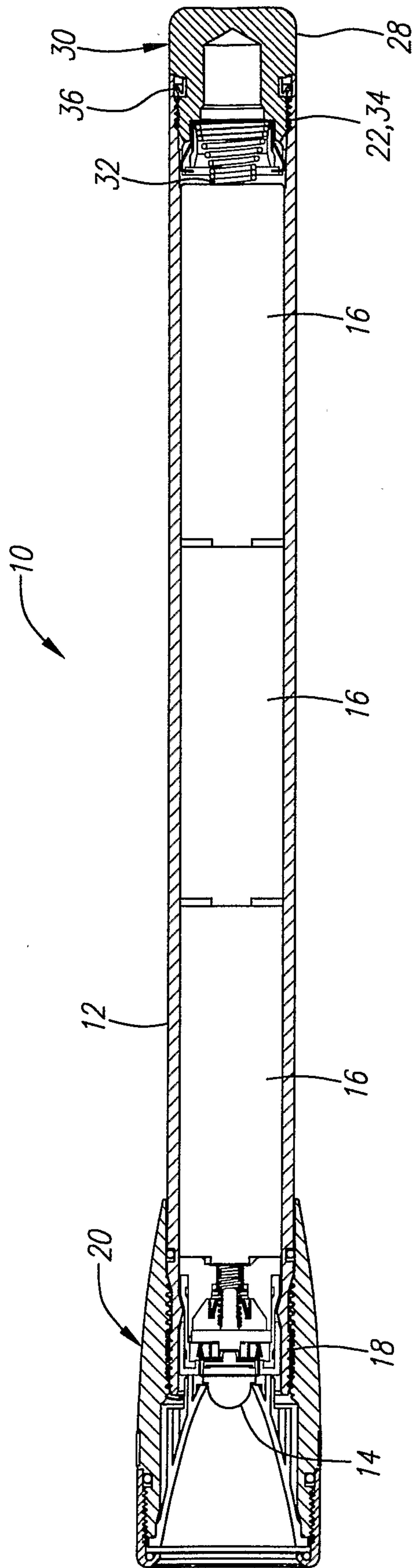


FIG. 3

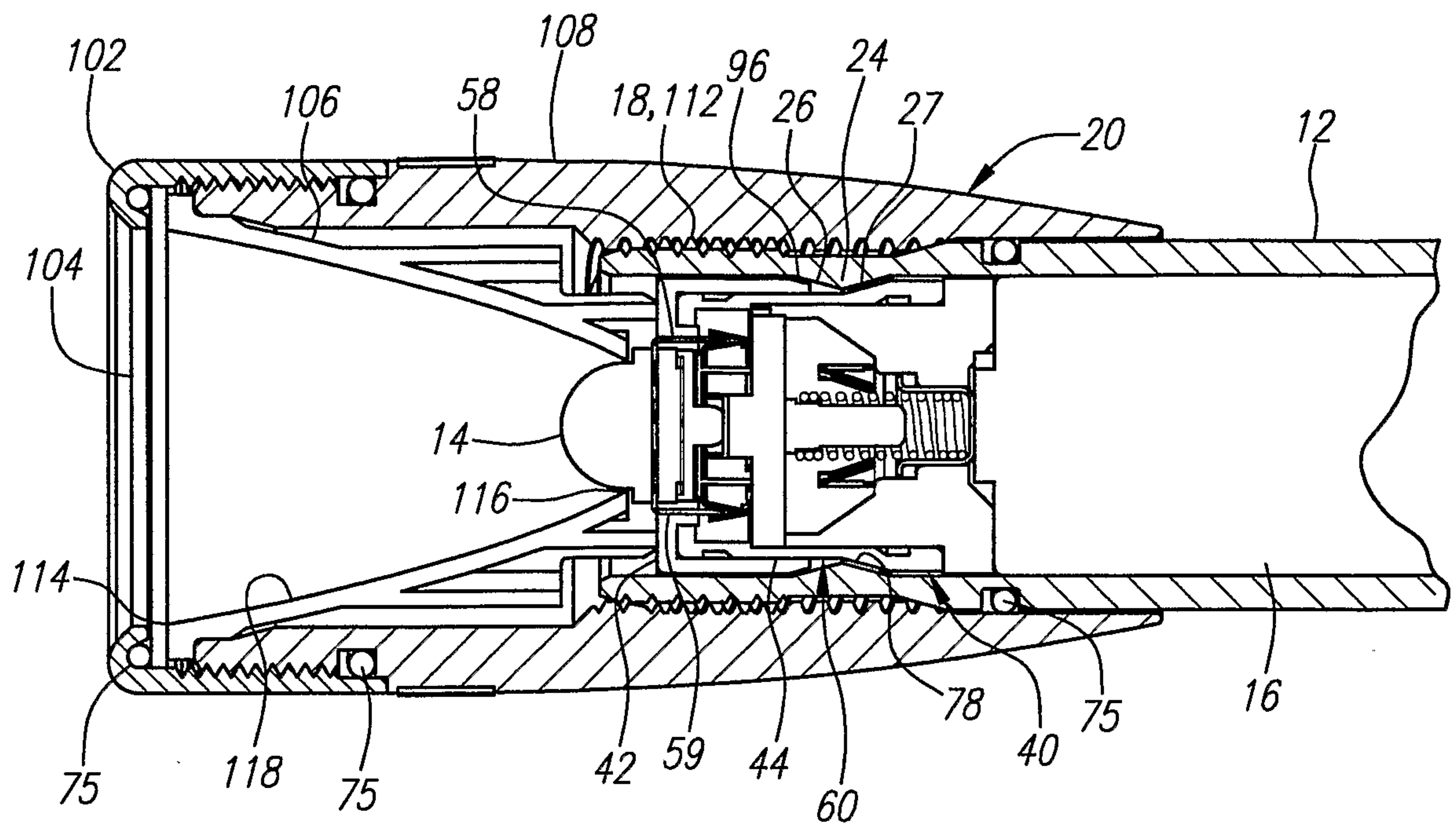


FIG. 4

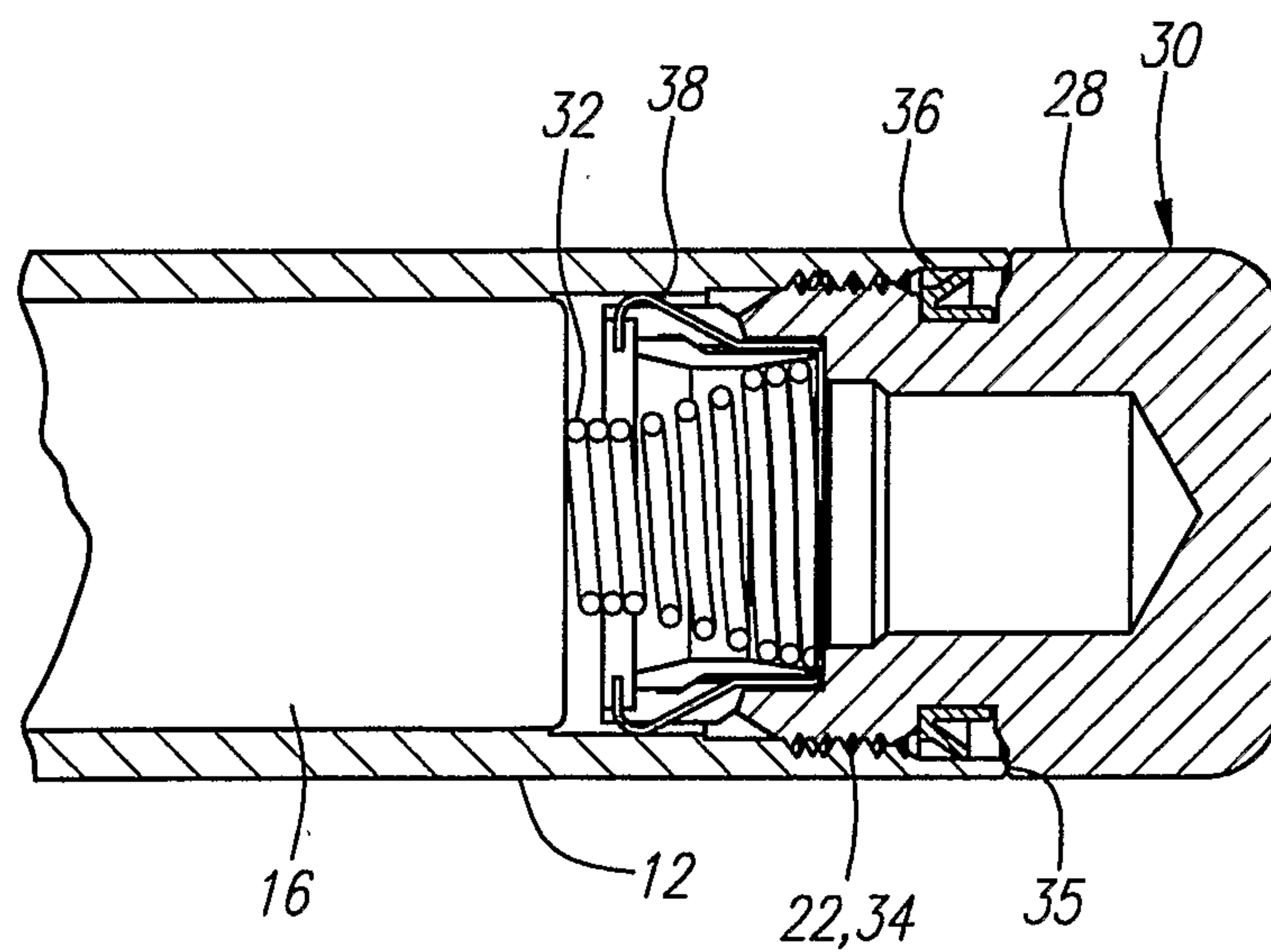
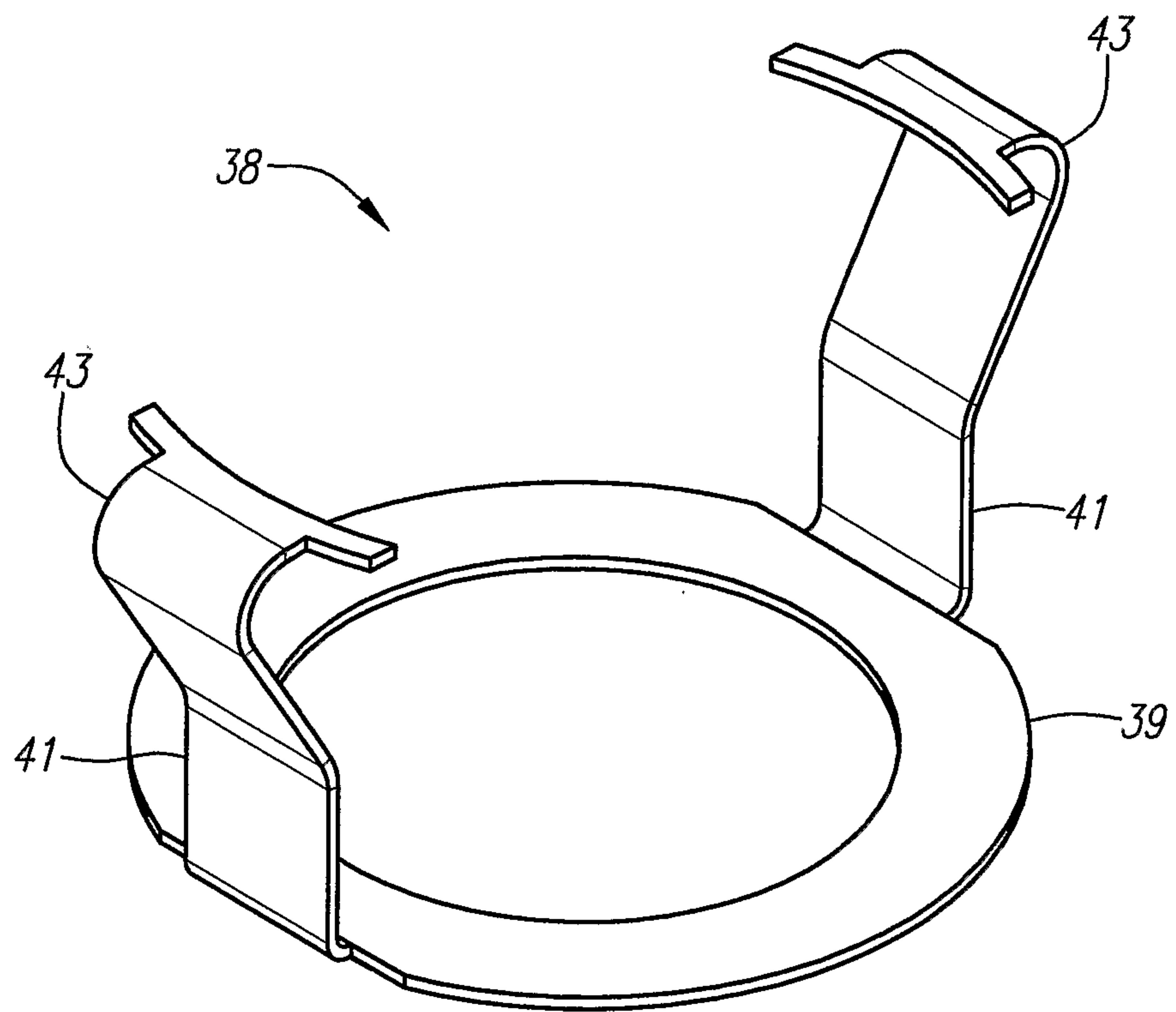


FIG. 5

*FIG. 6*

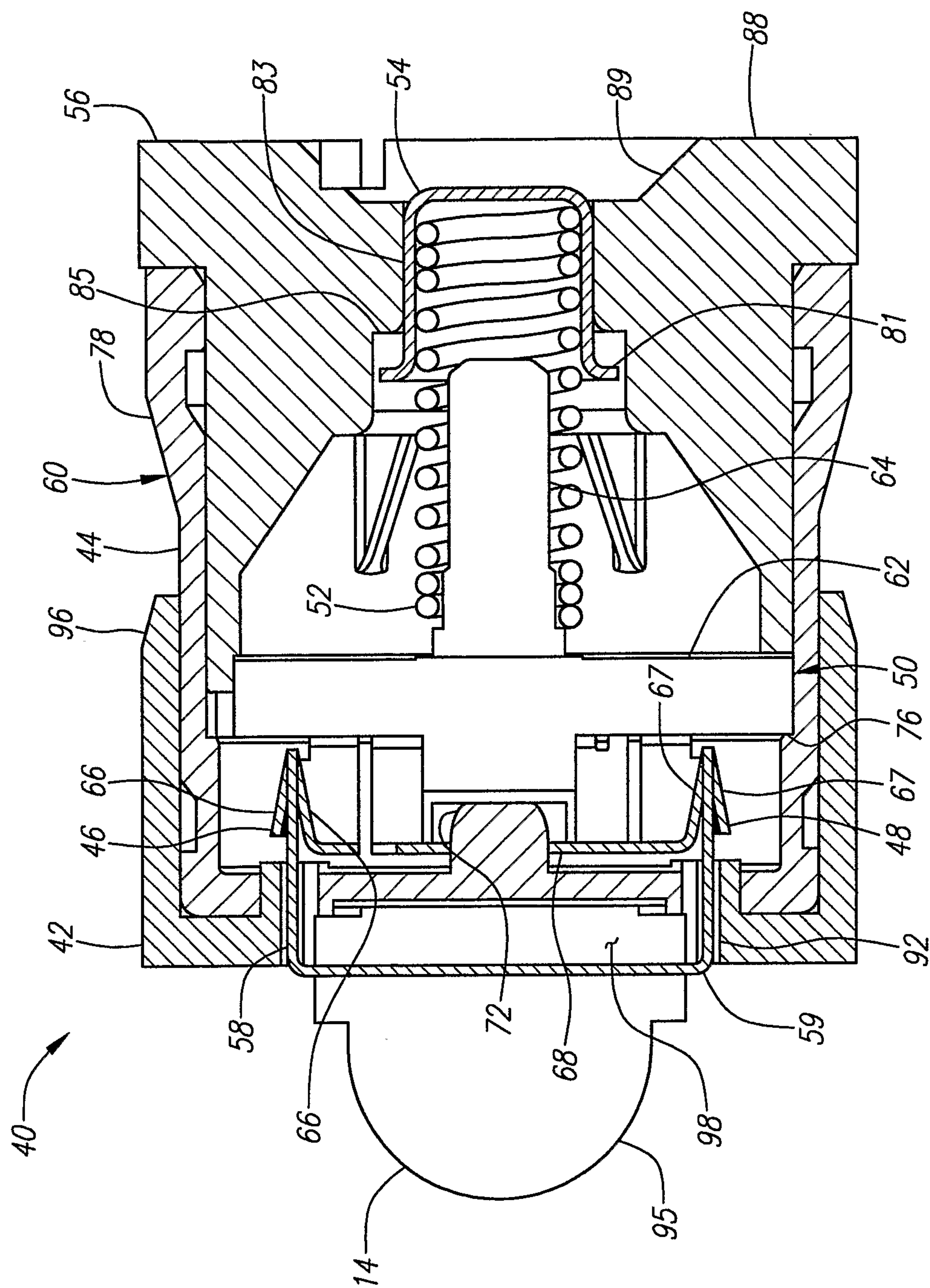
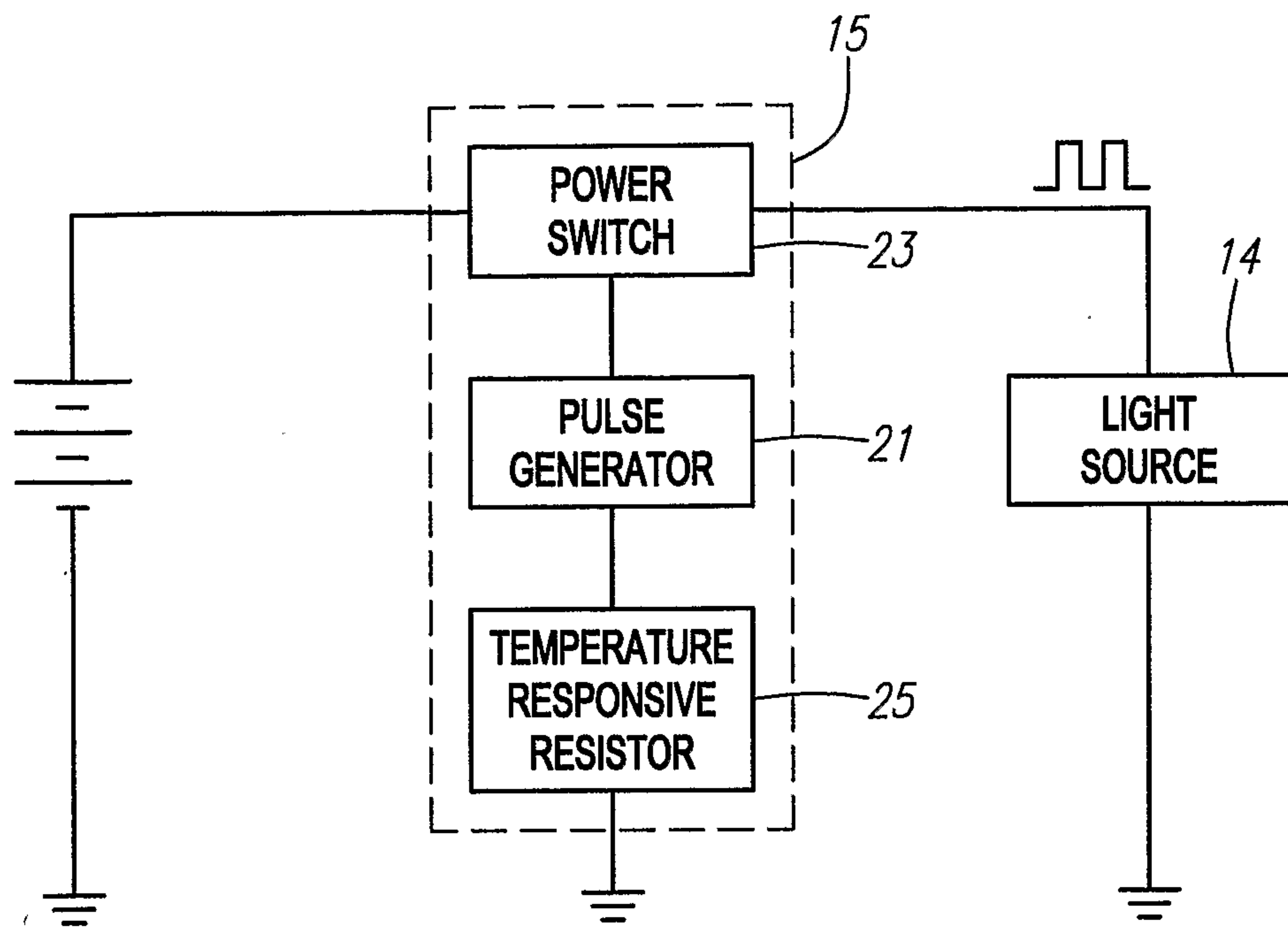


FIG. 7

*FIG. 8A*

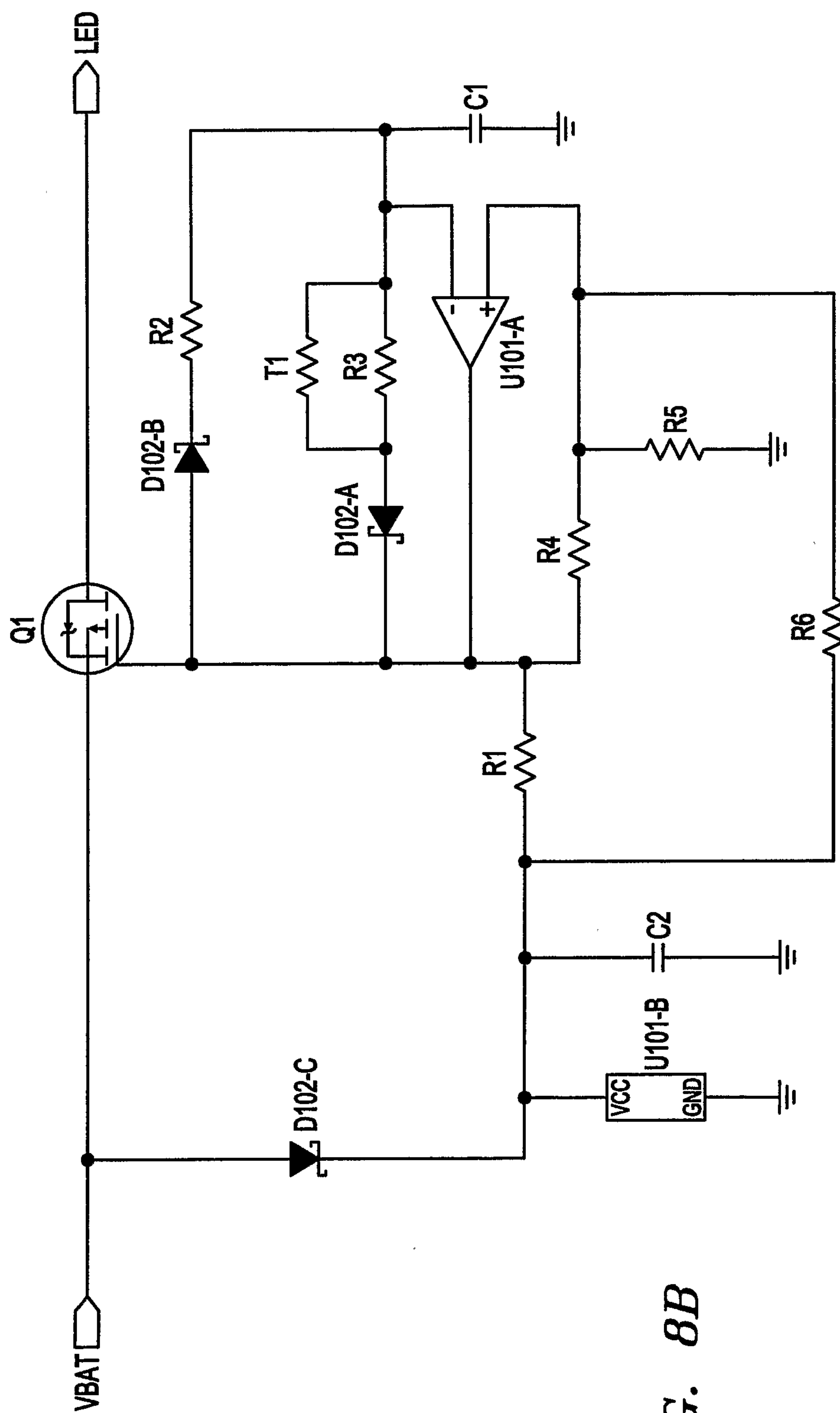
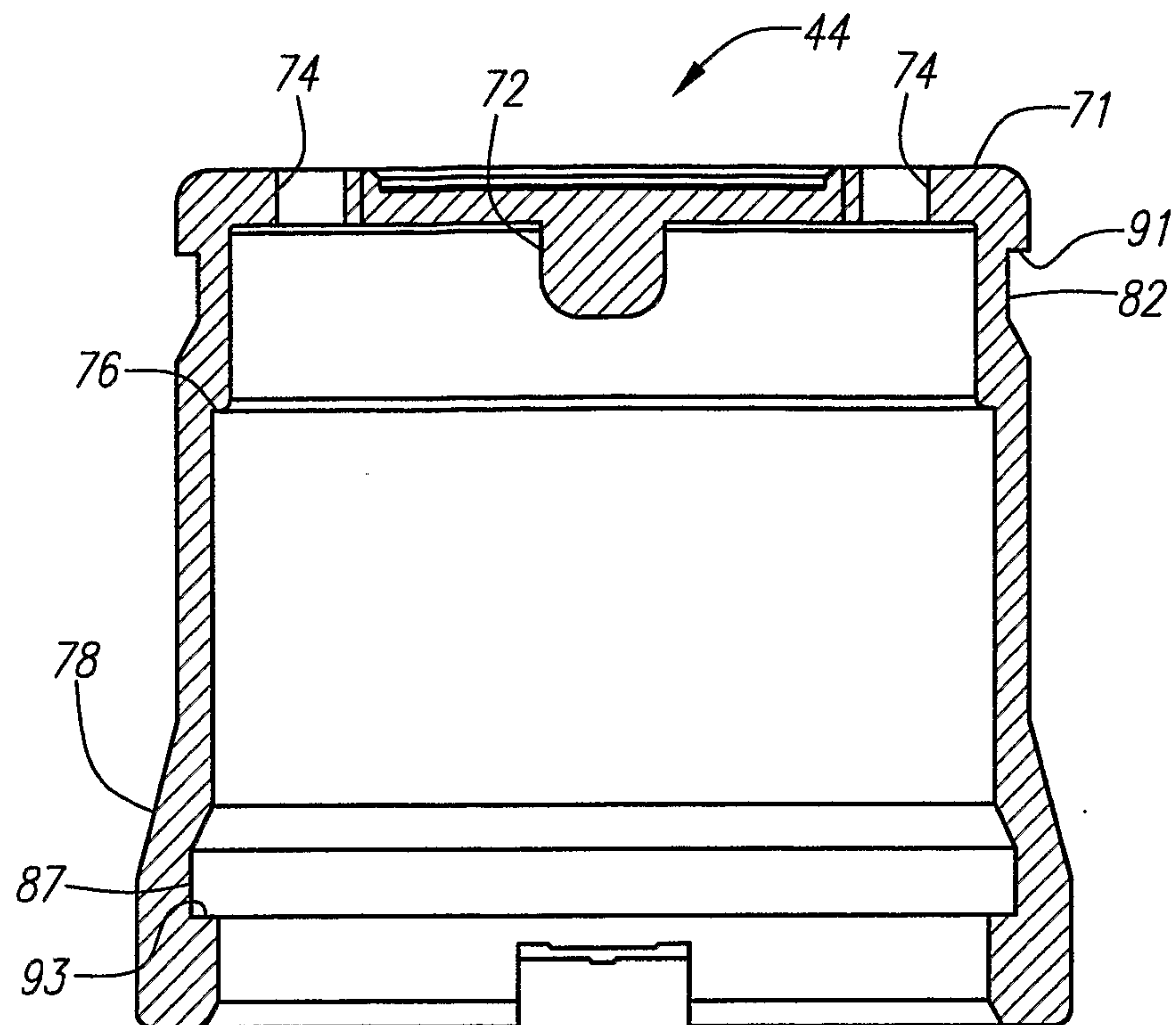
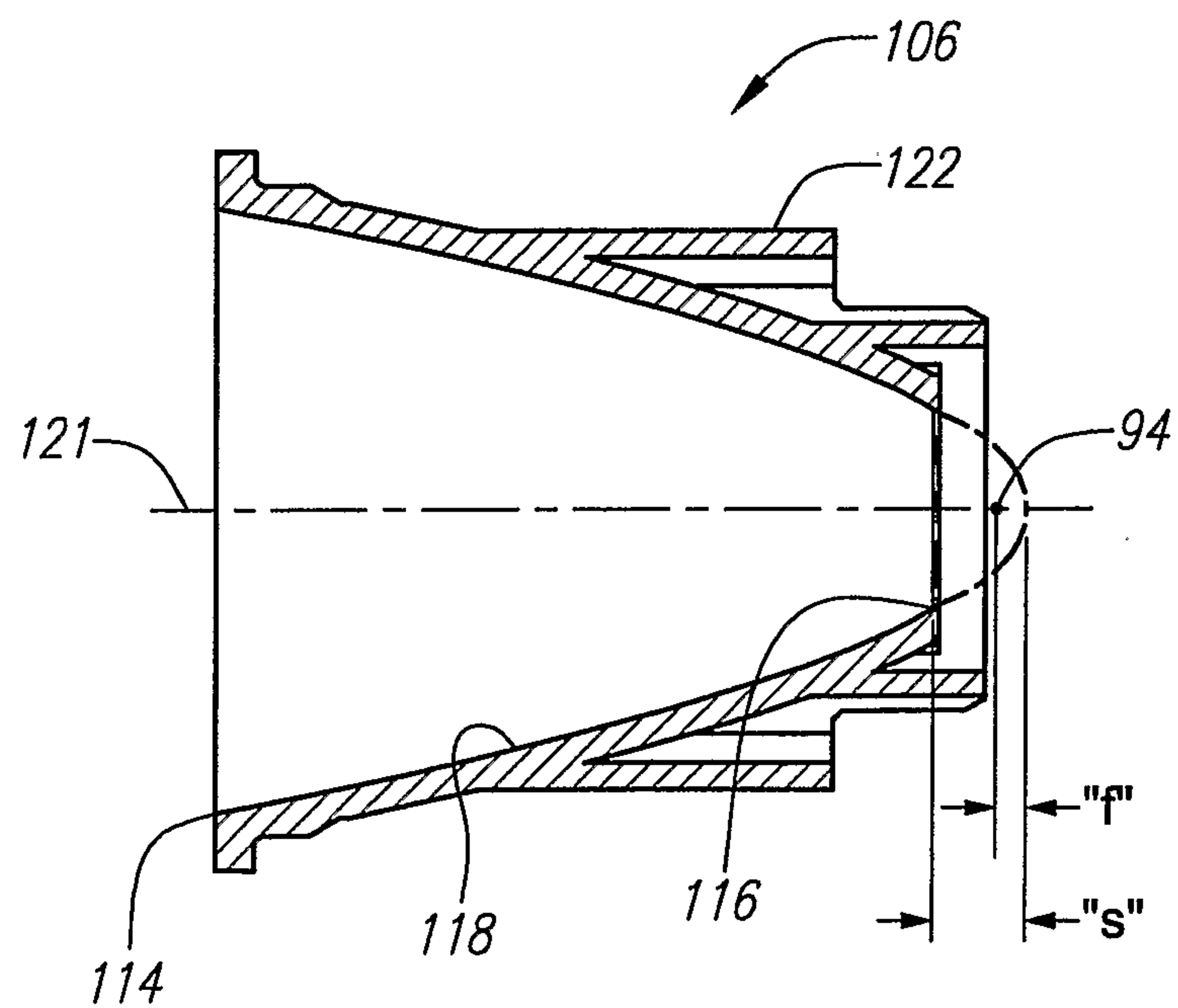
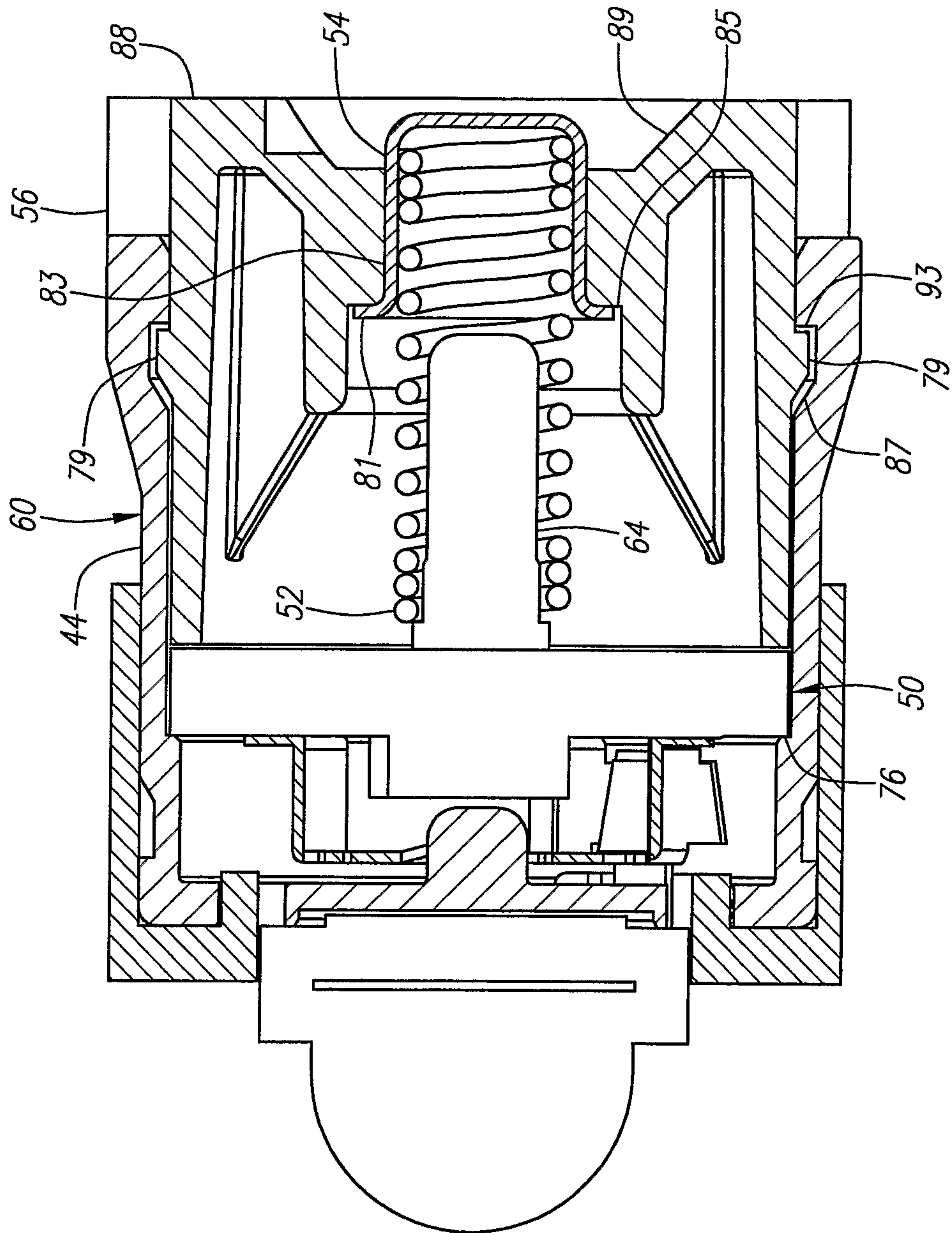


FIG. 8B

**FIG. 9****FIG. 10**

**FIG. 11**

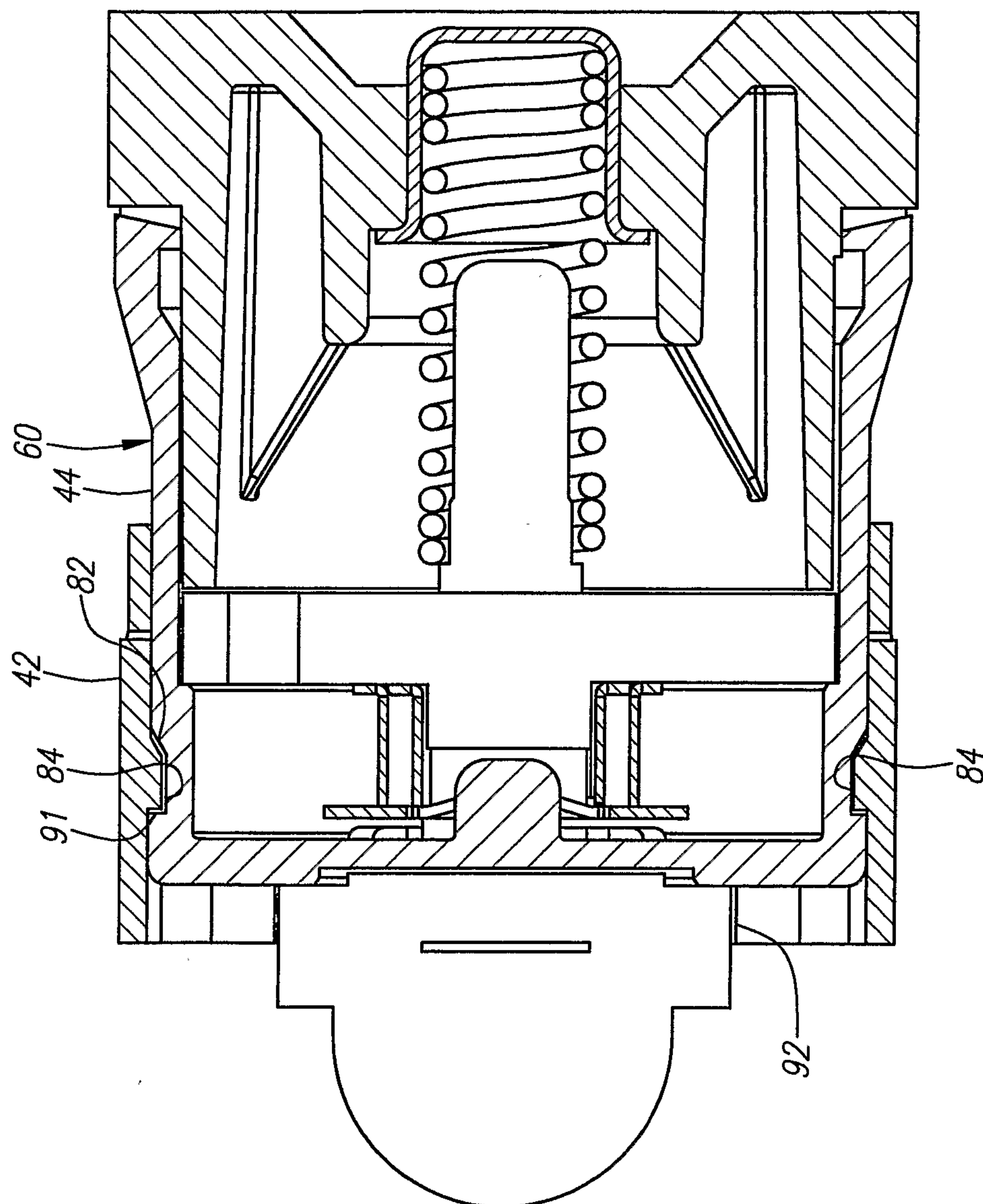


FIG. 12

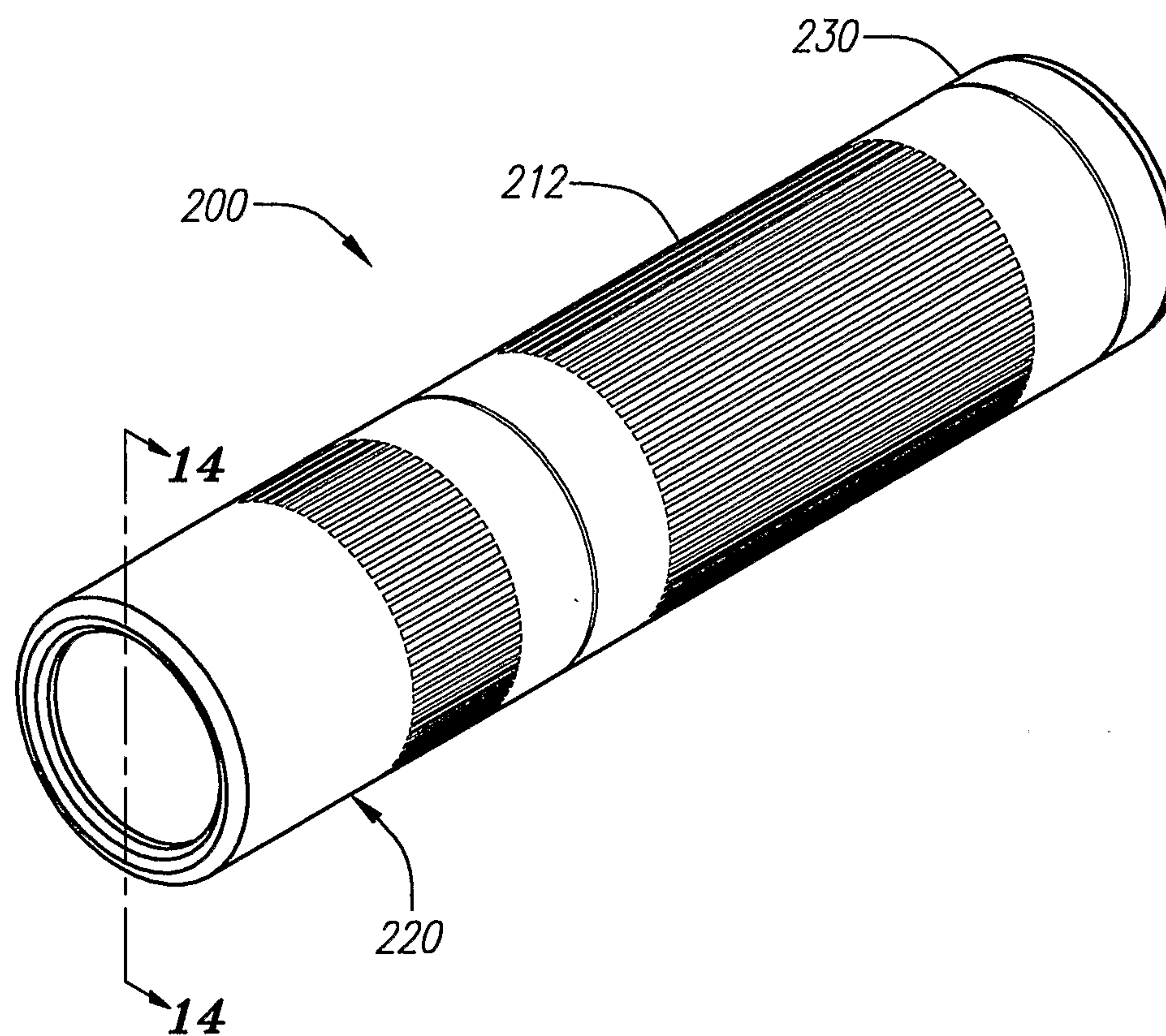
**FIG. 13**

FIG. 14

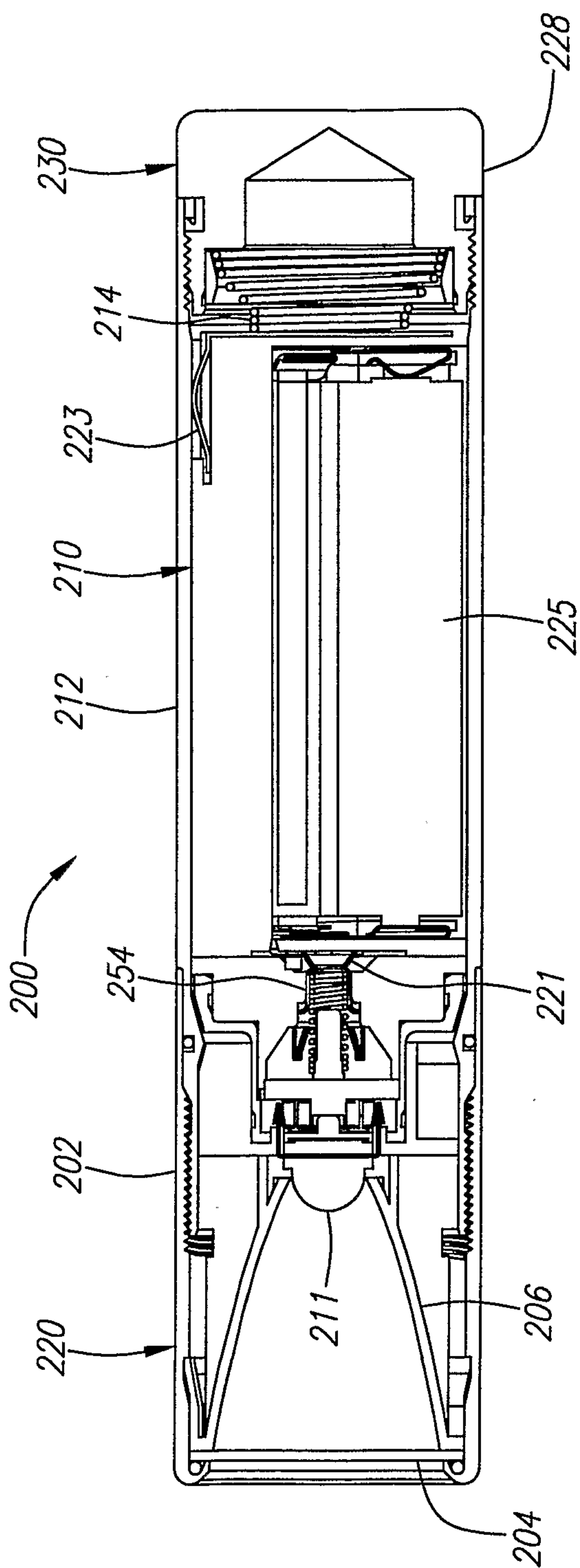


FIG. 15

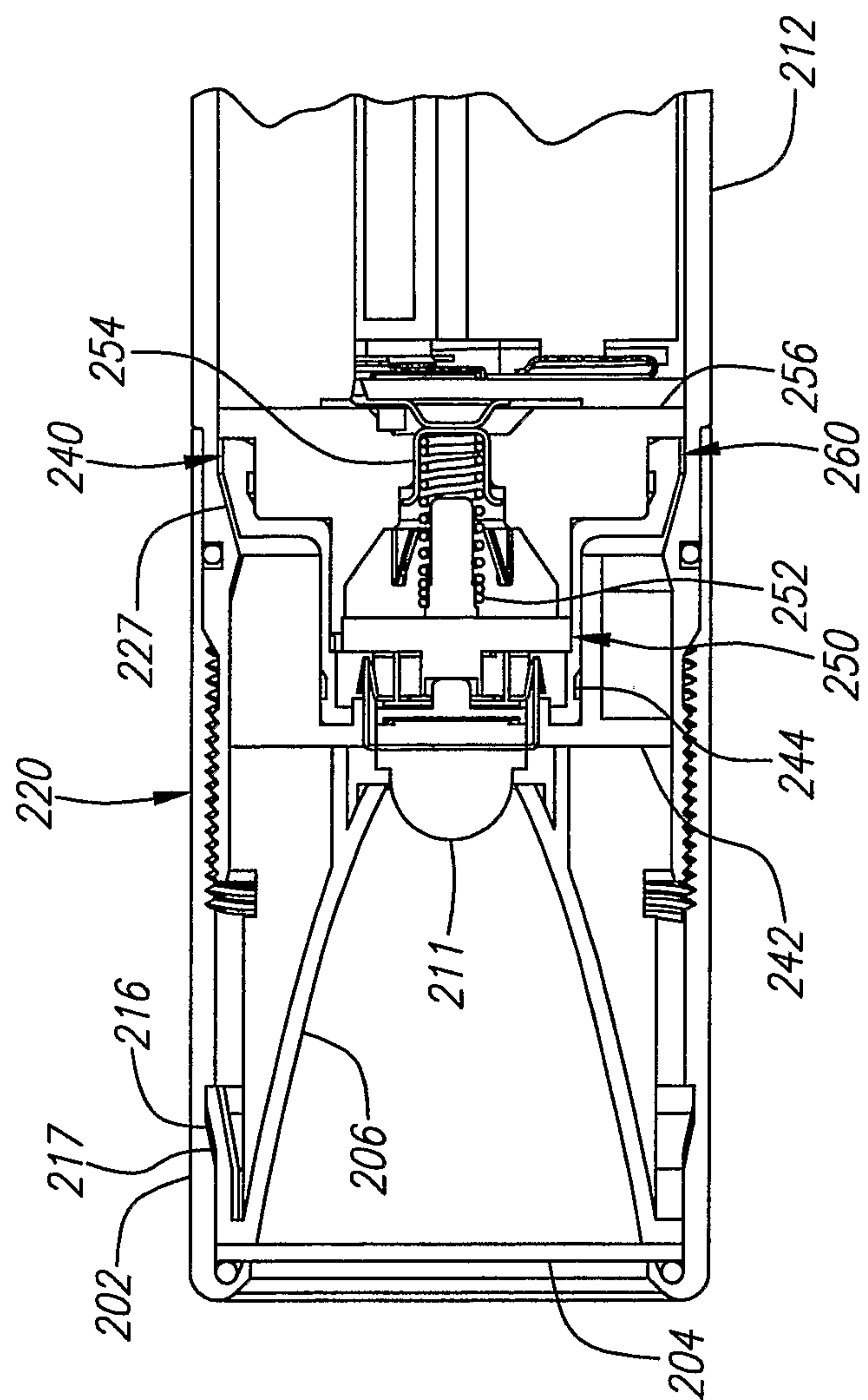
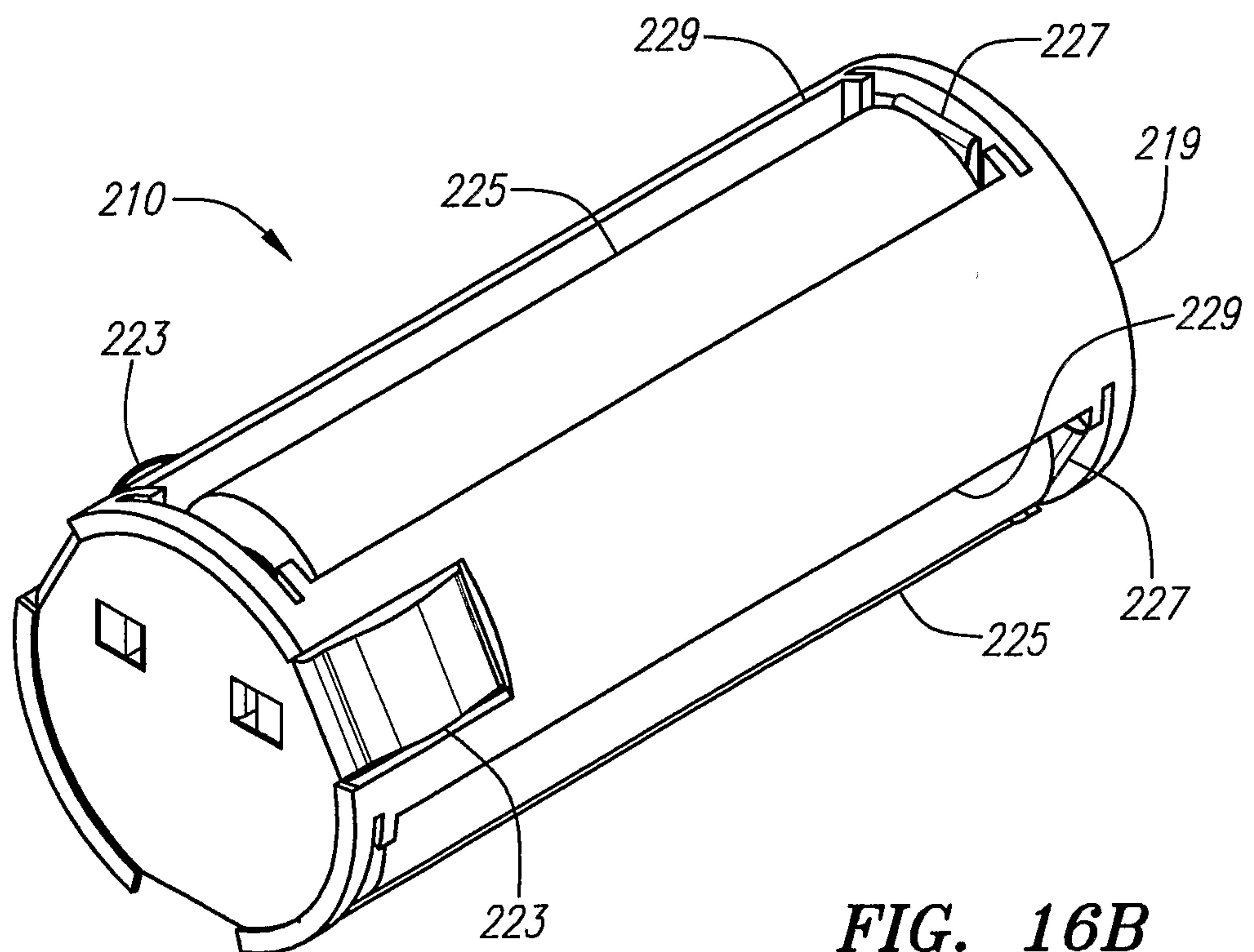
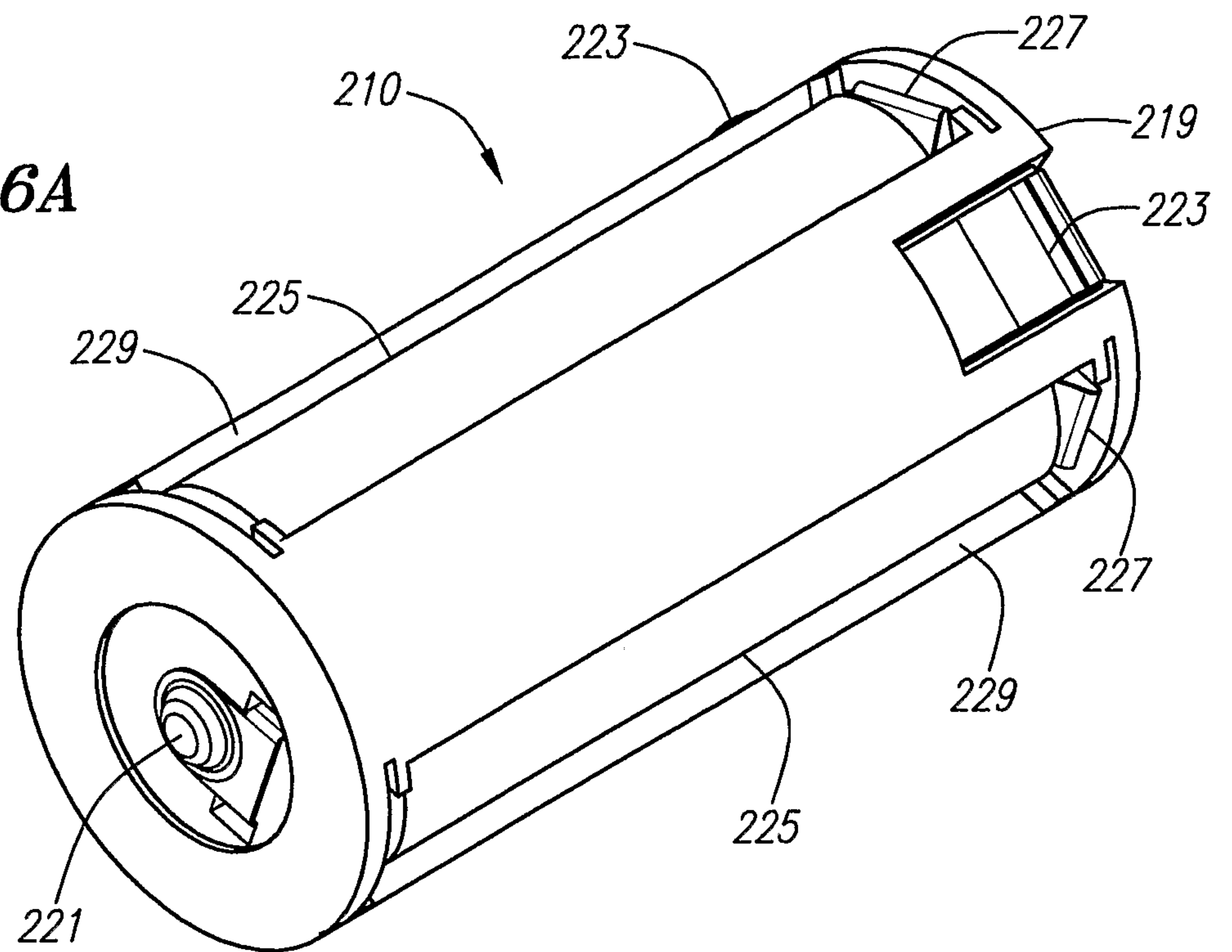


FIG. 16A**FIG. 16B**

