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(54) **ELECTRICAL ADAPTER FOR MEDICAL DIAGNOSTIC INSTRUMENTS USING LEDS AS ILLUMINATION SOURCES**

600/202, 245-249, 223; 323/221, 273, 902, 323/905, 911, 207; 320/114; 351/221  
See application file for complete search history.

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(57) **ABSTRACT**

An adapter for permitting a medical diagnostic instrument having an illumination source including at least one LED (light emitting diode) to be used with a power supply normally configured for use with a diagnostic instrument having at least one incandescent lamp as an illumination source. The adapter includes circuitry for compensating LED specific characteristics for permitting the power supply to be used with the LED.

**56 Claims, 11 Drawing Sheets**

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**Related U.S. Patent Documents**

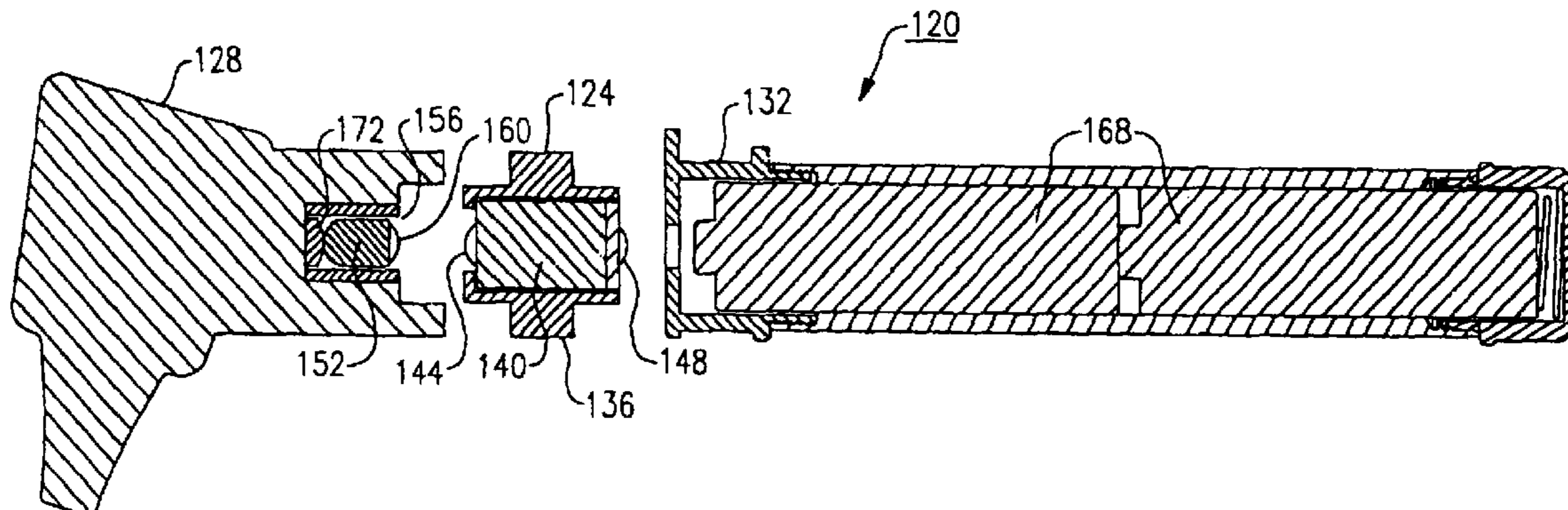
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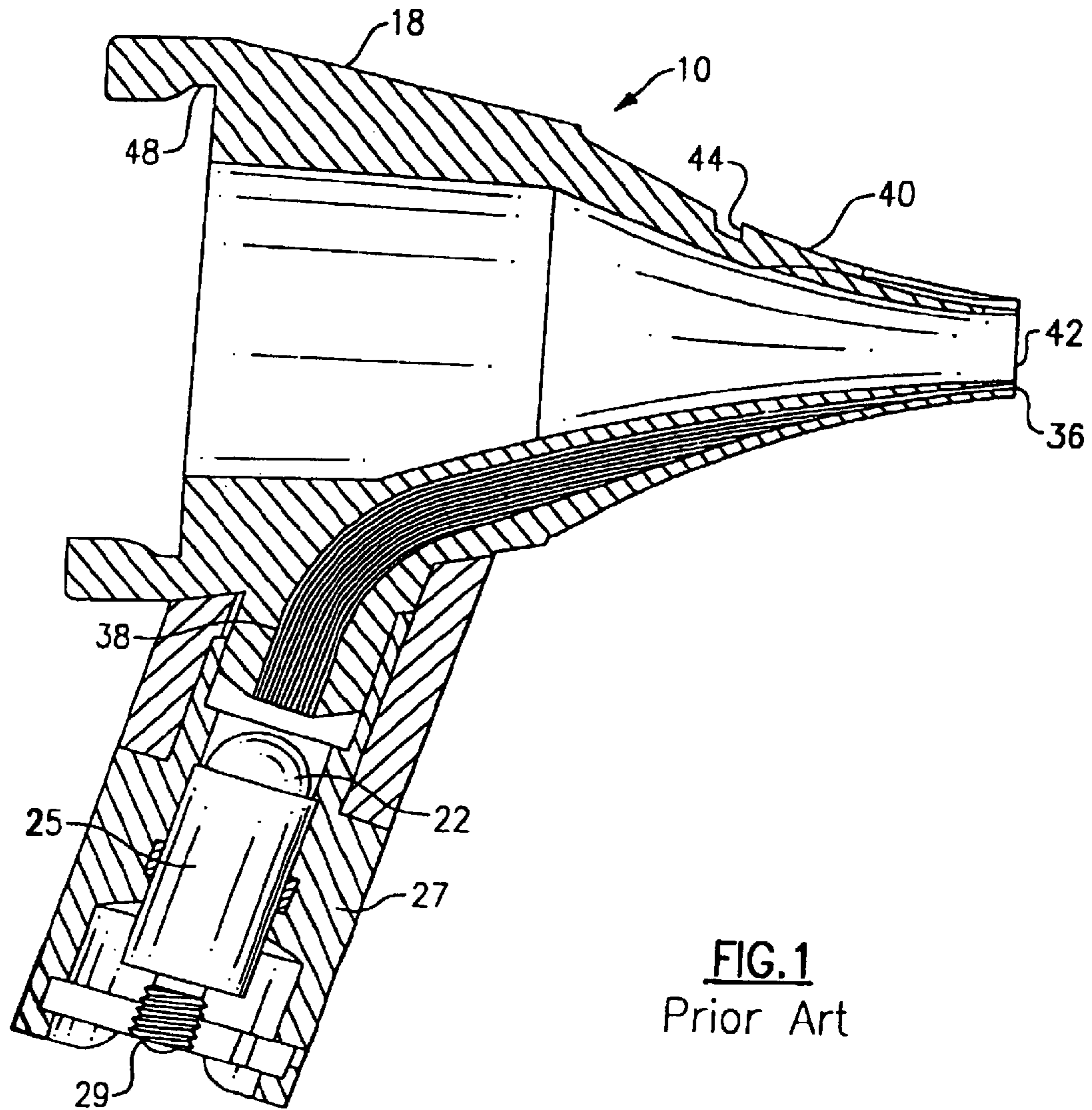
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**FIG. 1**  
Prior Art

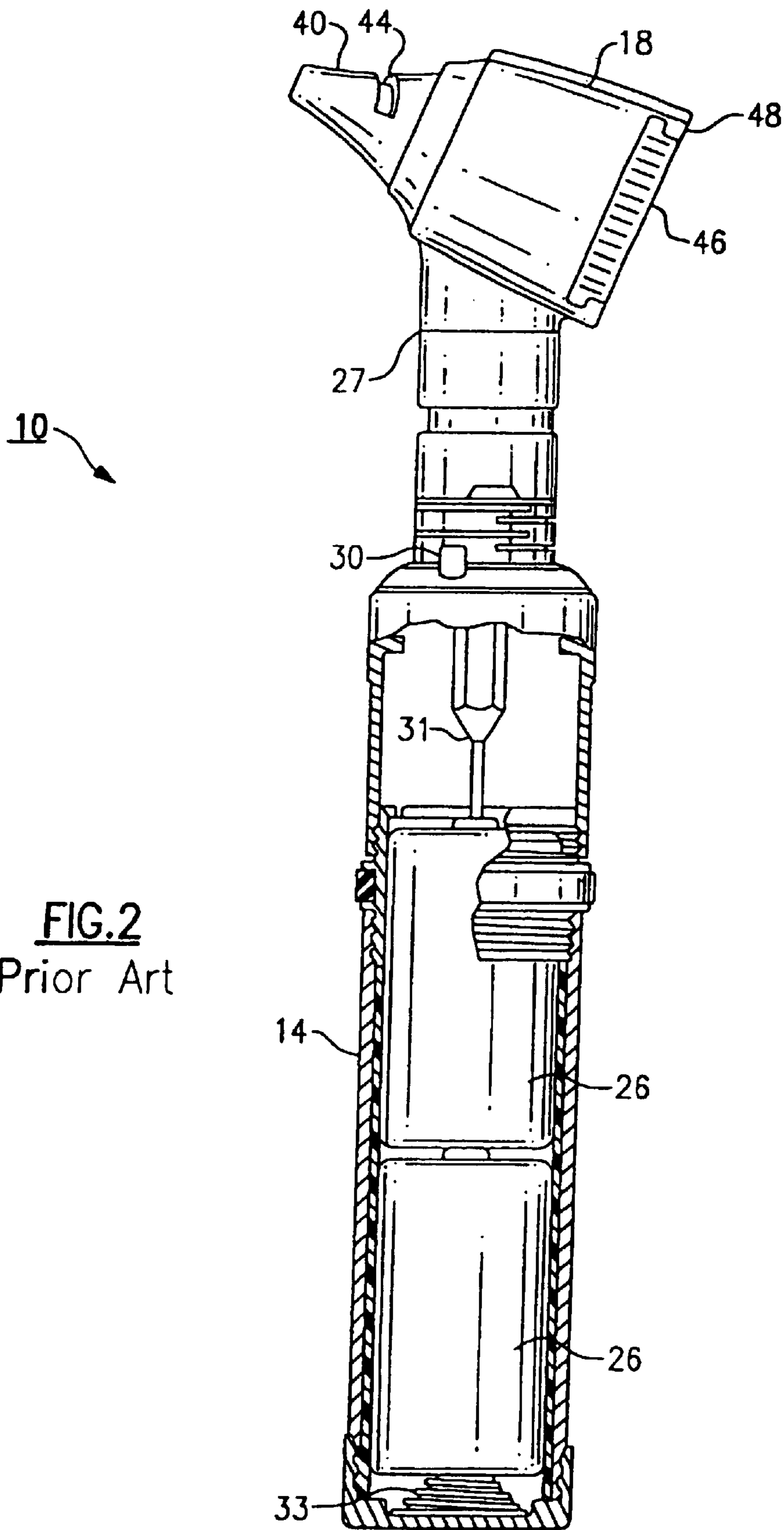
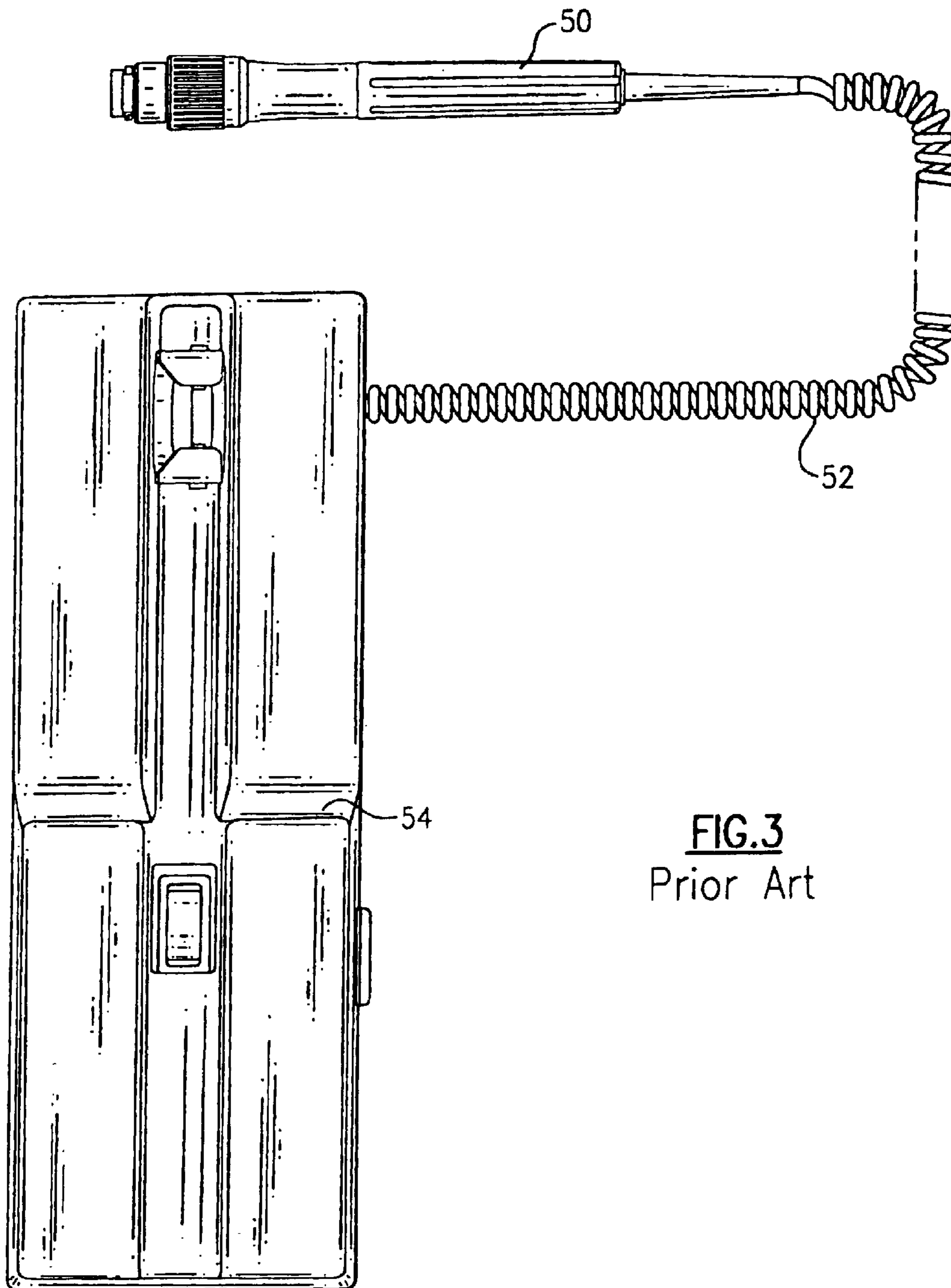
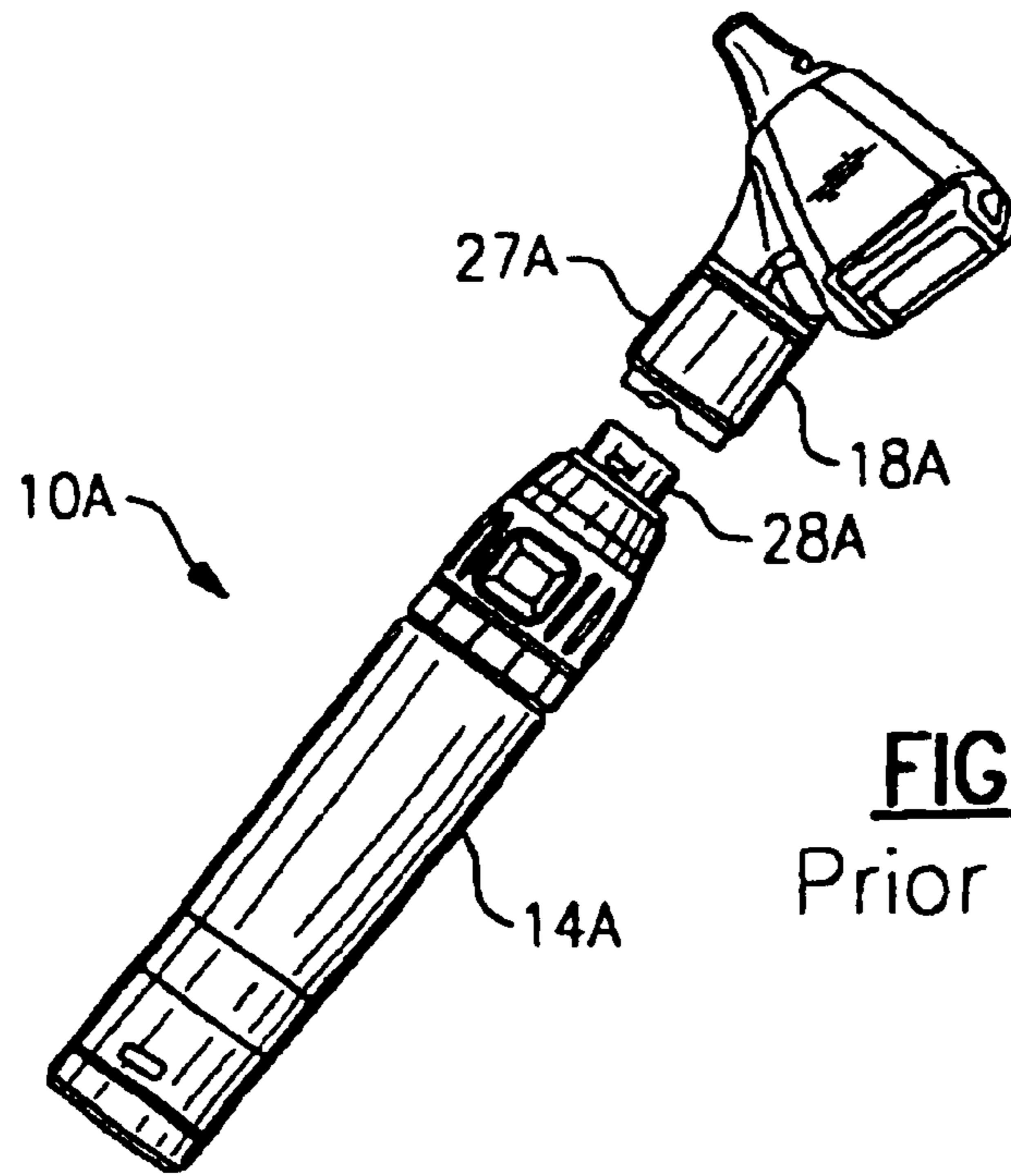


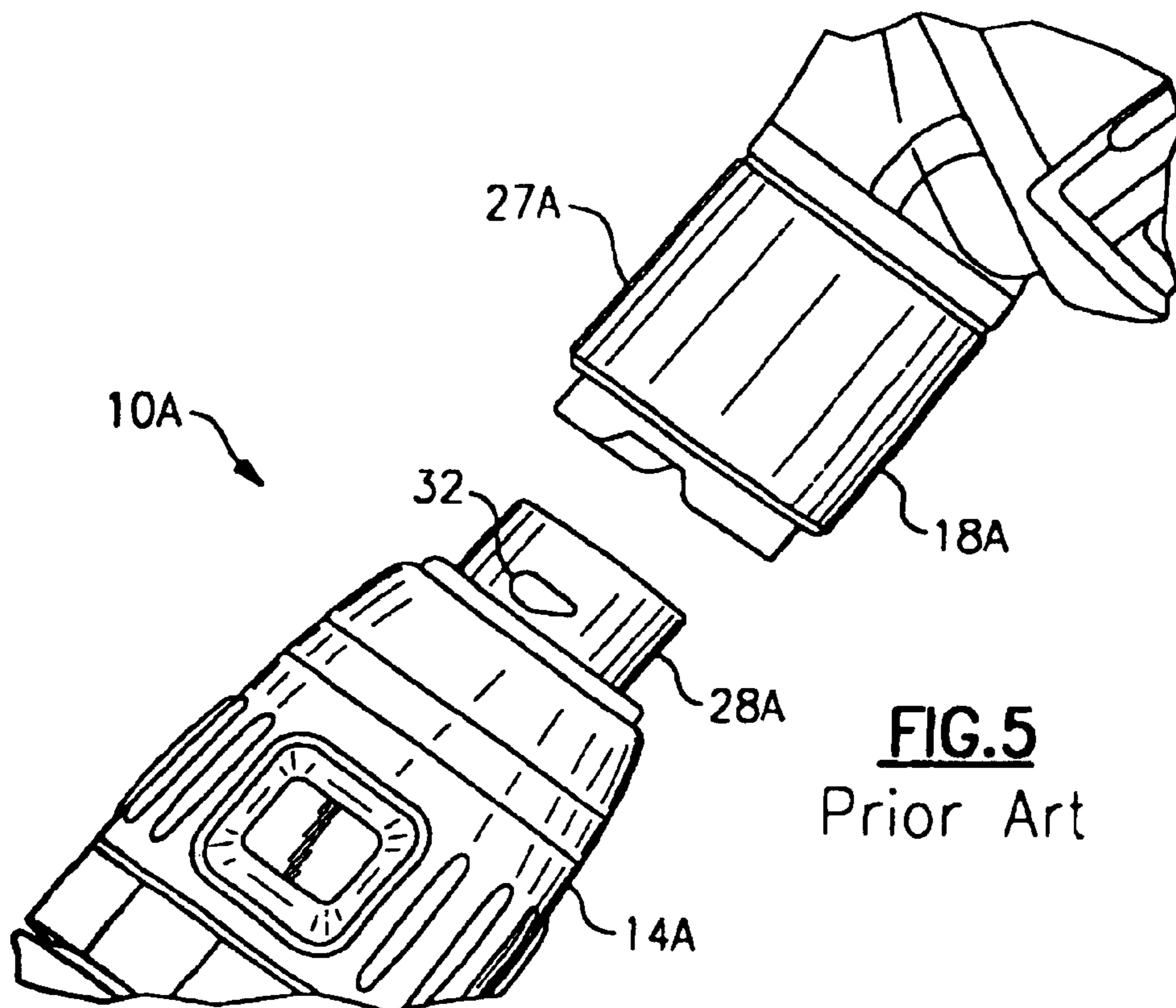
FIG.2  
Prior Art



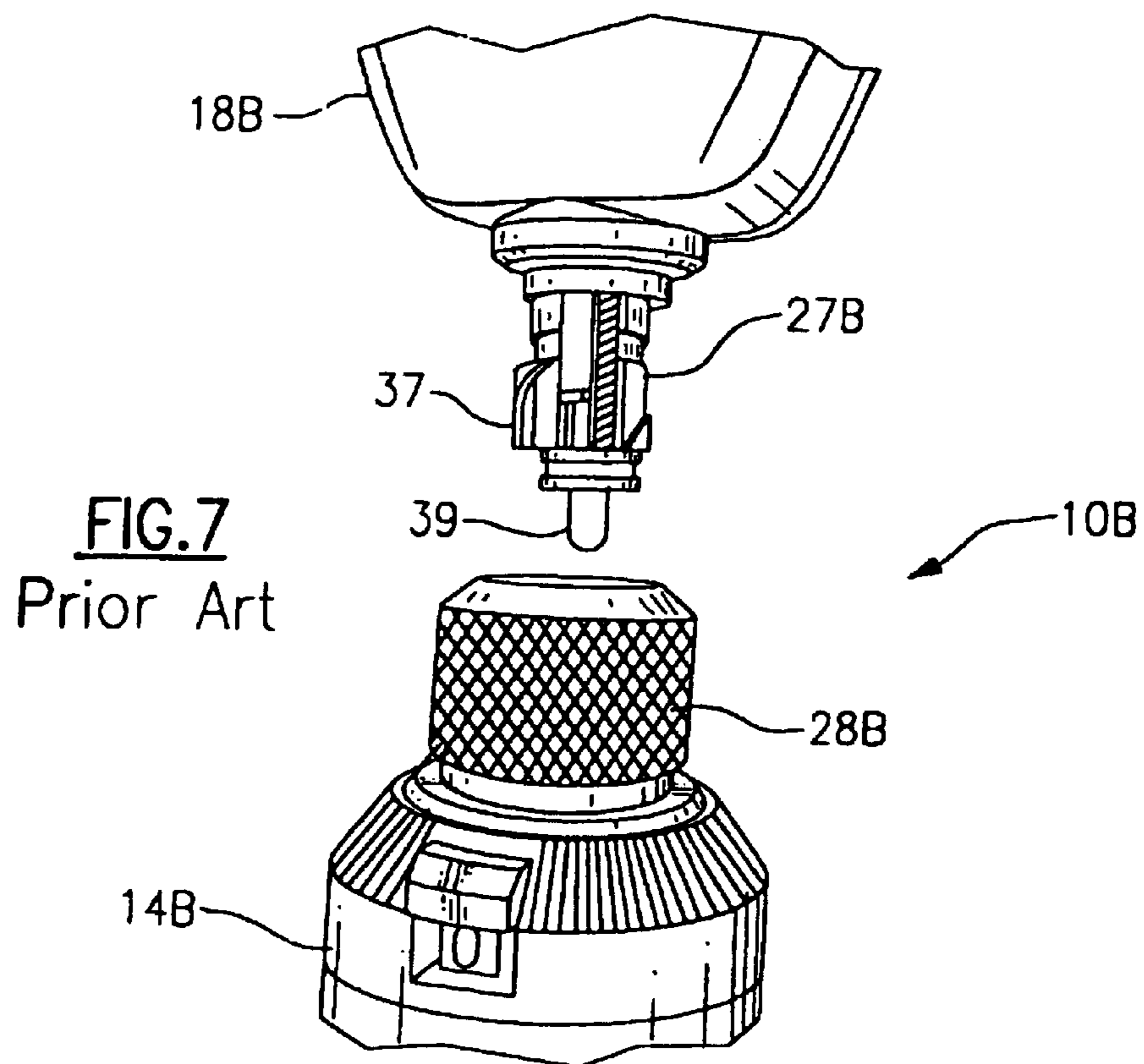
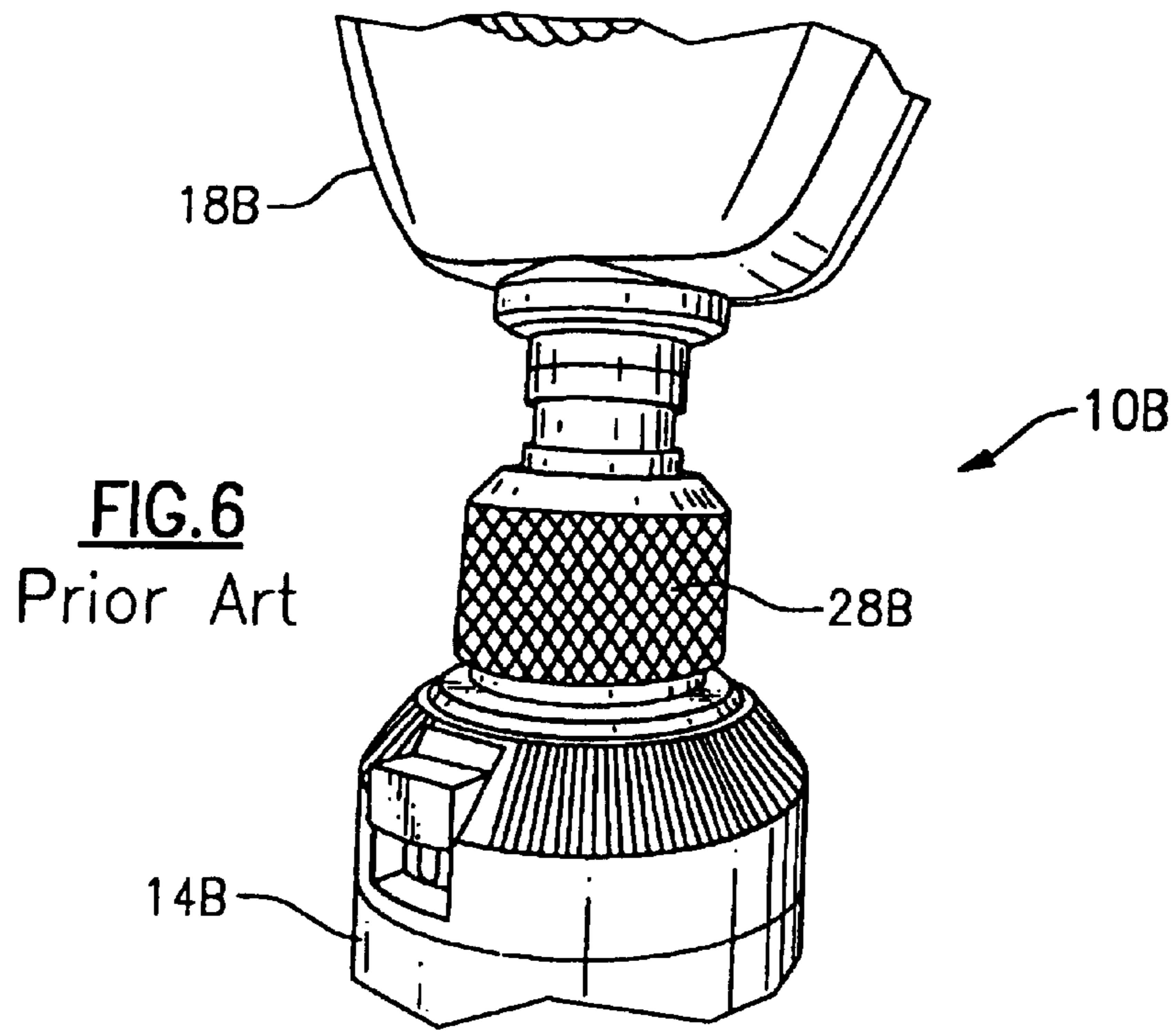
**FIG.3**  
Prior Art

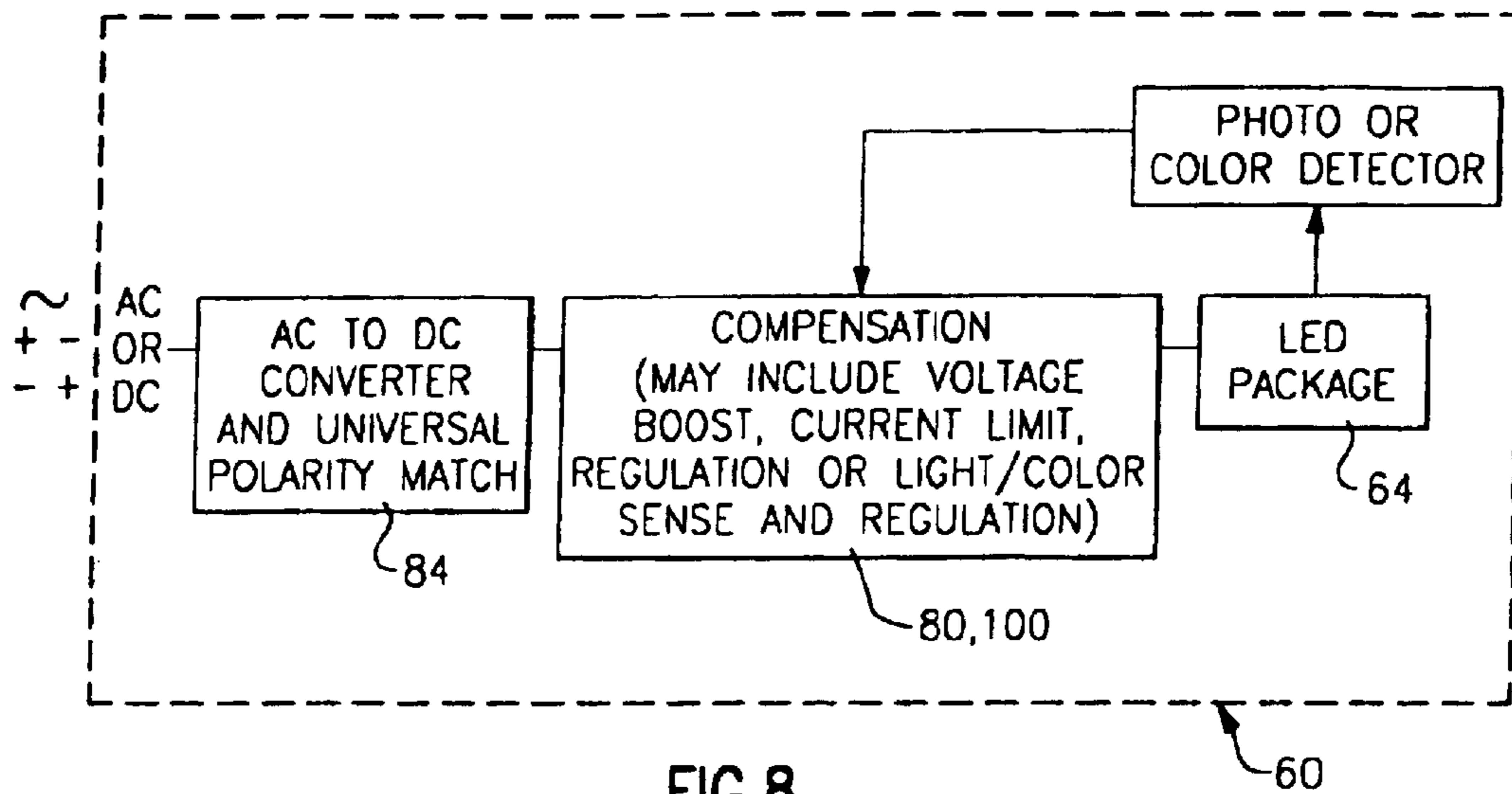


**FIG. 4**  
Prior Art

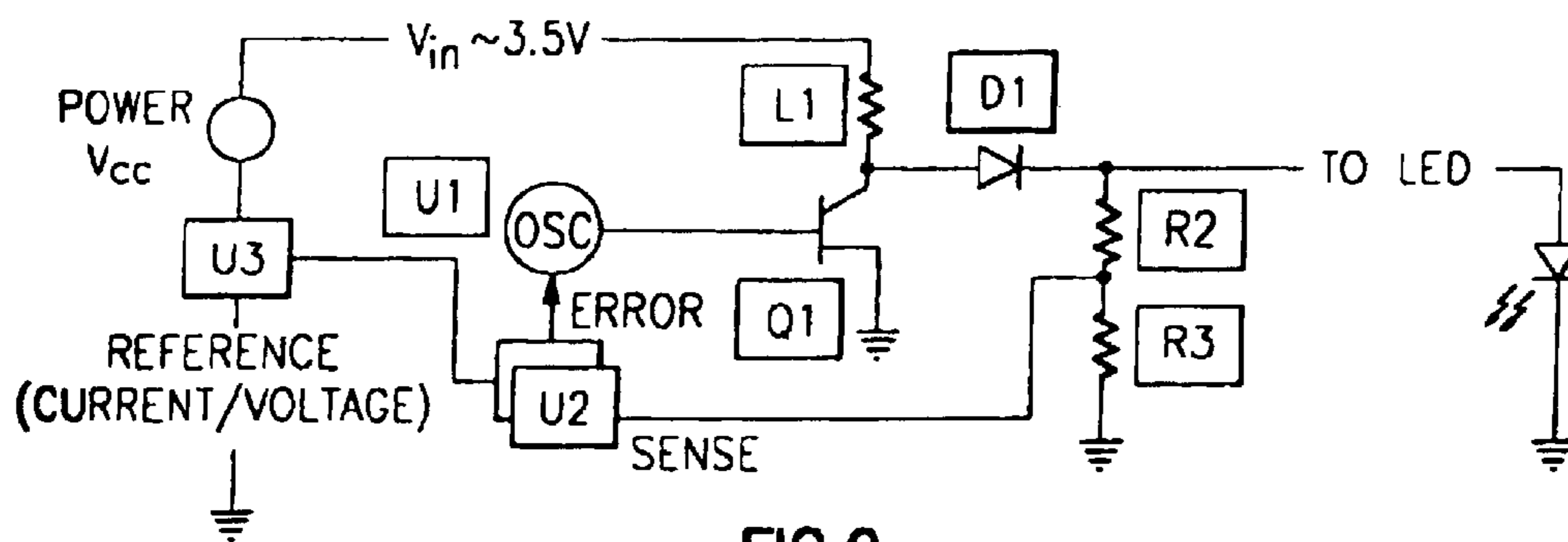


**FIG. 5**  
Prior Art





**FIG.8**



**FIG.9**



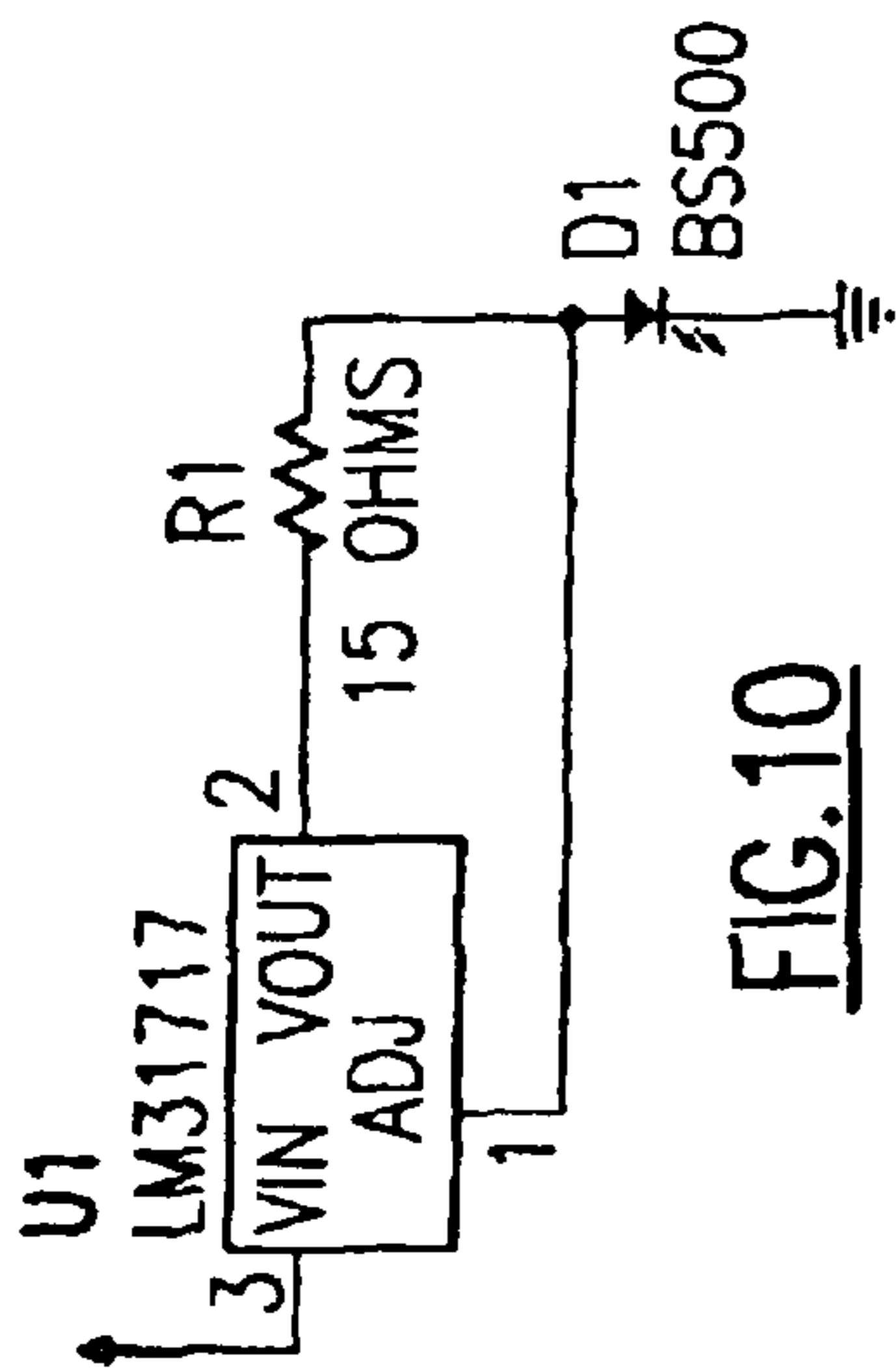


FIG.10

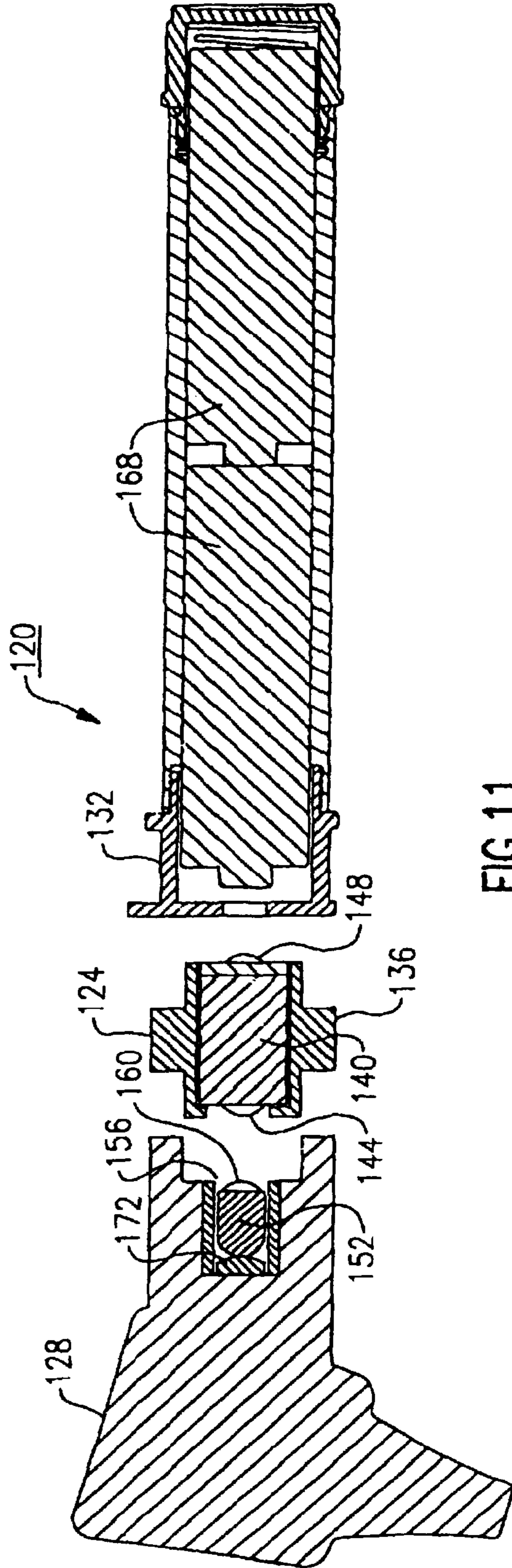


FIG.11

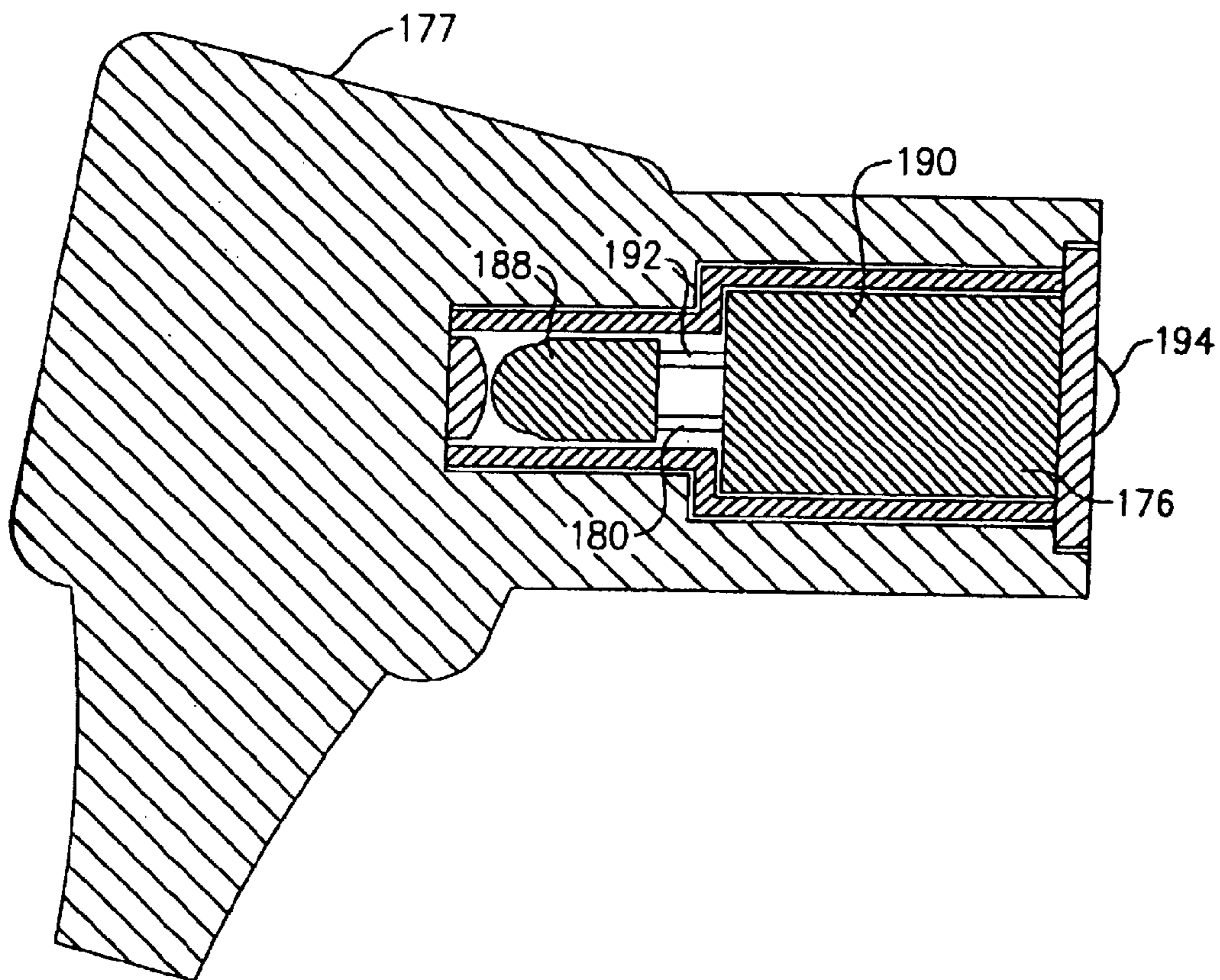
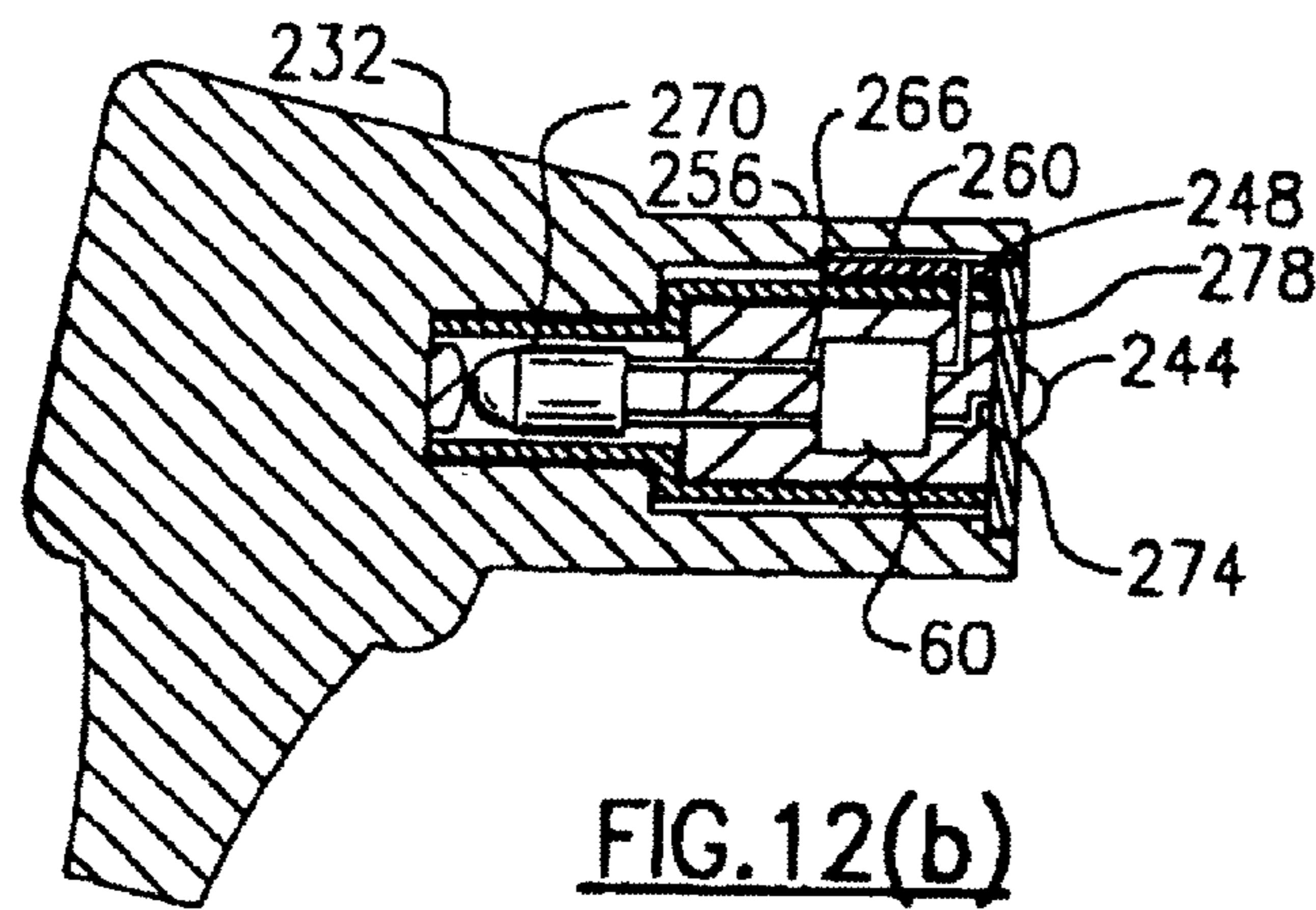
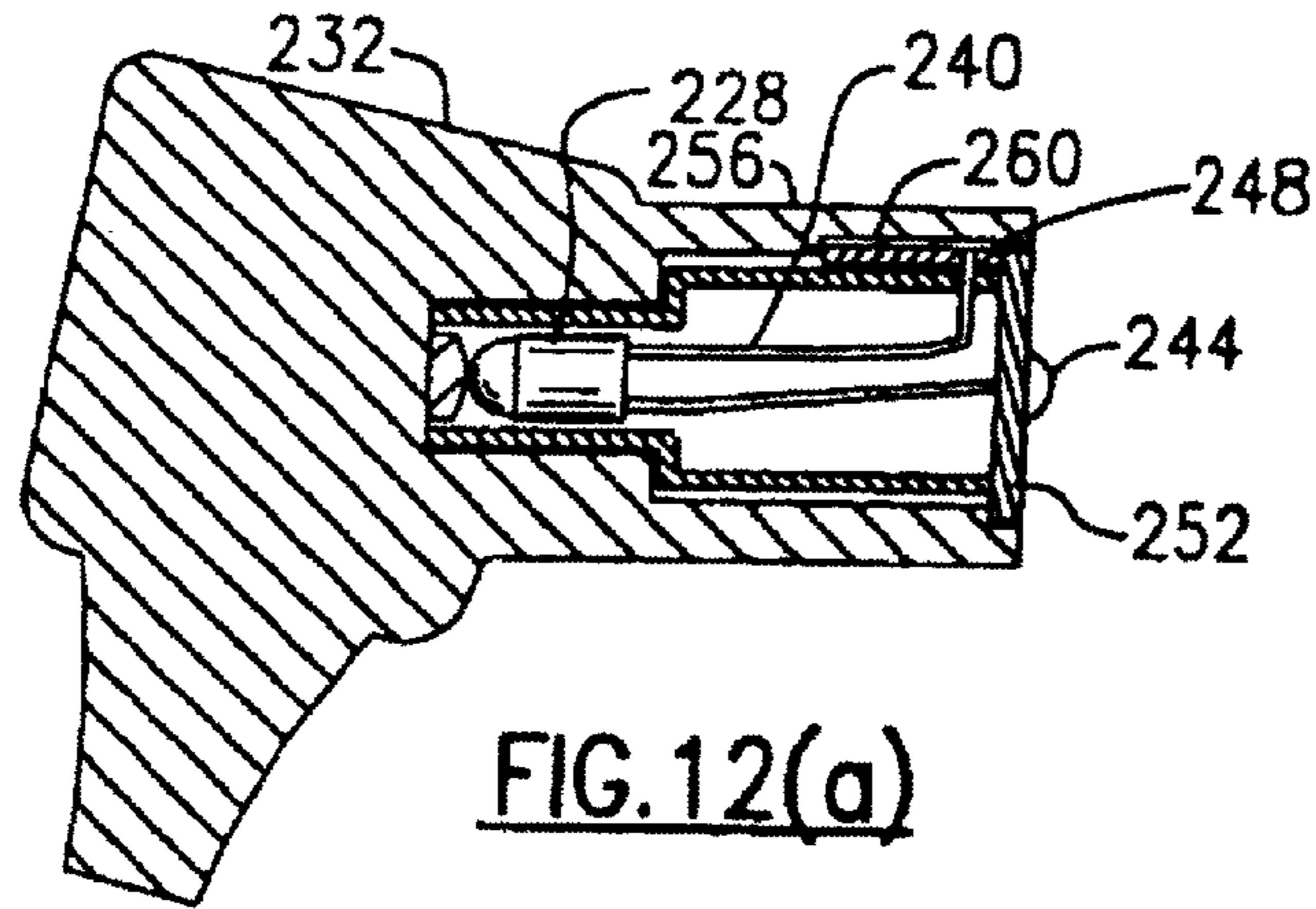


FIG.12



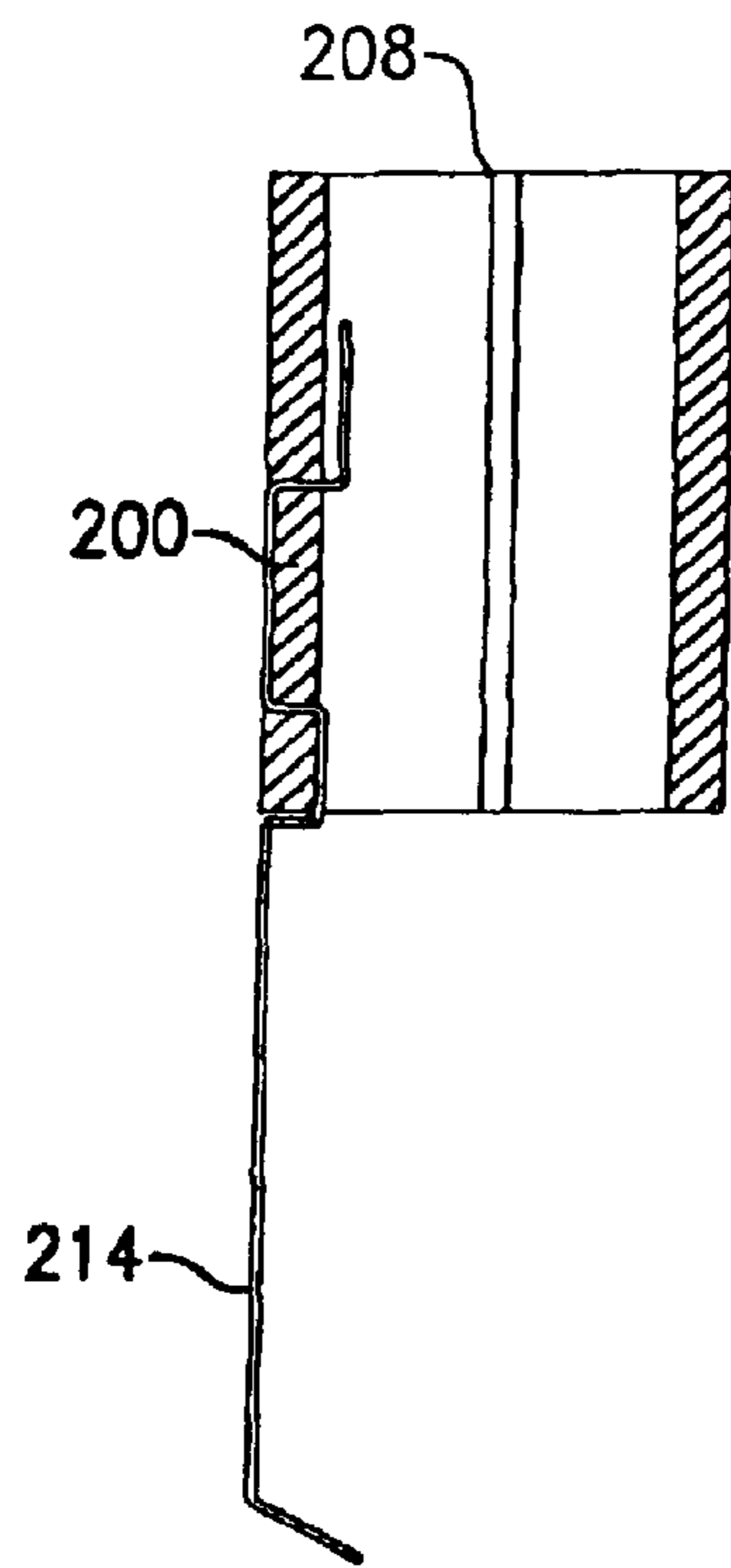


FIG. 14

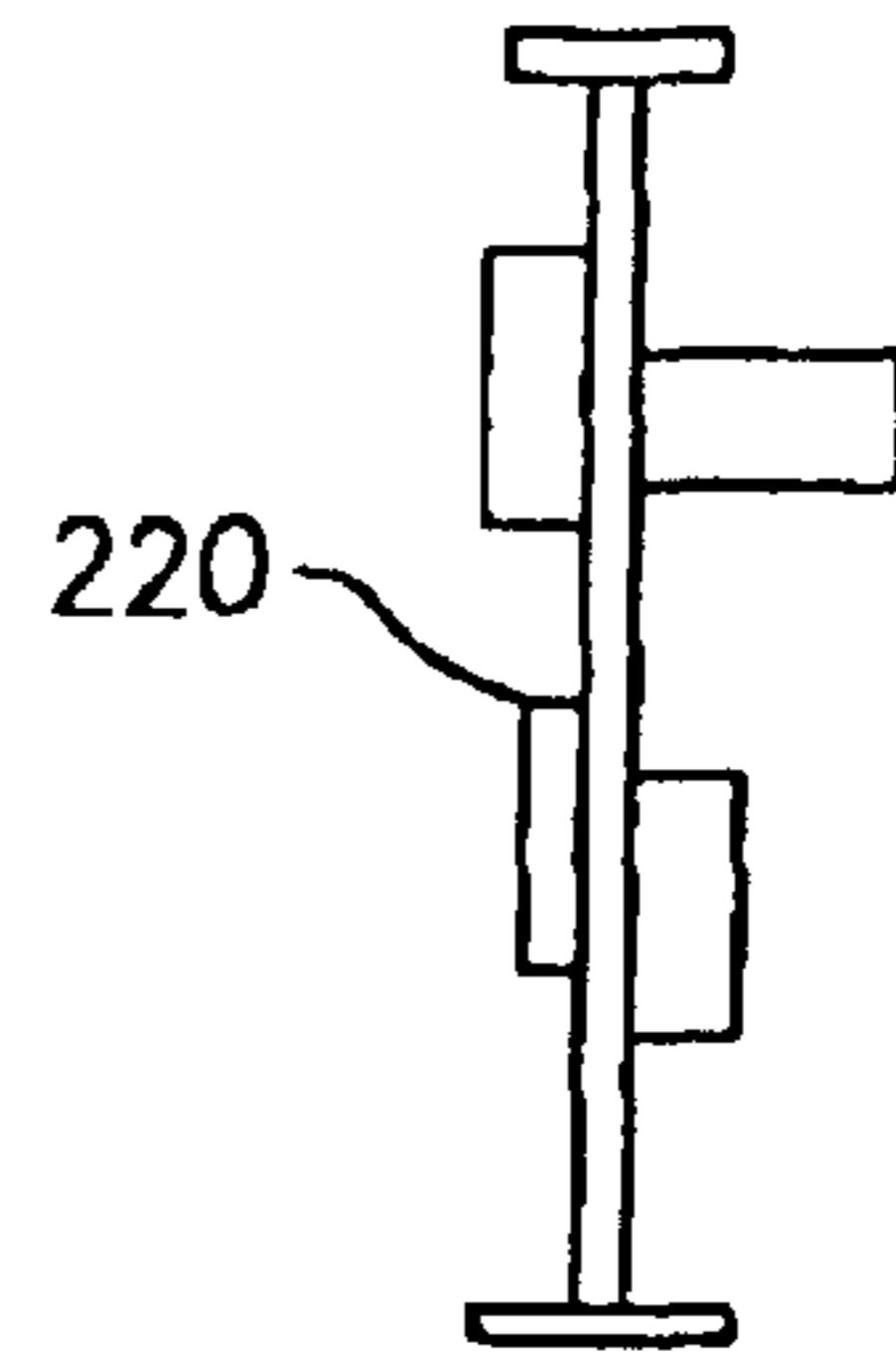


FIG. 15

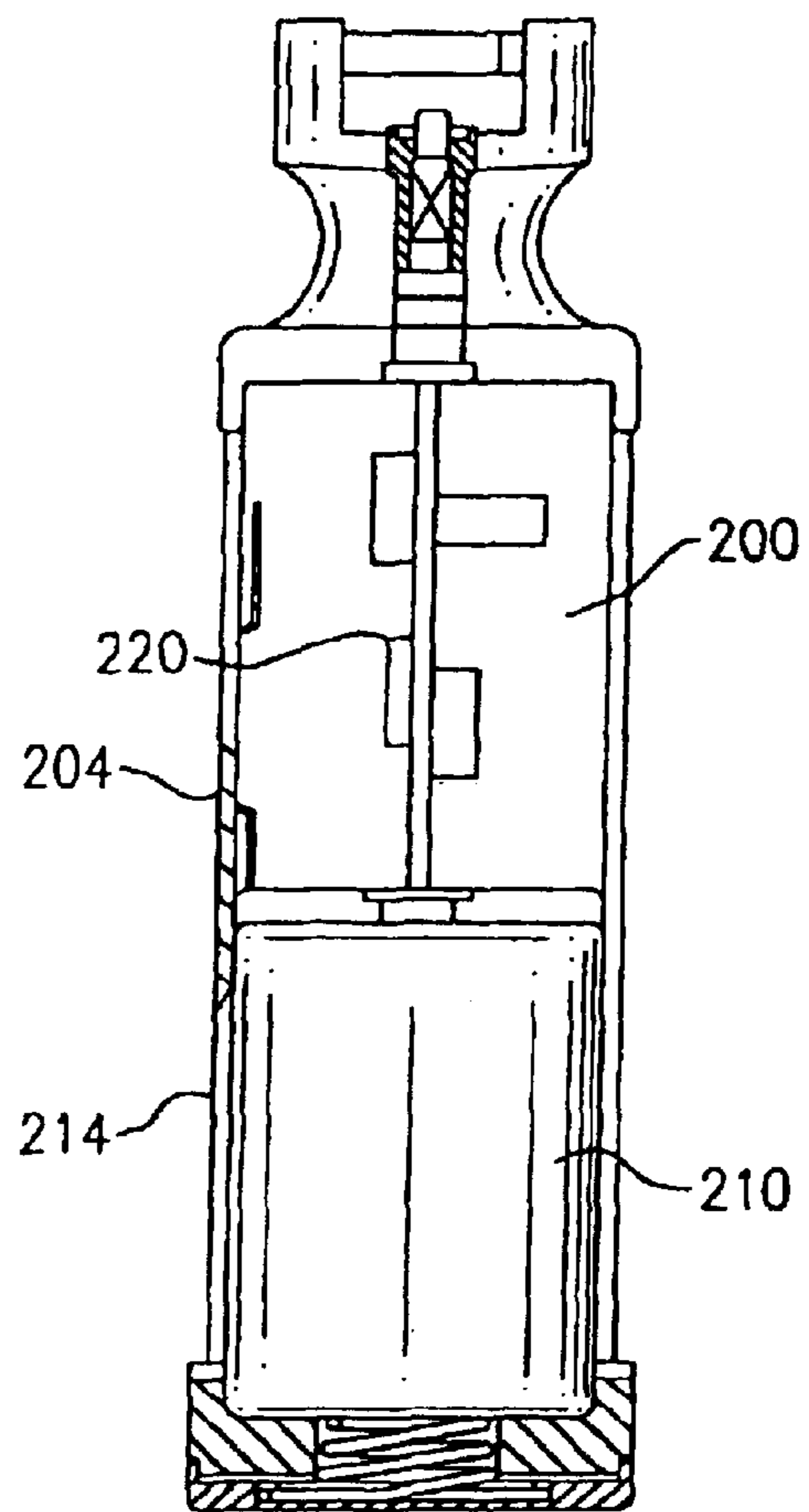


FIG. 13

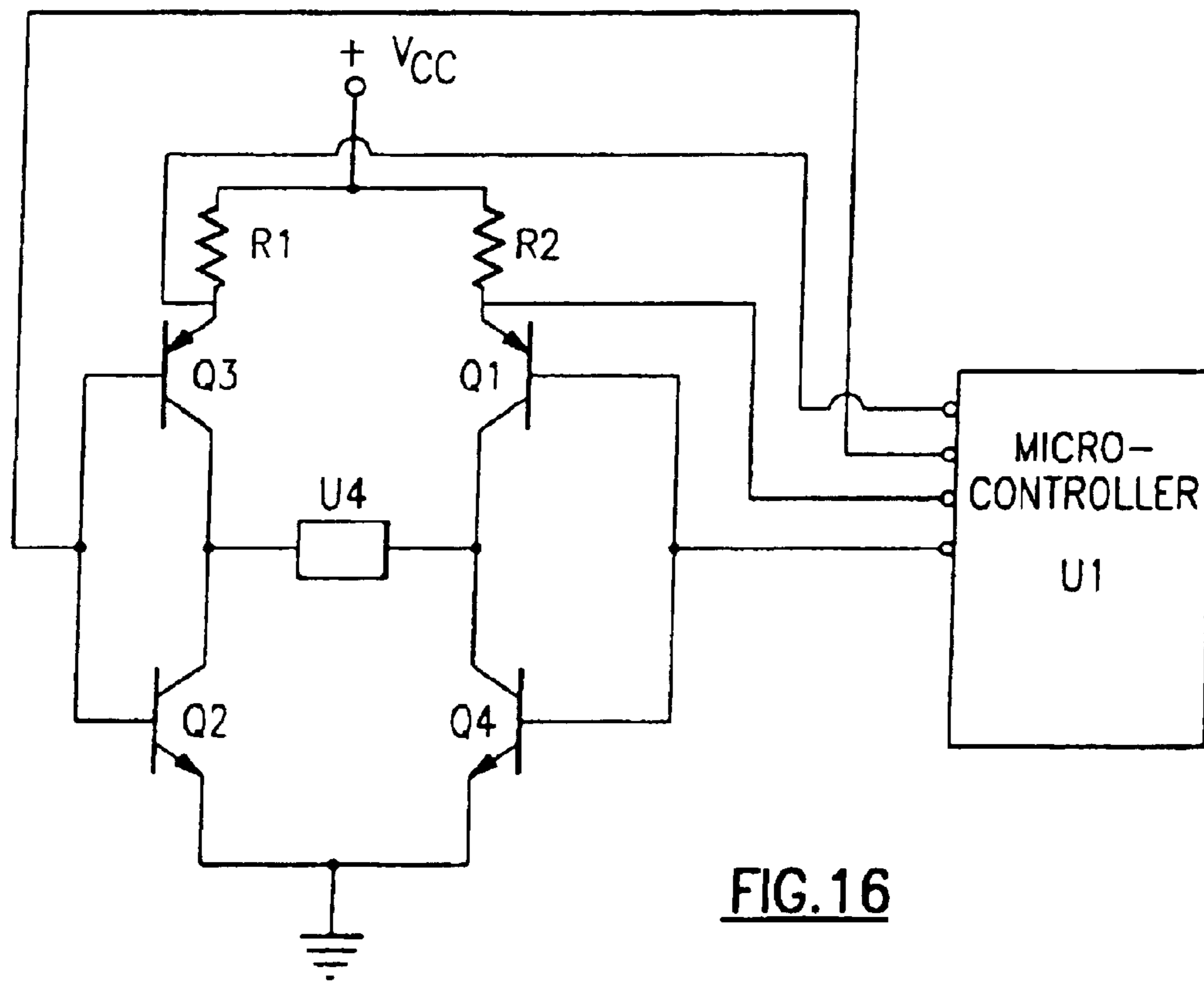


FIG. 16

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**ELECTRICAL ADAPTER FOR MEDICAL  
DIAGNOSTIC INSTRUMENTS USING LEDS  
AS ILLUMINATION SOURCES**

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.**

FIELD OF THE INVENTION

The following application generally relates to the field of illumination, and more particularly to an LED illumination system intended for use with hand held medical diagnostic instruments, such as those used in a physician's or health care provider's office, or other medical environments.

BACKGROUND OF THE INVENTION

Many manufacturers of hand-held medical diagnostic instrument products including otoscopes, ophthalmoscopes, et al., such as those from Heine Inc., Welch Allyn, Inc., and Keeler Instruments, among others, have long since utilized miniature incandescent lamps, such as halogen and xenon lamps, as illumination sources. These lamps are typically provided within the handle or the head of the instrument and utilize fiber optic bundles or other optical means to transmit the light from the miniature lamp to the tip opening of the diagnostic instrument, such as an ophthalmoscope, otoscope, or similar device.

Power sources for these lamps are typically either wall mounted or are portable, in the form of batteries provided in the instrument handle and having a nominal voltage of approximately 2.5 or 3.5 volts. These voltages are convenient values, since they match both a stacked arrangement of two or three Nickel cadmium batteries and 3.5 volts in particular is favored since it is also the voltage of a single lithium ion cell. Examples of instruments having same are described, for example, in U.S. Pat. Nos. 4,012,686, 5,559,422, 5,177,424, and 5,542,904.

More recently, there has been considerable interest in the field in light emitting diodes (LEDs) as a potential substitute for miniature incandescent lamps. White versions of these LEDs, such as those described, for example, in U.S. Pat. Nos. 6,069,440 and 5,998,925, among others, the entire contents of which are herein incorporated by reference, provide better illumination capability than predecessor LEDs and are therefore coveted for a myriad of applications due to their longer life, resistance to shock and impact loads, cooler operating temperatures and alternative spectral content as compared with the afore mentioned miniature incandescent lamps. Moreover and adding LEDs in general, such as color LEDs, provide additional benefits such as spectral tuning, IR, spectrally specific illumination, and the like.

It is a general desire in the field that future product improvements incorporating white LEDs as illumination sources be compatible with both the mechanical and electrical features of existing power supplies to which these instruments are interconnected. There are, however, a number of significant differences which must be recognized in the incorporation of the above illumination devices into any previously known medical diagnostic instrument. For example, white LEDs, such as those described above, experience a large variation in forward voltage as compared with miniature incandescent lamps, as well as significant differences in current versus light output and color characteristics. There are

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also mechanical issues relating to the incorporation of any adapter into a medical diagnostic instrument.

In summary, there is a need to develop an adaptive means which can be mechanically, optically and electrically incorporated into the design of a hand-held medical diagnostic instrument so as to permit an instrument having LEDs as an illumination source to be readily used with a variety of existing power supplies and charging apparatus. There is an additional need to enable current instrument heads which formerly used miniature incandescent lamps to utilize white or color LEDs with these existing power sources.

SUMMARY OF THE INVENTION

It is therefore a primary object of the present invention to overcome the above-noted deficiencies of the prior art.

It is another primary object of the present invention to develop electrical adapters that can permit LEDs, such as white LEDs, to be utilized in existing known hand-held medical diagnostic instruments without requiring major configuration changes to already existing power supplies and/or electrical charging apparatus.

It is yet another primary object of the present invention to provide an electrical adapter which permits white LEDs to be utilized in already existing hand-held diagnostic instruments, such as otoscopes, without significantly impacting the mechanical and/or optical function or design of the instruments.

Therefore and according to a preferred aspect of the invention, there is provided an electrical adapter for use with a medical diagnostic instrument typically configured with an incandescent lamp as an illumination source and a power supply for powering said incandescent lamp, said adapter having means for permitting at least one LED to be used as the illumination source for said instrument while permitting said existing power supply to be used therewith.

Preferably, means are included for compensating LED-specific characteristics for permitting the power supply to be used with the medical diagnostic instrument. The adapter preferably includes an AC to DC converter in order to compensate for variations in forward voltage of at least one white LED used as an illumination source and to effect polarity discrepancies. The AC to DC converter can consist of, for example, at least one diode bridge or a MOSFET switch. The adapter also preferably includes means for compensating LED specific differences such as current, voltage boost, regulation, and color sense, thereby permitting use of the diagnostic instrument having at least one white LED with already existing power supplies and/or battery charging apparatus.

According to one preferred embodiment, the LED electrical adapter can be disposed within the head of the diagnostic instrument so as to permit interchangeability of illumination devices; that is, in which one interchangeable instrument head can include a miniature incandescent lamp and another interchangeable head includes a least one white LED and an electrical adapter permitting the LED to be utilized with the remainder of the instrument whether the instrument includes a wall mounted power supply or batteries.

Alternatively and according to yet another preferred embodiment, the LED electrical adapter can be fitted in lieu of a conventional battery within the instrument handle. The adapter, in fact, can be manufactured and sized so as to effectively replace a battery within the handle.

According to yet another preferred aspect of the invention, there is provided in combination, an adapter for use with a medical diagnostic instrument, said instrument including a power supply, electrically configured for powering an incan-

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descent bulb as an illumination source, said instrument including an instrument head, a hand-grippable handle and at least one LED disposed in said instrument as the illumination source of said instrument, said adapter including means for electrically interconnecting said power supply and said at least one LED for effectively energizing said at least one LED.

According to still another preferred aspect of the present invention, there is provided a method for adapting a medical diagnostic instrument for use with at least one LED as an illumination source, said instrument including a power supply typically only electrically configured for energizing an incandescent lamp as an illumination source, said method comprising the steps of:

adding an adapter to at least one of said instrument head, said instrument handle, and said instrument power supply; and electrically connecting said adapter to said power supply and to said at least one LED to energize same without modification to said power supply.

According to yet another preferred aspect of the invention, there is provided a method for adapting a existing medical diagnostic instrument so as to incorporate at least one LED as an illumination source, said existing instrument including a power supply for energizing a miniature incandescent bulb as an illumination source, said instrument including an existing instrument head and a existing instrument handle wherein said existing instrument head and said existing instrument handle include mating interconnecting ends which interlock said instrument head and said handle in a mechanical interconnection while simultaneously maintaining an electrical interface between said incandescent lamp and said power supply, said method including the steps of:

attaching an adapter between said instrument head and said instrument handle, said adapter including means for electrically interconnecting at least one LED and said power supply as well as means for mechanically interconnecting said instrument head and said instrument handle; and

mounting said at least one LED in one of said adapter and said instrument head.

An advantage of the present invention is that the herein described electrical adapter permits a number of hand-held medical diagnostic instruments to be used with any previously existing power supplies or battery charging apparatus used therein without significant modification.

Still another advantage of the present invention is that the herein described electrical adapter permits each of the advantages of LEDs to be brought to the diagnostic instrument. These advantages which include longer lamp life, longer battery life, reduced maintenance, and higher reliability without significantly impacting cost which heretofore could not easily be brought to the instrument without significant redesign of the electrical system.

These and other objects, features, and advantages will become readily apparent from the following Detailed Description which should be read in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial side section view of the head of a prior art medical diagnostic instrument;

FIG. 2 is a partial side sectioned view of the medical diagnostic instrument of FIG. 1, including a portable battery power source;

FIG. 3 is a front view of another prior art medical instrument including a wall-mounted power supply;

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FIG. 4 is a side perspective view of a prior art diagnostic instrument illustrating the interconnection between an instrument head and the instrument handle/power supply;

FIG. 5 is an enlarged side perspective view of the instrument head/handle-power supply interconnection of FIG. 4;

FIG. 6 is a partial side view of the interconnection between another prior art instrument head and instrument handle;

FIG. 7 is an unassembled view of the instrument of FIG. 6;

FIG. 8 is a schematic block diagram of an LED electrical adapter made in accordance with the present invention;

FIG. 9 is an electrical circuit diagram of an embodiment of the LED electrical adapter of FIG. 8;

FIG. 10 is an electrical circuit diagram of a current compensation portion of the LED electrical adapter of FIG. 8;

FIG. 11 is a side elevational view, partially in section, of a medical diagnostic instrument having an LED electrical adapter made in accordance with a preferred embodiment of the present invention;

FIG. 12 is a side elevational view, partially in section, of a medical diagnostic instrument having an LED electrical adapter made in accordance with another preferred embodiment of the present invention;

FIGS. 12(a) and 12(b) are side elevational views of a diagnostic instrument head, partially in section, including means for detecting the illumination mode of the head in accordance with a preferred embodiment of the present invention;

FIG. 13 is a side elevational partial perspective view of a LED electrical adapter for a medical diagnostic instrument made in accordance with yet another preferred embodiment of the present invention;

FIG. 14 is a side perspective view of the LED electrical adapter of FIG. 13;

FIG. 15 is a side elevational view of a portion of the adapter of FIGS. 13 and 14; and

FIG. 16 is a circuit diagram of a microcontroller system for detecting the presence of an incandescent bulb or an LED.

#### DETAILED DESCRIPTION

The following description relates in general to an LED electrical adapter that can be used in a hand-held medical diagnostic instrument, such as an ophthalmoscope, otoscope, vaginoscope, and the like, though the embodiments described herein detail a specific instrument, namely an otoscope.

Prior to discussing the invention and referring to FIGS. 1 and 2, there is first shown a medical hand-held diagnostic instrument that is already known in accordance with the prior art. In this instance, the diagnostic instrument 10 is a conventional otoscope, used for the examination of the outer ear, including the tympanic membrane. This instrument 10 generally includes a hollow instrument handle 14 and an instrument head 18 that is attached to the top of the handle. The instrument head 18 is hollow and includes a frustoconical tip portion 40 onto which a disposable speculum (not shown) is fitted in a conventional manner, such as a bayonet 44. The speculum is sized for fitting a predetermined distance into the ear canal of a patient, the tip portion 40 having a distal tip opening 42. An eyepiece 46 attached to the proximal end 48 of the instrument head 18 forms an optical path with the distal tip opening 42 through the hollow instrument head 18 to permit viewing of the medical target.

A miniature incandescent lamp 22, such as a halogen or xenon lamp, is provided in a lamp housing 25 that is disposed in a base 27 of the instrument head 18, the lamp being electrically connected through a contact 29 and a vertically extending pin 31 to a series of stacked Nickel cadmium batteries 26 that are retained in a bottom compartment of the

instrument handle **14** for energizing the lamp **22**. The instrument handle **14** also contains a bottom or lower contact spring **33**. An adjustable voltage control **30** located on the exterior of the upper portion of the instrument handle **14** selectively adjusts the amount of illumination output provided by the miniature lamp **22**.

In addition to the above and referring to FIGS. **4-7**, an effective mechanical interface is essential in order to maintain electrical contact between a miniature incandescent lamp contained in the head in the manner detailed above and the contained power supply. A pair of prior art instruments **10A**, **10B** therefore each include a mechanical interface between the instrument head **18A**, **18B** and the upper end of the instrument handle **14A**, **14B** such that when the instrument head is attached to the handle that the above electrical connection is maintained between the lamp and the power supply for the instrument.

In the prior art examples illustrated in FIGS. **4-7**, each of the instruments employ a form of a bayonet connection. In the instrument according to FIGS. **4** and **5**, the base **27A** of the instrument head **18A** includes an interior set of slots (not shown) for engaging a circumferential set of ears **32** (only one being shown) provided on the exterior of the upper portion **28A** of the handle **14A**. A functionally similar instrument is shown in FIGS. **6** and **7** for an ophthalmoscope in which the base **27B** includes a set of ears **37** for engaging a corresponding set of slots located in the upper portion **28B** of the instrument handle **14B** to permit the electrical contact **39** to be placed into electrical contact with the power supply of the instrument to permit illumination of the lamp disposed within the base **27B**. Other suitably similar interfaces can be utilized as these depicted are intended only to be exemplary. In addition, it is known that by maintaining these mechanical and electrical interfaces/connections that various instrument heads and/or handles, including those from different manufacturers, can be combined in a single hand-held instrument.

Alternately and in lieu of batteries, a hand-held medical diagnostic instrument handle **50** can be tethered by means of a cord **52** directly to a wall transformer or similar power supply **54**, such as shown in FIG. **3**. In each particular instance and referring to FIG. **1**, a series of optical fibers **38** extend from the miniature incandescent lamp **22** through the base **27** of the instrument head **18**, to a bundle of light transmitting ends **36** or other optical means that are disposed at the distal tip opening **42** in order to provide illumination of the medical target (e.g., the tympanic membrane). One typical wall transformer is further described in U.S. Pat. No. 5,559,422, incorporated herein in its entirety.

With the preceding background and referring now to FIG. **8**, there is shown a block diagram of an LED electrical adapter **60** made in accordance with a preferred embodiment of the present invention. This electrical adapter **60** includes a number of primary features that are required in order to permit already existing power supplies, such as those shown in FIGS. **1-7**, to be used in conjunction with at least one white LED package **64** that would be substituted for the miniature incandescent lamp **22**, FIG. **1**, in a medical diagnostic instrument.

As will be apparent from the following discussion, the mechanical and electrical design of the inventive adapter can assume a plurality of electrical, mechanical and electrical configurations covered in general by all or some features of the block diagram of FIG. **8**, permitting the adapter to be used in conjunction with literally any existing power supply that provides power to an incandescent lamp-equipped medical diagnostic instrument.

In general, the LED electrical adapter **60** includes a voltage conversion portion **84** and a compensation portion **100**. Each

of these features will now be described in greater detail. It should be noted that for illustration purposes that the compensation portion is presumed to be a current compensation portion, although other characteristics such as voltage, light output and/or color compensation are similarly implemented.

First, the voltage conversion portion **84** herein is an AC or DC converter which can be constructed, for example, as a simple diode bridge so as to provide proper selection of the forward voltage drop of at least one white LED package **64**. Alternately, there are a number of so-called "no drop" MOSFET switches, such as those manufactured by Vishay-Siliconix, among others, could preferably facilitate the voltage conversion with minimal loss in power. Provision of this conversion portion **84** permits both AC and DC power supplies to be utilized. In addition, any polarity mismatch between the LED package **64** and the previously utilized miniature incandescent lamp **22** would also be corrected using this converter portion.

That is to say, while miniature incandescent lamps are unaffected by opposite polarity from a power source. LEDs require unipolar DC current in order to illuminate.

The current compensation portion **100** can include each of the following: a general current compensation means **104** for provided a limited maximum current, and a high/low stopper regulator **108**.

As far as simple current compensation is concerned, a resistor or a PTC (positive thermal coefficient e.g., thermistor) can be used, though it is believed this is not the optimal solution. There are two reasons for this belief. First, there are variabilities between LEDs in terms of output versus current. Therefore, this "solution" provides partial compensation to an "average" white LED in average conditions. Additionally, this form of current compensation may not adequately compensate under low and high supply voltage conditions because the resulting differential voltage between the power source and the LED forward voltage will be directly translated into current difference when using a PTC or resistor as the compensating element. In some instances, the LED forward voltage will be higher than the source voltage and therefore no conduction will occur at all. For instance, a typical 3.5 volt battery power handle ranges between 3.0 volts and 4.2 volts and a typical white LED (such as, for example, a Lumileds Luxeon LXHL-MWIA) has a forward voltage of between about 2.55 volts and about 3.99 volts. These low voltage conditions would occur as the batteries within the instrument handle discharge, or with low line or power supplies that are set at the low end of their manufacturing tolerances.

In addition, high voltage conditions could conversely cause excessive current to flow, resulting in very poor color or in the extreme, failure of the device itself. These high voltage conditions would occur with new, fully charged batteries, or at high line of power supplies set at the high end of manufacturing tolerances.

Regulating/limiting systems for current compensation can include for example, linear regulators, such as, for example, a National Semiconductor LM1117. Alternately, a bimetallic switch can be applied which can be set to create a duty cycle which averages a corrected current in order to produce a stable consistent output as long as the voltage provided by the power source is sufficiently above the forward voltage of the LED.

Referring to FIG. **9**, a circuit is herein described that controls the voltage to an LED which is used in lieu of a miniature incandescent bulb. As will be noted below and with relatively small modification, the circuit can further be configured to control the light output of the LED or the color output of the



LED by selecting the appropriate detector (photodiode with or without filter) and connecting the detector to the sense feed line. The voltage control circuit of FIG. 9 functions as follows:

An oscillator (U1) is assumed to be a voltage controlled oscillator having a base frequency and a duty cycle that is a function of the input voltage. There are many PWM (pulse width modulation) type devices available, and this circuit does not rely on any particular such device. Upon initial power up of the circuit, the voltage across a pair of resistors (R2) and (R3) would be zero, and the sense voltage would be zero. Once a comparator (U2) powers up, the sense voltage (zero at start) will be compared with the reference (U3) and a positive error signal will be generated. This error is fed to the oscillator (U1) which increases its on time cycle, thereby driving transistor (Q1) to turn on. The preceding causes current to flow through an inductor (L1) and stores energy as an electromagnetic field. During the "off" cycle of the oscillator (Q1) turns off and all current is then fed forward into a diode (D1). This feeding creates a voltage and drives current into the LED when the voltage becomes higher than the LED threshold (forward voltage) which is sensed via a pair of voltage dividers (R2) and (R3). If this voltage remains lower than the reference (U3), the error comparator (U2) continues to generate a positive error and the oscillator continues to increase its pulse width which increases the energy which is stored in (L1), and consequently the output voltage into the LED. When the output and therefore the sense voltage becomes higher than that of the reference (U3), the error comparator (U2) generating a negative error signal which decreases the oscillator on time to reduce the output voltage. This process continues and maintains the output close to the reference voltage that is selected. The reference voltage is chosen to be the optimum setting for LED operation.

While the above is a basis version, it should be noted that by including a resistor in series with the load, as shown in FIG. 10, rather than in parallel, this circuit represents a simplified current control, as represented in compensation block 100, FIG. 8. In addition, any other sensing means can be introduced such that the above circuit would respond to other changes such as light level, color, etc.

FIG. 9 includes a means for adequate energy storage in L1, FIG. 9, to bring the apparent source voltage to the LED above the forward voltage of the LED and then regulate the subsequent current which is drawn. Alternately, the regulator can be replaced by a low resistance MOSFET.

Including an oscillator to the design of the current compensation portion as in FIG. 9 would also permit dimming of the LED using either a duty cycle or a pulse width modulation technique. Since LEDs do not dim gradually and predictably with a decrease in voltage, use of the duty cycle would take advantage of the LEDs relatively fast "on/off" time to create "apparent" dimming for the user.

In addition, color will change as current is changed. Therefore, directly decreasing current to adjust light output, for example, will produce an undesirable variation in color. By utilizing either a duty cycle or pulse width modulation as a dimming "technique" for the LED, the LED is pulsed at virtually full power, but for shorter periods of time and therefore appears to dim. The current remains at the "normal" full on value during these pulses, therefore the color of the LED does not perceptibly change as the LED is dimmed.

Depending on the degree of complexity and/or cost considerations, the oscillator can be replaced with a bimetallic element. This substitution also provides the opportunity to modify the light output by rapidly pulsing the LED at a duty cycle which represents the modified intensity desired.

Having described the basic circuitry and referring now to FIGS. 11-15, a number of potential locations for the herein Described electrical LED adapter can be assumed, exemplary embodiments being herein described. For example and first referring to FIG. 11, there is illustrated a battery-powered diagnostic instrument 120, such as previously described in FIGS. 1 and 2, that further includes an adaptor module 124 carrying the electrical circuitry of FIGS. 9 and/or 10, the module being disposed between the instrument head 128 and the top of the handle 132. The adapter 124 includes a housing 136 including a resident printed circuit board 140 and respective electrical contacts 144, 148 provided at opposing ends of the housing. A white LED 152 such as described in U.S. Pat. No. 5,998,925, previously incorporated above, is disposed within a cavity 156 formed within the lower portion of the instrument head 128 wherein the LED includes at least one contact 160 that is placed in proximity with the upper facing contact 144 of the adapter 124. The lower facing contact 148 of the adapter 124 is arranged in relation to the retained batteries 168 disposed within the handle 132. A set of optics 172 are optionally disposed in relation to the LED die for coupling with the illumination output of the LED 152.

Referring to FIG. 12, a similarly designed LED electrical adapter 176 can assume other locations relative to the medical diagnostic instrument. The adapter 176, according to this embodiment, is disposed within a cavity 180 formed within the interior of the instrument head 177 along with an LED 188 having contacts that engage a printed circuit board 190 having the circuitry previously described. The adapter 176 further includes a lower contact 194 that engages the batteries (not shown) provided in the handle (not shown).

Referring to FIGS. 13-15, another embodiment of an LED electrical adapter is provided that includes a compact cartridge 200 that is sized so as to replace an existing battery typically retained within an instrument handle 204. The adapter cartridge 200 is preferably defined in a cylindrical shape and is sized similarly to that of a contained battery to permit fitting into the instrument handle 204 in lieu thereof. This electrical cartridge includes a slot 208 that retains specific voltage conversion means in the form of a voltage conversion means 220, having elements as defined above, the cartridge being disposed between one of the batteries 210 and the extending pin contact extending from the instrument head (not shown) as well as an extending negative contact strip 214 enabling a suitable electrical connection between the battery 210 and the LED (not shown). Each of the above assemblies can be retained in a housing (not shown for clarity) of convenient size.

In addition to and in complement of the herein described electrical adapter, an optical system can be added or modified to improve color. For example, a suitable filter and a collection lens can be placed at the light transmitting end of an LED having its top lens removed. The filter may also be part of this lens and the assembly may alternately be part of the LED or incorporated into part of the instrument head.

In addition to and in complement of the herein described electrical adapter, a means for detecting and switching the drive electronics from an LED version to an incandescent lamp version of a diagnostic instrument is beneficial, since this switching ability allows the same instrument to take advantage of each illumination system. There are several means for accomplishing this goal. The most basic technique is the incorporation of a mode switch which is manually actuated by the user of the instrument. This mode switch would connect the illumination to either the incandescent lamp drive circuitry or the LED drive circuitry based on the user's discretion.

The operation of an exemplary switch configuration is depicted in FIGS. 12(a) and 12(b) showing alternative illumination sources as previously described. In FIG. 12(a), an incandescent lamp 228 is disposed in a diagnostic instrument head 232, such as an otoscope head, the incandescent lamp having leads 236, 240 extending to respective contact surfaces 244, 248. Contact surface 244 is located at the bottom of the lamp module 252 in a proximal end of the instrument head while contact surface 248 is located adjacent the lamp module 252. A third contact surface 256 is established along the exterior of the instrument head 232, this portion of the head being separated from contact surface 244 by an insulator 260.

The operation of the mode switch is based upon the combination of contact surfaces engaged. According to this embodiment, the incandescent lamp 228 is energized by supplying electrical energy from the handle or otherwise between contact surfaces 256 and 244, each of which are in direct contact with the lamp module 252.

In the embodiment of FIG. 12(b), on the other hand, an LED module 266 is situated in the instrument head 232 wherein the LED 270 is energized by supplying electrical energy between contact surfaces 244 and 248, each of which are in direct electrical contact with the LED module through respective electrical contacts 274 and 278 via electrical adapter 60.

As described, the adapter can provide a means for different contacts for the LED and the incandescent lamp, such that simply inserting the desired illumination device automatically selects the proper drive circuitry/configuration. In yet another alternative of the invention, the mechanical contact geometry can be the same for both illumination devices, and the adapter electronics can detect the presence or lack of polarity whether the illumination is an LED (polarized) or an incandescent bulb (not polarized). The above objective can be accomplished, in a preferred embodiment, using a microcontroller system such as illustrated in FIG. 16.

Referring to FIG. 16, a microcontroller U1 turns on half H-bridges Q1/2 and Q3/4 sequentially and checks the resulting voltage at resistors R1 and R2. If the resulting voltage is the same, this provides an indicator that the current flow is symmetric in both directions, indicating a non-polarized illumination device and therefore the device located at U4 in this circuit would be determined to be an incandescent lamp. If the voltage is different between R1 and R2, the device would be determined to be polarized, indicating that the device located at U4 is an LED. In addition, the direction of polarity would also be known allowing the drive circuitry to be properly connected. One further benefit of the above detection scheme is that it would also allow detection of blown lamps or LED's if the current flow in each direction tested was found to be essentially zero. It is also noted that microcontroller U1 is presumed to include an analog to digital converter that is used to convert the analog voltage present at R1 and R2 to a digital reading. While there are several microcontrollers which have this feature, the analog to digital converter could be implemented separately if needed. Also, the drive circuitry and connection to U4 is intentionally left out of this diagram for the sake of simplicity and to convey the essential concepts of the invention. However it should be obvious to one of sufficient skill in the field that it can be accomplished even as simply as adding additional H-bridge sections (not shown) under microcontroller control.

Parts List for FIGS. 1-16

10 medical diagnostic instrument  
10A, 10B diagnostic instrument  
14 instrument handle  
14A, 14B instrument handle

18 instrument head  
18A, 18B instrument head  
22 miniature halogen lamp  
25 lamp housing  
5 26 batteries  
27 base  
27A, 27B base  
28A, 28B upper end  
29 contact  
10 30 adjustable voltage control  
31 pin  
32 ears  
33 contact spring  
36 light transmitting ends  
15 37 ears  
38 optical fibers  
39 contact pin  
40 tip portion  
42 distal tip opening  
20 44 bayonet  
46 eyepiece  
48 proximal end  
50 instrument handle  
52 cord  
25 54 wall transformer  
60 electrical LED adapter  
64 LED package  
84 AC or DC converter  
100 current compensation portion  
30 120 instrument  
124 adaptor module  
128 instrument head  
132 handle  
136 housing  
35 140 printed circuit board  
144 contact  
148 contact  
152 LED  
156 cavity  
40 160 contact  
168 batteries  
172 optics  
176 adapter  
177 instrument head  
45 180 cavity  
188 LED  
190 printed circuit board  
194 lower contact  
200 cartridge  
50 204 handle  
208 slot  
210 batteries  
214 negative contact strip  
220 voltage conversion means  
55 228 incandescent lamp  
232 instrument head  
236 lead  
240 lead  
244 contact surface  
60 248 contact surface  
252 lamp module  
256 contact surface  
260 insulator  
266 LED module  
65 270 LED  
274 electrical contact  
278 electrical contact

## 11

Though the following description has been made in terms of certain embodiments, it will be readily apparent that other modifications and variations are possible which encompass the spirit and scope of the herein claimed invention.

We claim:

1. An adapter for use with a medical diagnostic instrument originally configured with an incandescent lamp as an illumination source and a power supply specifically designed for powering said incandescent lamp, *and wherein:*

said adapter [having means] *is configured* for permitting at least one LED to be used as the illumination source for said instrument and permitting said power supply to be used without alteration to enable [energization of] *proper supply of electrical power to* said at least one LED, and

[means] *said adapter employing adapter electronics* for matching a polarity of said supply of electrical power between said power supply and said at least one LED [and said power supply].

2. An adapter as recited in claim 1, wherein said at least one LED is a white LED.]

3. An adapter as recited in claim 1, including means for limiting current supplied to said at least one LED by said power supply.

4. An adapter as recited in claim 3, including means for boosting the voltage supplied to said at least one LED by said power supply.

5. An adapter as recited in claim 1, including means for compensating current drawn by said at least one LED from said power supply.

6. An adapter as recited in claim 5, including means for boosting voltage supplied to said at least one LED by said power supply.

[7. An adapter as recited in claim 1, wherein said adapter includes said at least one LED.]

8. An adapter as recited in claim 1, including at least one optical element disposed in relation to said at least one LED used as the illumination source.

[9. An adapter as recited in claim 8, including at least one optical filter disposed in relation to said at least one optical element.]

10. An adapter as recited in claim 1, including means for compensating the color sense of said at least one LED.

[11. An adapter as recited in claim 10, wherein said color sense compensating means includes means for boosting voltage supplied to at least one LED.]

12. An adapter as recited in claim 1, including means for compensating voltage supplied to said at least one LED from said power supply.

[13. An adapter as recited in claim 12, wherein said voltage compensating means includes means for boosting voltage supplied to said at least one LED.]

14. An adapter as recited in claim 1, including means for compensating the light output of said at least one LED.

[15. An adapter as recited in claim 14, wherein said light output compensating means includes means for boosting voltage supplied to said at least one LED.]

[16. An adapter as recited in claim 14, including means for dimming said at least one LED.]

[17. An adapter as recited in claim 10, including at least one optical filter.]

[18. A method for adapting a existing medical diagnostic instrument so as to incorporate at least one white LED as an illumination source, said existing instrument including a power supply for energizing a miniature incandescent bulb as an illumination source, said instrument including an existing instrument head and a existing instrument handle wherein

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said existing instrument head and said existing instrument handle include mating interconnecting ends which interlock said instrument head and said handle in a mechanical interconnection while simultaneously maintaining an electrical interface between said incandescent lamp and said power supply, said method including the steps of:

attaching an adapter between said instrument head and said instrument handle, said adapter including means for electrically interconnecting at least one LED and said power supply as well as means for mechanically interconnecting said instrument head and said instrument handle; and

mounting said at least one LED in one of said adapter and said instrument head.]

[19. A method as recited in claim 18, including the step of attaching a new instrument head having said at least one LED to said adapter.]

[20. A method as recited in claim 18, including the steps of removing said incandescent bulb from said instrument head and mounting said existing instrument head onto said adapter, wherein said at least one LED is disposed in said adapter.]

21. A diagnostic instrument comprising:

a power supply;

an incandescent light source disposed in said instrument that is powered by said power supply; and

an adapter including at least one LED light source, said adapter having circuitry to permit said at least one LED light source to operate with said power supply when said adapter is attached to said instrument, said adapter being interchangeable with said incandescent light source to permit alternative operation of each said light source.

22. A method of using a diagnostic instrument, said method comprising the steps of:

providing an instrument with a releasably removable incandescent light source powered by a power supply; removing the incandescent light source from the instrument; and

attaching an interchangeable adapter having an LED light source and circuitry that operates with said power supply when said adapter is attached to said instrument to permit alternative operation of said instrument of each said light source.

23. In combination, an adapter for use with a medical diagnostic instrument, said instrument including a power supply that is electrically configured for solely powering an instrument having an incandescent lamp as an illumination source, said medical diagnostic instrument including an instrument head, a hand-grippable handle and at least one LED disposed in said instrument as the illumination source thereof, said adapter including means for electrically and mechanically interconnecting said power supply, and said at least one LED to enable said at least one LED to be used as said illumination source of said instrument and for effectively energizing said at least one LED, said adapter being independently attached between said instrument head and said hand-grippable handle and wherein said instrument head and said hand-grippable handle further include interconnect means for interconnecting said instrument head to said handle for providing a mechanical interface and maintaining an electrical interface between said power supply and an incandescent lamp when an incandescent lamp is typically used in the instrument, and in which said adapter includes respective ends adapted to connect to said interconnect means to provide said mechanical interface while creating an electrical interface between said power supply and said at least one LED.

**[24.** A combination as recited in claim 23, wherein said adapter is independently attached between said instrument head and said band-grippable handle.]

**[25.** A combination as recited in claim 23, wherein said at least one LED is part of an LED module.]

**[26.** A combination as recited in claim 25, wherein said adapter is disposed in said LED module.]

**[27.** A combination as recited in claim 25, wherein said module includes at least one optical element disposed in relation to the output of said LED.]

**[28.** A combination as recited in claim 23, wherein said at least one LED is disposed in at least a portion of the instrument head.]

**[29.** A combination as recited in claim 23, wherein said at least one LED is disposed in at least a portion of the adapter.]

**[30.** In combination, an adapter for use with a medical diagnostic instrument, including a power supply that is electrically configured for solely powering an instrument having an incandescent lamp as an illumination source, said medical diagnostic instrument including an instrument as the illumination source thereof, said adapter including means for electrically and mechanically interconnecting said power supply and said at least one LED to enable said at least one LED to be used as said illumination source of said instrument and for effectively energizing said at least one LED, wherein said adapter permits said at least one LED to be energized by said power supply without modification thereof wherein said instrument includes at least one of at least one LED and an incandescent lamp as the illumination source, said combination further including means for selectively activating said adapter depending on the illumination source provided in said instrument, including means for sensing the type of illumination source in said instrument.]

**[31.** A combination as recited in claim 23, wherein said adapter permits said at least one LED to be energized by said power supply without modification thereof.]

**[32.** A combination as recited in claim 30, wherein said adapter is disposed in at least a portion of said instrument head.]

**[33.** A combination as recited in claim 30, wherein said adapter is disposed in at least a portion of the hand-grippable handle.]

**[34.** A combination as recited in claim 30, including mode switching means connected to said adapter for enabling said adapter if at least one LED is used as the instrument illumination source.]

**[35.** A combination as recited in claim 30, wherein said illumination source sensing means includes means for sensing whether there is a polarity difference between said power supply and the illumination source and means for automatically enabling said adapter if there is a sensed polarity difference.]

**[36.** A combination as recited in claim 33, wherein said handle is modified to permit use of said at least one LED.]

**[37.** A combination as recited in claim 30, wherein said adapter is disposed in at least a portion of the power supply of said instrument.]

**[38.** A combination as recited in claim 30, wherein said at least one LED is a white LED.]

**[39.** A combination as recited in claim 30, wherein said at least one LED is disposed in at least a portion of an LED module.]

**[40.** A combination as recited in claim 39, wherein said LED module is disposed in at least a portion of said instrument head.]

**[41.** A combination as recited in claim 39, wherein said LED module is disposed in at least a portion of said adapter.]

**[42.** A combination as recited in claim 30, wherein said at least one LED is disposed in at least a portion of the instrument head.]

**43.** A method for adapting a medical diagnostic instrument for use with at least one LED as an illumination source, said instrument including a power supply typically only electrically configured for energizing an incandescent lamp as an illumination source, said method comprising the steps of:

adding an adapter to at least one of an instrument head, an instrument handle and said instrument power supply and electrically connecting said adapter to said power supply and said at least one LED to energize same without modification to said power supply; and

matching the polarity between said at least one LED and said power supply.

**44.** A method as recited in claim 43, including the step of independently attaching an adapter between said instrument head and said handle.

**45.** A method as recited in claim 43, including the step of disposing said at least one LED into at least a portion of said adapter.

**46.** A method as recited in claim 43, including the step of limiting current supplied to said at least one LED by said power supply.

**47.** A method as recited in claim 43, including the step of adjusting voltage supplied to said at least one LED by said power supply.

**48.** A method as recited in claim 43, including the step of compensating current drawn by said at least one LED from said power supply.

**49.** A method as recited in claim 47, including the step of boosting voltage supplied to said at least one LED by said power supply.

**50.** A method as recited in claim 44, wherein said at least one LED is part of an LED module and in which said method includes the step of disposing said adapter in at least a portion of said LED module.

**51.** A method as recited in claim 44, including the step of providing a mechanical interface between said instrument head and said instrument handle that maintains an electrical interface between said power supply and said at least one LED, said at least one LED being located in one of the instrument head and the adapter.

**52.** A method as recited in claim 43, including the step of compensating the color sense of said at least one LED.

**[53.** A method as recited in claim 52, wherein said color sense compensating step includes the step of boosting voltage of said at least one LED.]

**[54.** A method as recited in claim 52, including the step of optically filtering said at least one LED.]

**55.** A method as recited in claim 43, including the step of compensating voltage supplied to said at least one LED from said power supply.

**[56.** A method as recited in claim 55, wherein said voltage compensating step includes the step of boosting voltage supplied to said at least one LED.]

**57.** A method as recited in claim 43, including the step of compensating the light output of said at least one LED.

**[58.** A method as recited in claim 57, wherein said light output compensating step includes the step of boosting voltage supplied to said at least one LED.]

**[59.** A method as recited in claim 57, including the step of dimming said at least one LED.]

**60.** A method as recited in claim 43, including the step of coupling at least one optical element in relation to the output of said at least one LED.

**[61.** A method as recited in claim 60, including the step of placing at least one optical filter in relation to said at least one optical element.]

**62.** A method for adapting a medical diagnostic instrument for use with at least one LED as an illumination source, said instrument including a power supply typically only electrically configured for energizing an incandescent lamp as an illumination source, said method comprising the steps of:

adding an adapter to at least one of an instrument head, and instrument handle and said instrument power supply and electrically connecting said adapter to said power supply and said at least one LED to energize same without modification to said power supply, wherein said instrument includes at least one of at least one LED and an incandescent lamp as the illumination source for said instrument, said method further including the additional steps of selectively activating said adapter depending on the illumination source provided in said instrument and of sensing the illumination source in said instrument.

**63.** A method as recited in claim 62, including the step of limiting current to said at least one LED from said power supply.

**64.** A method as recited in claim 62, including the step of compensating current drawn by said at least one LED from said power supply.

**65.** A method as recited in claim 63, including the step of boosting voltage supplied to said at least one LED from the power supply.

**[66.** A method as recited in claim 64, including the step of boosting voltage supplied to said at least one LED from the power supply.]

**[67.** A method as recited in claim 62, including the step of independently attaching an adapter between said instrument head and said handle.]

**68.** A method as recited in claim [67] 62, wherein said at least one LED is part of an LED module and in which said method includes the step of disposing said adapter in at least a portion of said LED module.

**69.** A method as recited in claim 62, including the step of disposing said at least one LED into at least a portion of said adapter.

**70.** A method as recited in claim 69, wherein said illumination sensing step includes the additional steps of determining if there is a polarity difference between said power supply and the illumination source and automatically enabling said adapter if there is a sensed polarity difference.

**71.** A method as recited in claim 62, including the step of compensating the light output of said at least one LED.

**[72.** A method as recited in claim 71, wherein said light output compensating step includes the step of boosting voltage supplied to said at least one LED.]

**[73.** A method as recited in claim 71, including the step of dimming said at least one LED.]

**74.** A method as recited in claim 62, including the step of compensating the color sense of said at least one LED.

**[75.** A method as recited in claim 74, wherein said color compensating step includes the step of boosting voltage of said at least one LED.]

**[76.** A method as recited in claim 75, including the step of optically filtering said at least one LED.]

**[77.** A method as recited in claim 62, including the step of compensating voltage supplied to said at least one LED from said power supply.]

**78.** A method as recited in claim [77] 62, wherein said voltage compensating step includes the step of boosting voltage supplied to said at least one LED.

**79.** A method as recited in claim 62, including the step of coupling at least one optical element in relation to the output of said at least one LED.

**[80.** A method as recited in claim 79, including the step of placing at least one optical filter in relation to said at least one optical element.]

*81. The adapter of claim 1, wherein said adapter electronics are employed for turning on a first half H-bridge and turning on a second half H-bridge sequentially, and measuring and comparing a first resulting voltage and a second resulting voltage respectively, and determining whether a non-polarized illumination source is used if the resulting voltages are equal or whether a polarized illumination source is used if the resulting voltages are different, and determining whether there is a direction of polarity based upon the comparing of the resulting voltages in order to supply electrical power with proper polarity to said at least one light emitting diode.*

*82. An adaptor that is configured for providing electrical power to a light-emitting diode that is incorporated into a hand held device that was originally designed to project light via an incandescent illumination source, said adapter comprising:*

*at least one output electrical contact through which output electrical power is transferred to at least one light-emitting diode;*

*at least one input electrical contact through which input electrical power is received from an electrical power supply that is designed to supply power to an incandescent light source; and*

*means for matching a polarity between said at least one light emitting diode and said power supply and wherein said adaptor is configured to transfer electrical power to said light emitting diode while said adaptor and said light-emitting diode are incorporated within a hand-held device,*

*said device having a body that is comprised of at least a first portion and a second portion that are mechanically attachable and detachable with respect to each other via a connection location of said device; and wherein said adaptor is configured to be incorporated into said device via insertion of said adaptor through said connection location of said device,*

*for enabling said device to use light from said light emitting diode.*

*83. The adaptor of claim 82, wherein said device has a first portion that is an instrument head and a second portion that is an instrument handle.*

*84. The adaptor of claim 82, wherein said adaptor is packaged within a one piece enclosure that includes or attaches to said light emitting diode.*

*85. The adaptor of claim 82, wherein said adaptor is packaged to include a battery that functions as said electrical power source.*

*86. The adaptor of claim 82, wherein said adaptor is current limiting.*

*87. The adaptor of claim 82, wherein said adaptor is configured to convert electrical voltage of said input electrical power to energize said light-emitting diode.*

*88. The adaptor of claim 82, wherein said adaptor is configured to convert said input electrical power to a proper polarity.*

*89. The adaptor of claim 88, wherein said adaptor includes a diode bridge and a AC to DC converter configured for converting said input electrical power to current limited direct current at said proper polarity.*

90. The adaptor of claim 82, wherein said adaptor is configured to be selectively operated to supply electrical power to either said light emitting diode or an incandescent light source, in accordance with respective requirements of either said light emitting diode or said incandescent light source. 5

91. The adaptor of claim 82, wherein said device is a medical diagnostic instrument.

92. The adaptor of claim 82, wherein said adaptor and said light-emitting diode are configured to be physically substituted for a non-light emitting diode light source. 10

93. The adaptor of claim 82, wherein said adaptor is configured to be incorporated into said device through one of a first interconnecting end and a second interconnecting end while said first interconnecting end and said second interconnecting end are detached from each other and wherein re-attachment of said interconnecting ends maintains electrical contact between said adapter and said light-emitting diode and between said adapter and said device. 15

94. The adaptor of claim 83, wherein the adaptor is incorporated into the instrument head. 20

95. An adaptor that is configured for providing electrical power to a light emitting diode, comprising:

at least one output electrical contact through which output electrical power is transferred to at least one light-emitting diode;

at least one input electrical contact through which input electrical power is received from an input electrical power source that is designed to supply power to a non light-emitting diode light source; and

means for matching a polarity between said at least one light emitting diode and said power supply, wherein said adaptor being configured to transfer power from said input electrical power source to said light emitting diode while said adaptor and said at least one light-emitting diode are incorporated into a hand held medical diagnostic device, enabling said device to project light from said at least one light emitting diode; and wherein 30 35

said device being configured to provide an opening through which to access said non light-emitting diode light source; and wherein

said adaptor is configured to be incorporated into said device via insertion of said adaptor through said opening of said device.

96. The adaptor of claim 95, where said transfer of power includes transformation of one or more characteristics of said input electrical power to characteristics of said output electrical power. 10

97. The adapter of claim 96, wherein said transformation includes transformation of at least one of a current, voltage and polarity characteristic of said power.

98. The adapter of claim 95, wherein said adaptor is configured to be incorporated into said device through one of a first interconnecting end and a second interconnecting end while said first interconnecting end and said second interconnecting end are detached from each other and wherein re-attachment of said interconnecting ends maintains electrical contact between said adapter and said at least one light-emitting diode and between said adapter and said device. 15 20

99. The adapter of claim 95, wherein said non light-emitting diode light source is an incandescent light source.

100. An adapter for use with a medical diagnostic instrument originally configured with an incandescent lamp as an illumination source and a power supply specifically designed for powering said incandescent lamp, 25

said adapter having means for permitting at least one LED to be used as the illumination source for said instrument and permitting said power supply to be used without alteration to enable energization of said at least one LED, and

means for matching a polarity between said at least one LED and said power supply. 30 35

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : RE44,806 E  
APPLICATION NO. : 12/572811  
DATED : March 18, 2014  
INVENTOR(S) : Chris R. Roberts et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Claim 70

Column 15

Line 46, please change "raid" to --said--

Signed and Sealed this  
First Day of July, 2014



Michelle K. Lee  
*Deputy Director of the United States Patent and Trademark Office*