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(54) **LED FLASHLIGHT AND HEAT SINK ARRANGEMENT**

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F21V 29/00 (2006.01)
F21L 4/00 (2006.01)

(52) **U.S. Cl.**
USPC **362/294**; 362/196; 362/200; 362/373

(58) **Field of Classification Search**
USPC 362/196, 200, 294, 373, 545, 547, 362/202–208, 646, 631, 249.02, 218, 345
See application file for complete search history.

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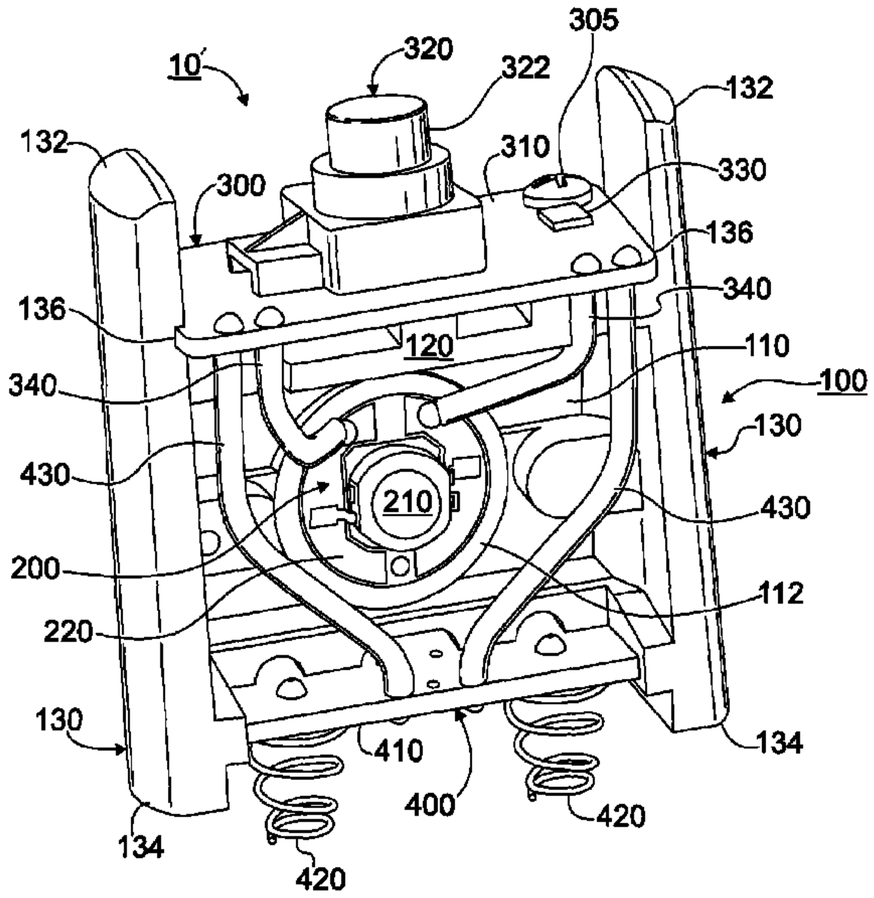
(57) **ABSTRACT**

An LED light may comprise a light emitting diode selectively energizable for producing light; an electronic circuit for selectively energizing the light emitting diode; and a heat sink of a thermally conductive material, wherein the light emitting diode is thermally bonded to the heat sink; and wherein the electronic circuit is attached to the heat sink. The light may have a pair of contact springs extending from the heat sink and the electronic circuit may include thermal conductivity enhancing features.

84 Claims, 5 Drawing Sheets



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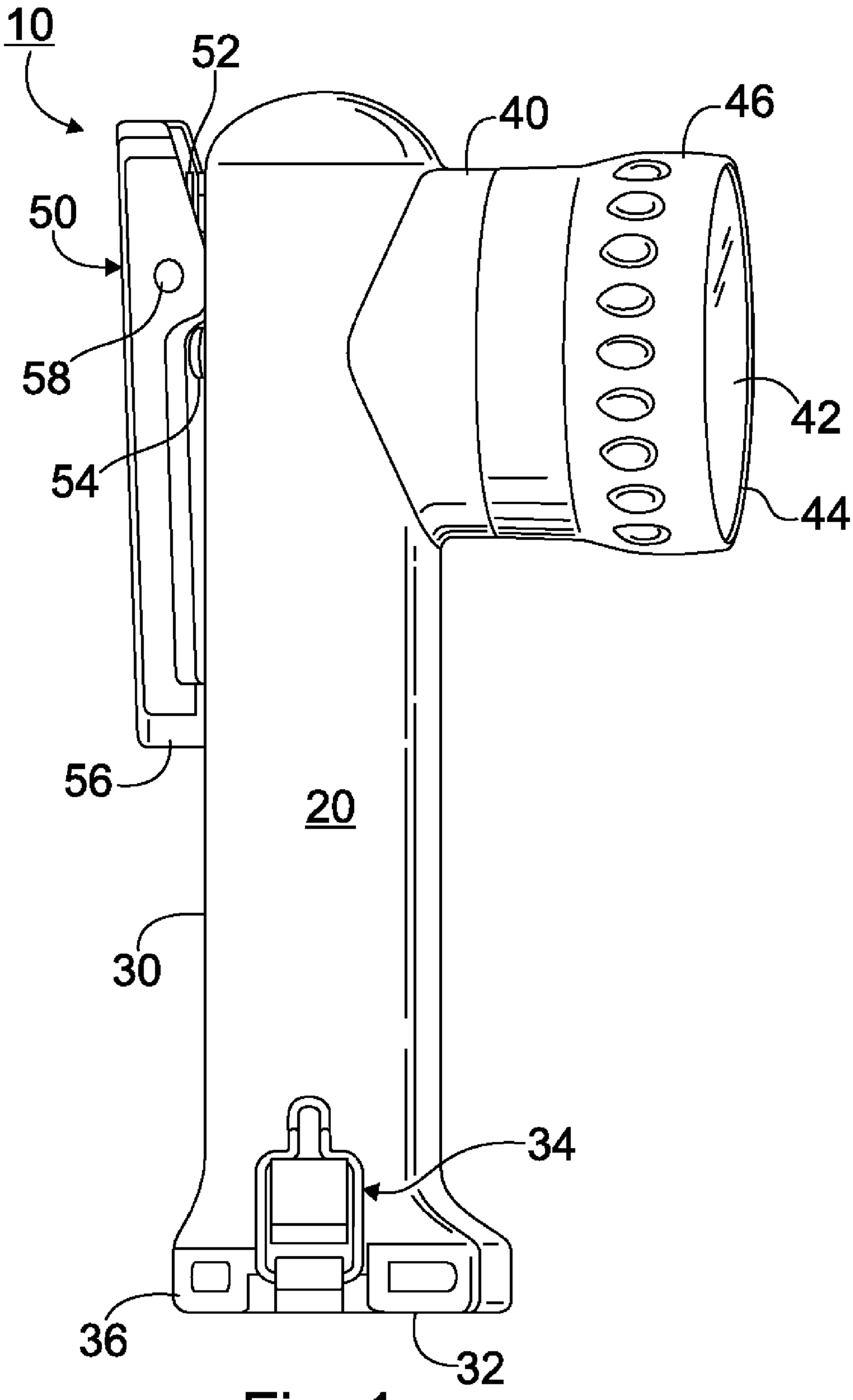


Fig. 1

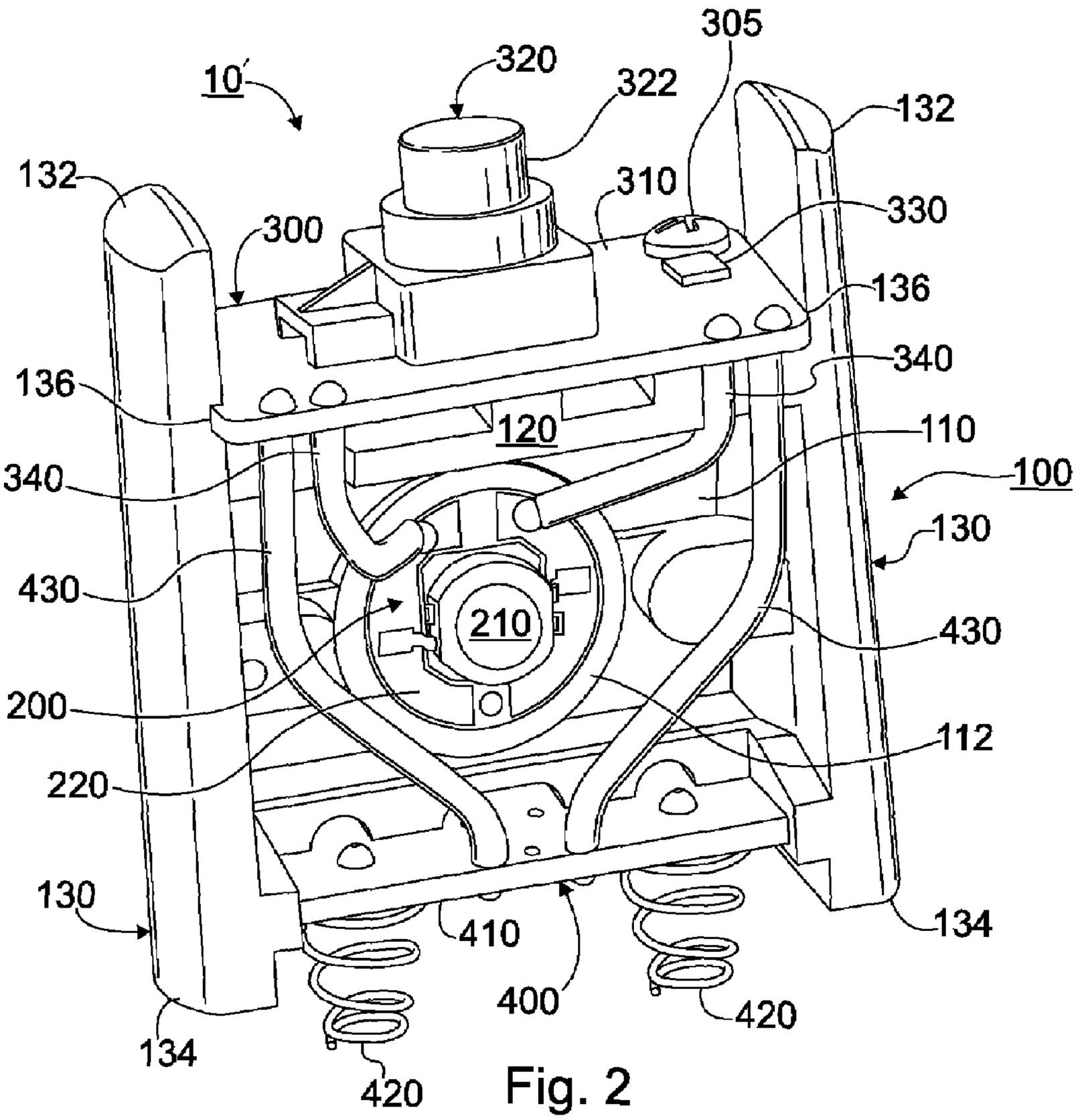
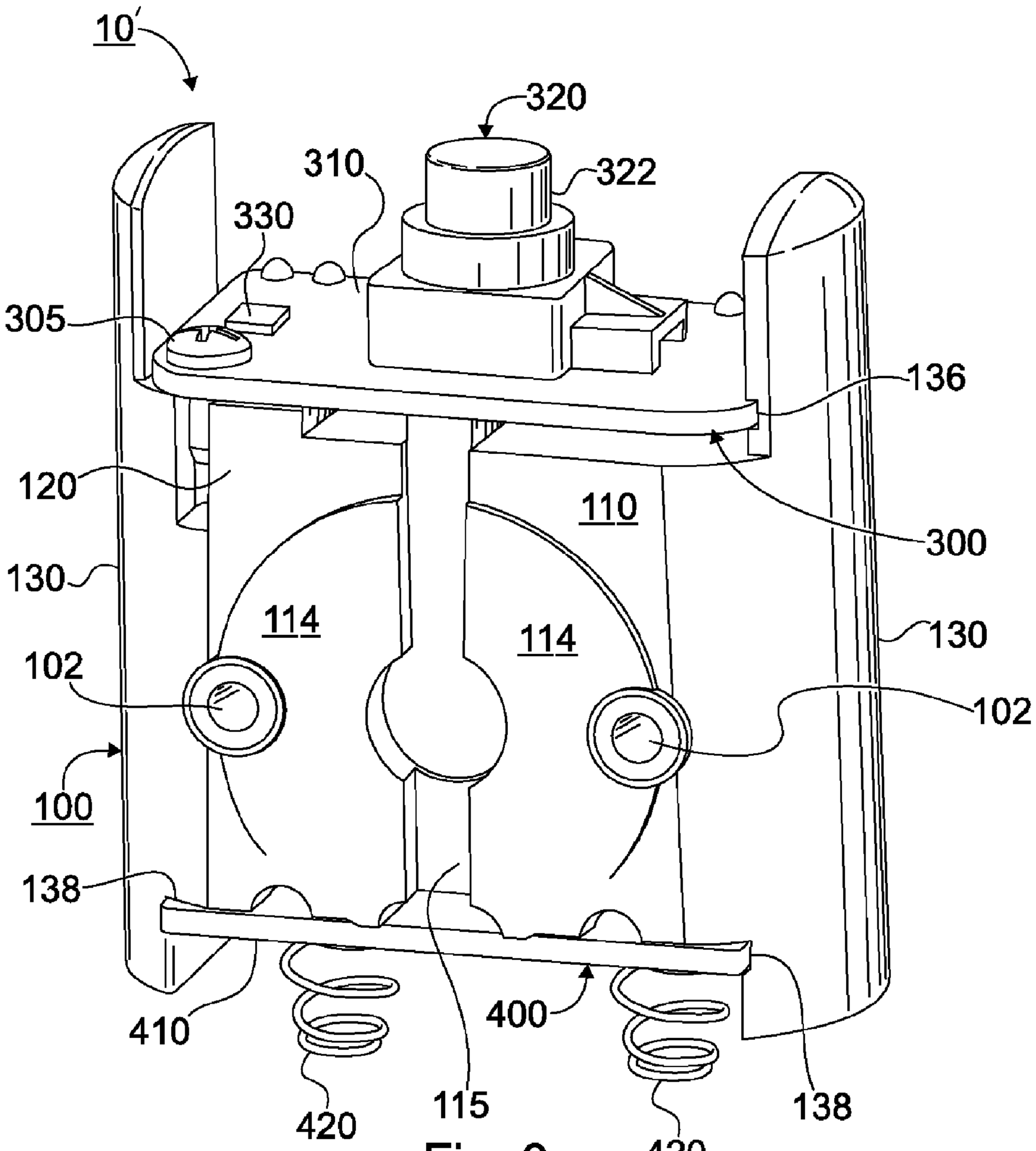

10'
320
322
305
132
310
330
300
136
340
120
110
100
130
430
210
200
112
220
130
410
134
400
420
420

Fig. 2


10'
320
310
322
330
305
136
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130
114
114
130
102
102
100
138
410
400
420
115
420
138

Fig. 3

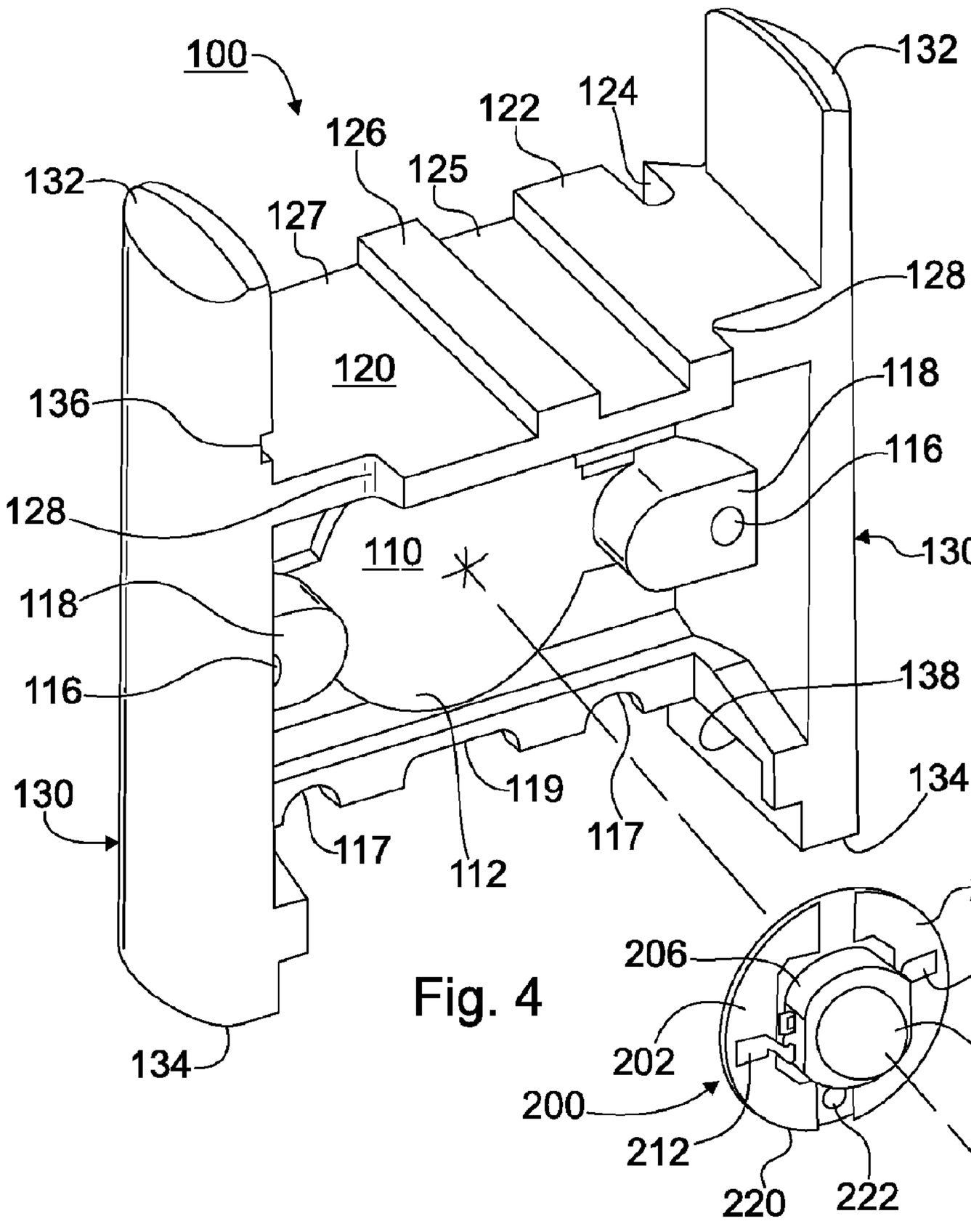

Fig. 4

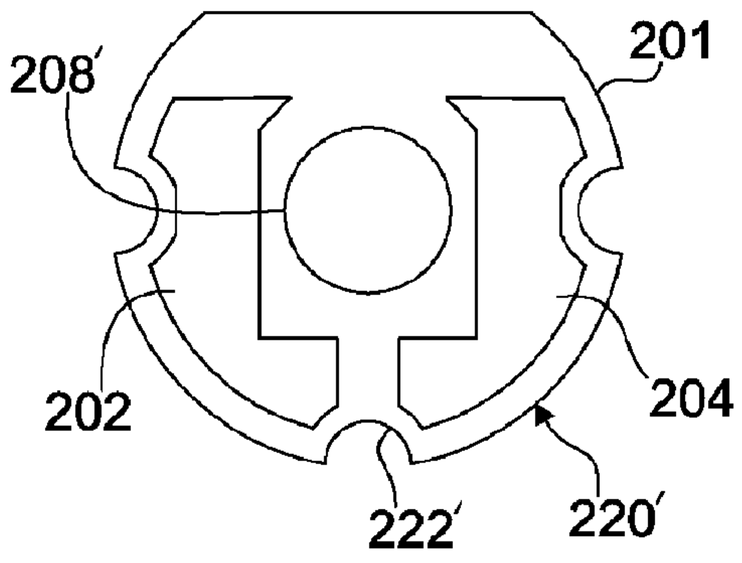

Fig. 4A

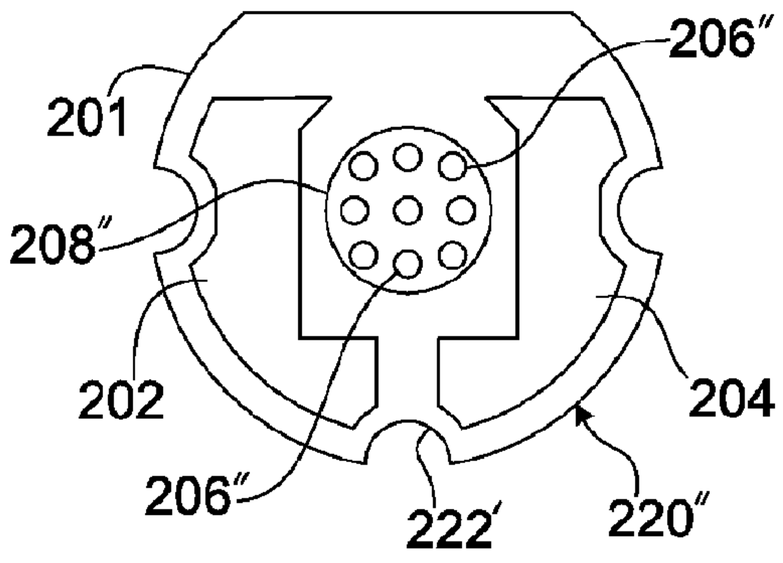

Fig. 4B

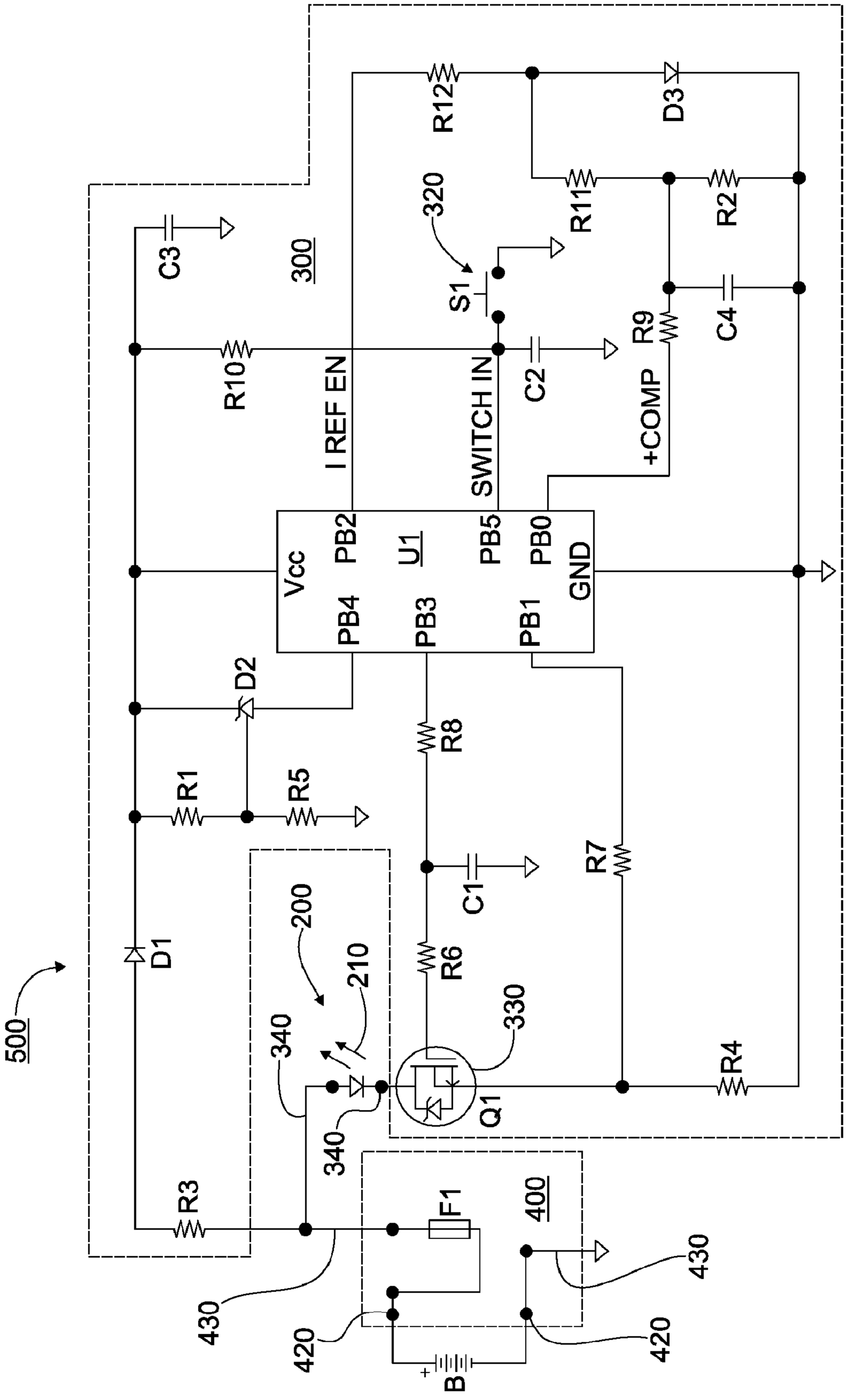
R12
D3
320
R11
R2
C3
300
S1
C4
R9
R10
I REF EN
SWITCH IN
C2
+COMP
Vcc
PB2
U1
PB5
PB0
GND
PB4
PB3
PB1
D2
R8
R1
R5
R7
C1
200
D1
210
R6
330
340
340
Q1
R4
R3
F1
400
430
430
420
420
B
500

Fig. 5

LED FLASHLIGHT AND HEAT SINK ARRANGEMENT

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.

This Application claims the benefit of U.S. Provisional Patent Application No. 60/832,106 filed Jul. 20, 2006, each of which is hereby incorporated herein by reference in its entirety.

The present invention relates to a light and, in particular, to a light having a light emitting diode and a heat sink.

Increasingly, flashlights and other portable lights are employing a solid state light source, such as a light-emitting diode (LED), particularly as the brightness of the available LEDs has improved and as LEDs have become available that produce bright "white" light.

Unlike incandescent lamps which depend upon the heating of a light producing filament to a high temperature to produce light, LEDs are desirably operated at lower temperatures at which their efficiency and reliability is better. Thus, whereas it was relatively unimportant in many instances to remove the heat generated by an incandescent lamp, it may be quite important that heat generated by a high-power LED be removed.

While incandescent lamps may be satisfactorily operated by applying a voltage, e.g., a battery voltage, directly to the lamp, such is not a desirable way in which to operate a solid state light source such as an LED. Thus, along with the use of LEDs as light sources in portable lights has come the utilization of electronic circuits for conditioning the electrical power provided by an electrical power source into a form more suitable for the LED, for example, for controlling the level of current flowing through the LED.

As such power regulating circuit technology has been developed, power regulating circuits have also come to be employed with incandescent light sources as well as with solid state light sources. As a result, portable lights have come to include electronic circuitry as well as the usual battery (or batteries) and light sources.

Because heat can be detrimental to electronic circuitry, there is a need to remove heat from such circuitry. In addition, certain failure and/or fault conditions may cause additional heat to be produced that could raise the temperature of electronic circuitry to a temperature that is not only detrimental to the circuitry, but that could also be a hazard or a danger to the circuitry or otherwise.

Accordingly, there is a need for light including a heat sink arrangement for removing heat from a light source and/or electronic circuitry of the light.

To this end, a light may comprise a light emitting diode selectively energizable for producing light; an electronic circuit for selectively energizing the light emitting diode; and a heat sink of a thermally conductive material, wherein the light emitting diode is thermally bonded to the heat sink; and wherein the electronic circuit is attached to the heat sink.

According to another aspect, a light may comprise a heat sink including a first generally rectangular planar member, two opposing elongated members each integrally joined to the first rectangular planar member, and a second generally rectangular member integrally joined to the two elongated members and to the first generally rectangular member. A light emitting diode may be attached to the first generally

rectangular planar member between the two elongated members and circuitry for energizing the light emitting diode may be attached to the second generally rectangular planar member between the two opposing elongated members.

BRIEF DESCRIPTION OF THE DRAWING

The detailed description of the preferred embodiment(s) will be more easily and better understood when read in conjunction with the FIGURES of the Drawing which include:

FIG. **1** is a view of an example embodiment of a light including the present arrangement;

FIG. **2** is an isometric view of a first side of an example embodiment of a light according to the present arrangement;

FIG. **3** is an isometric view of a second side of the example embodiment of a light according to FIGS. **1** and **2**;

FIG. **4** is an exploded isometric view of the heat sink and LED assembly of the example embodiment of a light according to FIGS. **1-3**;

FIGS. **4**A and **4**B are plan views of alternative example embodiments of a circuit board of an example LED assembly as shown in FIGS. **2** and **4**; and

FIG. **5** is a schematic diagram of an example electronic circuit useful with the light of FIGS. **1-4**.

In the Drawing, where an element or feature is shown in more than one drawing figure, the same alphanumeric designation may be used to designate such element or feature in each figure, and where a closely related or modified element is shown in a figure, the same alphanumerical designation primed or designated "a" or "b" or the like may be used to designate the modified element or feature. It is noted that, according to common practice, the various features of the drawing are not to scale, and the dimensions of the various features are arbitrarily expanded or reduced for clarity, and any value stated in any Figure is given by way of example only.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

FIG. **1** is a view of an example embodiment of a light **10** including the present arrangement. Light **10** includes a housing **20** including a portion **30** in which a battery or batteries may be provided and a portion **40** in which are a reflector **42** and light **10'** and a source of electrical power such as a battery **40**. Housing portion **40** may be angled with respect to housing portion **30**, e.g., approximately perpendicularly as illustrated, or at another angle, or housing portions **30**, **40** may be axially aligned, as may be desired. In the illustrated arrangement, light **10** may desirably be placed with base **32** on a generally horizontal surface or into a charger unit and remain standing thereon with light produced by light **10'** emanating outwardly in a generally horizontal direction.

A light **10'** (not visible, described below) may be disposed at the base of reflector **42** internal to housing **20** substantially at the intersection of the rear of light housing **40** and the upper end of battery housing **30**, thereby to project a beam of light from reflector **40** through lens **44**. Within housing **20** of light **10** is a heat sink **100** (not visible, described below) which generally conforms to the geometry and shape of housing **20** and which dissipates heat generated by light **10'** therein and which supports the light source and electronic control circuitry therefor.

Battery housing portion **30** may include at its base **32** an access cover **36** that has hinges and/or clasps **34** for attaching cover **36** to battery housing portion **30** and through which the battery or battery may be inserted and removed, and may

optionally include contacts for making electrical connection with a charger unit into which light **10** may be placed for charging the battery in housing portion **30**.

Light source housing portion **40** may include a ring member that removably attaches to housing portion **40**, e.g., in a threaded engagement therewith, for retaining reflector **42** and lens **44** in housing portion **40**. Ring member **46** could be rotatable for manipulating a mechanism for adjusting the shape and/or focus of the beam of light produced by light **10** and projected outwardly through lens **34**.

Housing **20** may also include a clip **50**, e.g., secured at the rear of housing **20** by screws **54** engaging housing **20** and heat sink **100** therein, as described below. Optionally, clip **50** may be pivoted, e.g., on pivot pin **58**, and end **56** of clip **50** may be biased against housing **20** by a spring **52** and so the end **56** of clip **50** may be moved toward and away from housing **20**, thereby to facilitate clipping light **10** to a pocket, belt or other item, as may be convenient and/or desirable. Clip **50** may have an optional projection extending from end **56** towards housing **20** (as illustrated) or not.

Typically, battery housing portion **30** may have a race-track or oval shaped cross-section, e.g. for receiving four size AA battery cells in a side-by-side arrangement, and light source housing portion **40** may be circular in cross-section. The four AA size battery cells may be alkaline cells, rechargeable NiCd cells, or another suitable battery cell(s), and may be utilized as cells or may be disposed in a common package to be a battery pack.

Although terms such as front, back, top, bottom, and side may be employed in describing the example embodiment as illustrated by the FIGURES, the present arrangement may be utilized in any orientation, and so what is termed top or bottom herein may or may not be the top or bottom in utilization, what is termed front or back may or may not be the front or back in utilization, and so forth.

FIG. **2** is an isometric view of a first side (or front side) of an example embodiment of a light **10'** and FIG. **3** is an isometric view of a second side (or rear side) of the example embodiment of light **10'** according to the present arrangement. Light **10'** may comprise a heat sink **100**, a light emitting diode (LED) assembly **200** attached thereto, and electronic circuit boards **300**, **400** attached thereto. A source of electrical power, such as a battery, may be connected to circuit board **400** and light **10'** may be, and typically is, disposed in a case or housing.

When light **10**, **10'** is operated under normal operating conditions, certain electronic components thereof, e.g., the light source (e.g., LED assembly **200**) and a control device for the light source (e.g., component **330** on circuit board **300**), typically generate heat that must be dissipated to prevent the temperature of such components from increasing excessively, e.g., to where such component could be damaged or fail, or to where a dangerously high temperature occurs. In normal operation, the light source is typically the predominant generator of heat.

In addition, under fault conditions such as the failure of an electronic component or a short circuit, the light source (e.g., LED assembly **200**) and components controlling the light source (e.g., component **330** on circuit board **300**) may generate more heat than under normal conditions. Under fault conditions, the control device often typically generates substantially greater heat than other components and than it does under normal operation.

Thus heat sink **100** serves the dual functions of dissipating heat from the light source **200** under normal operation and of dissipating heat from other components under fault conditions. Desirably, heat sink **100** dissipates sufficient heat under both normal and fault conditions such that no component will reach or exceed a temperature which is considered by Underwriters' Laboratory (UL) to be dangerously hot, thereby to be eligible for UL approval of light **10**, **10'** as a Class I, Division I, device. For UL approval for use in an environment subject to T4 gases, the maximum allowable component temperature for UL approval is 200° C. when the light is in a 40° C. ambient temperature environment. In addition, heat sink **100** also serves the functions of supporting LED **210**, of positioning LED **210** to be aligned with reflector **30** of light **10**, and of supporting electronic circuit board **300** that controls the operation of LED **210**.

Heat sink **100** includes a first generally rectangular member **110** that is generally planar and that has front and back broad surfaces. Heat sink **100** may include two elongated members **130** that are **[**integrallyjoined**]** *integrally joined* to opposing edges, e.g., side edges, of first generally rectangular member **110**, and each opposing elongated member **130** typically has opposing ends **132**, **134** that extend beyond the top and bottom edges of first generally rectangular member **110**.

A second generally rectangular member **120** is integrally joined to one edge, e.g., the top edge, of first generally rectangular member **110**, and between the two elongated members **130** to which its opposing ends are **[**integrallyjoined**]** *integrally joined*. Typically, because ends **132**, **134** of elongated members **130** in the example embodiment extend beyond the top and bottom edges of first generally rectangular member **110** and beyond second generally rectangular member **120**, and so heat sink **100** may be described as having an "H"-like shape.

LED assembly **200** is attached to one of the broad surfaces, e.g., the front surface, of first generally rectangular member **110**, and is typically bonded to a central region of the front surface thereof by a suitable thermally conductive adhesive. As a result LED **210** of LED assembly is thermally coupled to heat sink **100** for facilitating the removal of heat produced by LED **210** when it is energized to produce light. LED assembly **200** includes light emitting diode (LED) **210** that may attached for convenience in assembly to an electronic circuit board (described below) for making electrical connections between LED **210** and electronic circuit board **300**, such as by conductors **340**, e.g., insulated wires **340**. Conductors **340** may be electrically connected to circuit board **300** by soldering, by electrically conductive adhesive, by mechanical crimping or swaging, or by another suitable connection.

Electronic circuit board **300** typically carries electronic circuitry for controlling the energization of LED **210**, and may comprise an electronic circuit board substrate **310** on which are provided various conductors and electronic components in conventional fashion, e.g., on either or both of the broad surfaces thereof. Examples of such electronic components carried on substrate **310** may include, e.g., an electrical switch **320** directly or indirectly energizing and de-energizing LED **210**, an electronic control device **330** for applying, removing and/or regulating or otherwise controlling electrical power applied to LED **210**, and optionally various integrated circuits, transistors, diodes, resistors, capacitors, and the like.

Electronic circuit board **300** may be attached to heat sink **100** in various ways, however, a preferred attachment includes circuit board **300** being adjacent to second generally rectangular member **120**, e.g., for facilitating removal of heat from the electronic components thereon. While such heat may be produced in normal operation of light **10'**, additional heat may be produced under a fault condition, e.g., damage to or failure of an electronic component on circuit board **300** or of LED **210** or of an electrical short circuit.

In one such mounting arrangement for circuit board **300**, a groove **136** is provided in one elongated member **130** adjacent second generally rectangular member **120** for supporting a first end of circuit board **300** and a fastener **305**, such as a screw or bolt, supports another end of circuit board **300**. In particular, it is preferred that electronic components, such as a control device **330**, that may generate substantial heat under normal operation and/or under a fault condition be disposed on circuit board substrate **310** in a location that is proximate to fastener **305**, thereby to be thermally coupled to second generally rectangular member **120** by a relatively short thermal conduction path.

Control device **330** may be, e.g., a transistor that controls application of electrical power to LED **210**, such as a MOSFET transistor, that operates as a power switching device, as a power controlling device, as a power regulating device, or for otherwise controlling electrical voltage or current. Circuit substrate **310** may include substantial electrical conductor area, a thicker electrical conductor, conductive vias, or another arrangement, proximate to the location thereon where fastener **305** attaches circuit board **300** to heat sink **100** for reducing the thermal resistance between one or more heat generating components, e.g., control device **330**, and heat sink **100**. While a thermally conductive grease or adhesive may be employed between circuit board **300** to heat sink **100**, it has been found that fastener **305** alone typically is sufficient and that such thermal grease or adhesive is not needed in the example arrangement.

Heat sink **100** in the example embodiment preferably is sufficient to dissipate and/or distribute heat generated by light **10'** under normal operation and fault conditions without having an exposed surface or being attached to a highly thermally conductive case or housing. Examples of fault conditions might include a short circuit of LED **210** or a short circuit directly applying full battery voltage to LED **210**. Under normal operation and fault conditions, heat sink **100** maintains LED **200**, **210** and all electronic components including certain power handling components on circuit board **300** to a safe temperature, e.g., to a temperature less than 200° C., whereby light **10**, **10'** is eligible for Underwriters' Laboratory (UL) certification as a Division I, Class I, device and/or in a T4 gas environment.

Electronic circuit board **400** includes circuit board substrate **410** that carries electrical conductors and various electronic and other components in conventional fashion. Electrical contacts **420**, which may be coiled spring-like structures of electrically conductive wire, extend from circuit board substrate **310** in a direction away from heat sink **100** for making electrical contact with the terminals of a battery or other source of electrical power for light **10'** and that may be carried either externally to light **10'** or in a case or housing thereof. Electrical power from such power source may be carried by conductors **430**, e.g., insulated wires **430**, connecting between electronic circuit board **400** and electronic circuit board **300**. Conductors **430** may be electrically connected to circuit boards **300** and **400** by soldering, by electrically conductive adhesive, by mechanical crimping or swaging, or by another suitable connection.

Electronic circuit board **400** is preferably attached to heat sink **100**. For example, heat sink **100** may have a pair of opposing grooves or slots **130** in opposing elongated members **130** into which circuit board **400** is inserted. Because circuit board **400** in the example embodiment does not carry electronic components that would produce significant heat under either normal operation or fault conditions, it is not necessary to provide good thermal coupling between circuit board **400** and heat sink **100**. Should such components be carried by circuit board **400**, then circuit board **400** could be attached to heat sink **100** is similar manner to that employed for circuit board **300**.

Heat sink **100** may have one or more features for increasing its thermal conduction capability. For example, a raised circular area **112** on the front surface of first generally rectangular member **110** may be provided to increase the thickness of member **110** proximate to where LED assembly **200** is attached thereto, thereby to reduce the thermal resistance and increase the thermal mass of member **110**. In addition, raised ridges may be provided extending from the raised circular area to further reduce thermal resistance and increase thermal mass. Two raised substantially semi-circular features **114** on the rear surface of heat sink **100** have a similar benefit.

Substantially semi-circular features **114** also provide surfaces that can contact the interior surface of housing **20** when screws **54** are tightened, and define a groove or slot **115** which allows any gas that might be generated by the battery or batteries in housing portion **30** to flow upward to a venting valve (not visible) typically located near or at the top of light **10** proximate light portion **40**.

Heat sink **100** is typically and preferably disposed in a case or housing in use, and may be provided with a means for attaching heat sink **100** to such case or housing. For example, one or more holes **102** may be provided on the rear surface of heat sink **100** to receive fasteners inserted through corresponding holes in the case or housing. Holes **102** may be tapped or have threaded inserts to receive screws or bolts, or may receive self-tapping or other fasteners. The fasteners that engage holes **102** may also be utilized to attach a part or parts to the outside of the case or housing, e.g., to attach a pocket clip, a belt clip, a spring-loaded clip, a lanyard ring, and/or other part.

Heat dissipation by heat sink **100** includes conducting heat from the relatively small areas whereat heat is generated, e.g., at LED **210** and/or at control device **330** on circuit board **300**, to the various members of heat sink **100**, thereby to reduce temperature by spreading the heat over a substantially larger area and/or by allowing heat to be dissipated over that substantially larger area.

For example, heat generated by LED **210** on first generally rectangular member **110** is conducted due to the relatively high thermal conductivity of heat sink **100** from first generally rectangular member **110** to second generally rectangular member **120** and to both elongated members **130** which would tend to be cooler because there is no heat generating element thereon. Similarly, heat generated by control device **330** on electronic circuit board **300** is conducted through circuit board substrate **310** and fastener **305** to second generally rectangular member **120** is conducted due to the relatively high thermal conductivity of heat sink **100** from second generally rectangular member **120** to first generally rectangular member **110** and to both elongated members **130** which would tend to be cooler because there is no heat generating element thereon.

If and when both LED **210** and control device **330** were to be generating substantial heat at the same time, the heat therefrom is conducted to first and second generally rectangular members **110**, **120** and from first and second generally rectangular members **110**, **120** to both elongated members **130** which would tend to be cooler because there is no heat generating element thereon.

In addition to heat conduction through heat sink **100** due to the relatively high thermal conductivity thereof, heat is also removed to a lesser extent by convection and by radiation, e.g., from the elements that are generating substantial heat as well as from the surface of heat sink **100**. Further, removal of

heat from heat sink **100** is thought to be aided by the exterior of heat sink **100**, e.g., by the curved outer surfaces of elongated members **130**, being shaped to generally conform geometrically to the interior surface of housing **20** in which heat sink **100** is disposed.

Because heat sink **100**, e.g., as in the example embodiment, preferably is sufficient to dissipate and/or distribute heat generated by light **10'** under normal operation and fault conditions without having an exposed surface or being attached to a highly thermally conductive case or housing. Thus, the case or housing of light **10**, **10'** need not be made of a thermally conductive material

Typically, certain external surfaces of heat sink **100** may be shaped to conform to the inside configuration of a case or housing, e.g., in the example embodiment, elongated members **130** are extended and have curved outer surfaces to conform to the height and shape of a housing that has a flat rear surface and curved side surfaces. Such housing may have a flat top surface through which actuator **322** of switch **320** may be actuated, either directly or through a flexible boot or button.

FIG. **4** is an exploded isometric view of heat sink **100** and LED assembly **200** of the example embodiment of a light **10'** according to FIGS. **1-3**. Heat sink **100** and LED assembly **200** are described above and so that description will not be repeated here except in relation to certain features more evident in FIG. **4**.

First generally rectangular member **110** is seen to have a raised circular feature **112** on the front face thereof which provides a convenient flat surface on which to attach LED assembly **200**. Because raised circular feature **112** increases the thickness of generally rectangular member **110**, it also reduces the thermal resistance and increases the thermal mass of heat sink **100**. A bevel may be provided along the edge where first and second generally rectangular members **110**, **120** join, which increases the thermal mass and reduces thermal resistance therebetween.

Second generally rectangular member **120** is seen to have a generally planar raised area **122** against which one end of circuit board **300** may bear, preferably the end of circuit board **300** that carries electronic components that generate heat under normal operation and/or under fault conditions. Slot or hole **124** therein is for receiving fastener **305** which attaches circuit board **300** to second generally rectangular member **120**. Raised ridge **126** may be flat at its top and may provide support for circuit board **300** in a region thereof under electrical switch **320** so that circuit board **300** can withstand any stress caused by a user pressing on actuator **322** of switch **320**. Area **122** and ridge **126** define a recess **125** therebetween and ridge **126** and elongated member **130** define a recess therebetween that may provide clearance between second generally rectangular member **120** and circuit board **300** for leads of electronic components and solder areas of circuit board **300**. Because raised area **122** and raised ridge **126** increase the thickness of second generally rectangular member **120**, they also reduce the thermal resistance and increase the thermal mass of heat sink **100**.

LED assembly **200** comprises LED **210** and electronic circuit board **220**. LED **210** is preferably an LED that produces substantial light so as to be useable for general illumination, e.g., as a flashlight. LED **210** is preferably a white emitting LED and is typically rated as a one-watt LED or greater. LED **210** is typically provided by the manufacturer in the form of an integrated package including a small heat sink, e.g. a thermally conductive disc, on which the actual diode element that emits light is mounted and encapsulated in clear plastic to provide a lens, and from which two electrical contacts **212**, **214** extend for making electrical connection to the diode element.

Electronic circuit board **220** typically has two conductive areas **202**, **204** to which electrical contacts **212**, **214** of LED **210** are electrically and mechanically connected, e.g., by soldering or by electrically conductive adhesive, so that LED **210** and circuit board **220** are attached to each other and may be handled as an assembly **200**. Conductors **340** may be electrically connected to conductive areas **202**, **204** of circuit board **220**, e.g., by soldering or by electrically conductive adhesive. Circuit board **220** is conveniently circular in shape and has a central opening **206** into which LED **210** is disposed when contacts **212**, **214** are connected to conductive areas **202**, **204**. Specifically, the integral heat sink of LED **210** is disposed in opening **206** so that it is exposed at the rear of LED assembly **200** and may be bonded to circular area **112** of heat sink **100**.

LED assembly **200** is preferably attached to circular area **112** of first generally rectangular member **110** of heat sink **100** by bonding with a thermally conductive adhesive so as to provide for the conduction of heat from LED **210** to heat sink **100**, thereby to reduce the temperature to which LED **210** rises when energized to less than, e.g., 200° C. Desirably, because LED **210** is exposed at the rear of LED assembly **200** through opening **206**, the heat sink integral to LED **210** is thermally bonded directly to heat sink **100**, thereby to increase heat transfer from LED **210** to heat sink **100**. It is noted that circuit board **220** may be provided for convenience in assembly and attachment of LED **210** to heat sink **100** and in making electrical connections to LED **210**, but circuit board **220** is not necessary to the satisfactory operation of light **10**, **10'** as described.

LED **210** is desirably placed in a predetermined location on heat sink **100** so that when heat sink **100** is in light **10**, LED **210** and reflector **30** of light **10** will be in desired relative positions for producing a beam of light of a desired shape. Proper relative positioning may be provided by positioning and bonding LED **210** on heat sink **100** within suitable tolerance, and by positioning heat sink **100** in light **10** within suitable tolerance. To this end, heat sink **100** may include alignment features, e.g., alignment holes **116**, to aid in properly positioning LED **210** in relation to heat sink **100**.

For example, heat sink **100** may include two or more alignment holes **116** the locations of which are accurately known with respect to the center of circular area **112** of heat sink **100**. An alignment tool may be provided that has two alignment features that are in known positions for engaging alignment features **116** of heat sink **100**, e.g., two posts or projections that may be inserted into alignment holes **116**. The alignment tool may also have a recess into which LED **210**, specifically the plastic lens of LED **210**, fits so as to be in a known position relative to the alignment projections thereof that engage alignment holes **116**. Thus, when LED **210** or LED assembly **200** is placed in the alignment tool and the alignment tool is placed adjacent heat sink **100** with its alignment projections in alignment holes **116** of heat sink **100**, LED **210** will be in the desired location on heat sink **100** to within the desired tolerance, thereby to properly align with reflector **30** of light **10**.

Alternatively and optionally, circuit board **220** may have an alignment hole **222** therein for positioning LED **210** in a known predetermined location relative to circuit board **220**, or for engaging a corresponding alignment feature, e.g., a projection or post, of the alignment tool. Where alignment hole **222** is utilized for positioning LED **210**, LED **210** is accurately located in relation to circuit board **220**. Alterna-

tively, central opening **206** of circuit board **220** may be accurately shaped and sized to receive LED **210** with suitable accuracy so that LED **210** and circuit board **220** are accurately positioned in relation to each other. Alternatively, the alignment tool may have a feature that engages alignment hole **222**, which may be used so that LED **210** and LED assembly **200** can be placed on and bonded to heat sink **100** with suitable tolerance.

In a typical assembly sequence, LED **210** and wires **340** are soldered to circuit board **220**, thermally conductive adhesive is applied to LED assembly **200** or to circular area **112** of heat sink **100**, LED assembly **200** is placed into the alignment tool, the alignment tool is placed adjacent heat sink **100** with its alignment projections in alignment holes **116** thereof to press LED assembly towards heat sink **100** so that it becomes thermally bonded thereto by the thermally conductive adhesive. Alternatively, thermally conductive adhesive may be placed on LED **210** in sufficient amount that it will spread to bond circuit board **220** as well as LED **210** to heat sink **100**. In either case, a predetermined amount of adhesive is typically dispensed onto heat sink region **112** or onto the rear surface of LED **210**, and the adhesive spreads when LED **210** is pressed against heat sink raised region **112** so as to bond both LED **210** and optional circuit board **220** thereto. Circuit board **300** may then be placed in groove **136** and adjacent to second generally rectangular member **120** and attached thereto by a screw **305**, circuit board **400** may be placed into grooves **138**, and wires **340** and **430** may be soldered to circuit boards **300** and **400**. Such assembly sequence may be automated in whole or in part, or may be performed manually.

Heat sink may **100** may include raised projections or lugs **118** to provide sufficient material into which to open alignment holes **116**. In the example embodiment illustrated, lugs **118** are larger than needed for alignment holes **116** so that lugs **118** also provide material into which holes **102** may be made from the rear of heat sink **100**.

Heat sink **100** may also have recesses, cut-outs, notches and/or grooves to provide clearance or additional clearance for certain elements. For example, first generally rectangular member **110** may have recesses, notches or grooves **117** in the edge thereof adjacent to circuit board **400** for providing clearance for ends of contact springs **420** that extend through circuit board substrate **410** of circuit board **400** and are soldered thereto, and may have a recess, notch or groove **119** for facilitating placement of circuit board **400** when conductors **430** are attached thereto. Second generally rectangular member **120** may have cut-outs or notches **128** through which conductors **340** and **430** may pass for connection to circuit board **300**.

In an example embodiment, heat sink **100** is of die-cast aluminum and has an anodized surface coating so as to be electrically insulated while being highly thermally conductive, as is preferred. Such heat sink **100** is a single unitary piece of thermally conductive material, and could also be made by machining, molding, forging, or other suitable method. Alternatively, any or all of the first generally rectangular member **110**, the second generally rectangular member **120**, and the elongated members **130** of heat sink **100** could be made as separate pieces from thermally conductive material, and then integrally joined, e.g., by welding, by brazing, by soldering, by a permanent adhesive, by a permanent thermally conductive adhesive, or by any combination thereof, to form heat sink **100**.

In the example embodiment, LED **210** is a type LXHL-PW09 or K2 white light emitting diode available as LUXEON® LEDs from Lumiled Lighting, U.S., LLC, located in San Jose, Calif. Other examples of high-power LEDs include LEDs available from sources such as Nichia Semiconductor located in Tokushima, Japan, Seoul Semiconductor located in Korea, Cree Inc. located in Durham, N.C., OSRAM Semiconductor located in Regensburg, Germany, and CML Innovative Technologies located in Hackensack, N.J. LUXEON® and other LEDs are available, e.g., in one watt, three waft, five waft, and other power levels, for producing "white" light as well as other colors of light, e.g., red, green, blue, amber, and the like. LED **210** is bonded to heat sink **100** by type I-4173 thermally conductive adhesive available from Dow Corning located in Midland, Mich. Suitable adhesive materials may also include, e.g., STYCAST #4954 and #5954 silicone high temperature encapsulants, and STYCAST #4952 epoxy, which are available from Emerson & Cuming located in Billerica, Mass. Housing **20** of light **10** may be of type ST801 nylon available from Clariant Corporation located in Charlotte, N.C., or may be of another suitable material, such as a nylon, ABS plastic, polystyrene, or of any other suitable plastic, and lens **32** may be of LEXAN® plastic available from General Electric Company, GE Plastics, located in New York, polycarbonate or other suitable plastic or glass.

FIGS. **4**A and **4**B are plan views of alternative example embodiments of circuit board **220** of LED assembly **200** as shown in FIGS. **2** and **4**. Electrical circuit board **220'** of FIG. **4**A has a generally circular periphery **201** and has one or more alignment openings **222'**, such as a slot or notch **222'**, for suitably aligning circuit board **220'** and LED **210** of LED assembly **200** on heat sink **100** in similar manner to that described herein in relation to circuit board **220**. Circuit board **220'** typically includes an electrically insulating substrate, e.g., of FR4 material, on which are electrically conductive contact areas **202** and **204**, e.g., of copper, to which the electrical leads **212**, **214** of LED **210** are respectively electrically connected, e.g, by soldering, and further has a centrally located contact area **208'**, of copper, to which the base of LED **210** is mechanically and thermally coupled, e.g, by soldering. In a preferred arrangement, the base and electrical leads **212**, **214** of LED **210** are electrically and mechanically connected to contact areas **208'**, **202**, **204**, respectively, by reflow soldering or another soldering operation, thereby to thermally bond LED **210** to circuit board **220'** of LED assembly **200**. Circuit board **220'** differs from circuit board **220** in that it does not have a central opening **206** in which LED **210** is disposed, and heat may be conducted away from the base of LED **210** to heat sink **100** through circuit board **220'** which is preferably relatively thin, e.g., typically less than about 1.0 mm (about 0.04 inch). LED assembly **200** including LED **210** and circuit board **220** is preferably thermally bonded to heat sink **100** as described herein.

Electrical circuit board **220"** of FIG. **4**B has a generally circular periphery **201** and has one or more alignment openings **222'**, such as a slot or notch **222'**, for suitably aligning circuit board **220"** and LED **210** of LED assembly **200** on heat sink **100** in similar manner to that described herein in relation to circuit board **220**. Circuit board **220"** typically includes an electrically insulating substrate, e.g., of FR4 material, on which are electrically conductive contact areas **202** and **204**, e.g., of copper, to which the electrical leads **212**, **214** of LED **210** are respectively electrically connected, e.g, by soldering, and further has a centrally located contact area **208"**, e.g., of copper, to which the base of LED **210** is mechanically and thermally coupled, e.g, by soldering. Contact area **208"** preferably has a plurality of relatively small openings or holes **206"** through circuit board **220"**, and plural holes **206"** are preferably filled with a thermally conductive material. In a preferred arrangement, the base and electrical leads **212**, **214**

of LED **210** are electrically and mechanically connected to contact areas **208"**, **202**, **204**, respectively, by reflow soldering or another soldering operation, thereby to thermally bond LED **210** to circuit board **220"** of LED assembly **200**. Circuit board **220"** differs from circuit board **220** in that it does not have a large central opening **206**, but has plural smaller openings **206"** that may be filled with thermally conductive material through which heat may be conducted away from the base of LED **210** to heat sink **100** through circuit board **220"**. Circuit board **220"** is preferably relatively thin, e.g., typically less than about 1.0 mm (about 0.04 inch), and typically about 0.75 mm (about 0.03 inch). LED assembly **200** including LED **210** and circuit board **220"** is preferably thermally bonded to heat sink **100** as described herein.

Also in a preferred arrangement, plural holes **206"** of circuit board **220"** may be conductive vias that are filled with copper, e.g., plated copper as in plated full plated-through holes, or with solder, e.g., in the reflow soldering or in another soldering step, or another thermally conductive material, e.g., a thermally conductive epoxy or other thermally conductive adhesive, such as the adhesive used to attach LED assembly **200** to heat sink **100**. Plural holes **206"** preferably provide thermally conductive paths through circuit board **220"** over a substantial portion of the area of contact area **208"** and so are typically substantially smaller in diameter than is contact area **208"**. For example, the diameter of holes **206"** may be about 1.0 mm (about 0.04 inch), but may be larger or smaller, where openings/holes **206"** are plated holes, or are conductive vias, or are plated-through holes, or are plated full plated-through holes, e.g., plated-through holes that are plated full with copper, or are holes that are filled with solder. The pattern, size (or sizes) and number of holes **206"**, and the material, if any, that fills holes **206"**, may be selected for providing a desired thermal conductivity through circuit board **220"**, e.g., between LED **210** and heat sink **100**.

It is noted that in each of the arrangements of FIGS. **4**, **4**A and **4**B, LED **210** is attached to circuit board **220**, **220'**, **220"**, and/or is thermally bonded to heat sink **100** through circuit board **220**, **220'**, **220"**, whether directly, e.g., by being disposed in opening **206**, or indirectly, e.g., by being attached and/or thermally bonded to contact area **208'**, **208"**. LED **210** is supported by circuit board **220**, **220'**, **220"**. LED **210** also may be attached to and/or thermally bonded to heat sink **100** without a circuit board **220**, **220'**, **220"**. Thermal bonding of LED **210** is preferably provided by solder, by a highly thermally conductive epoxy or by another highly thermally conductive adhesive, e.g., of the sorts described herein. Thermal bonding of LED assembly **200** is preferably provided by a highly thermally conductive epoxy or by another highly thermally conductive adhesive, e.g., of the sorts described herein.

FIG. **5** is a schematic diagram of an example electronic circuit **500** useful with the light **10**, **10'** of FIGS. **1-4**. Circuit **500** is responsive to closures of switch **320**, which *is connected to microprocessor U1 via the SWITCH IN pin PB5 and* typically may be a **[**pushbufton**]** *pushbutton* switch having normally open momentary contacts S**1**, for selectively applying power from battery B to LED **210** for energizing LED **210** for producing light. Operating conditions or modes for LED light source **210** that are selectable by pressing pushbutton switch S**1**, **320** may include, for example, some or all of momentary ON, continuous ON, OFF, safe, dimmed, cyclical dimming, flashing, blinking, timed ON, and other conditions. Such operating conditions may be selected by some or all of momentarily pressing **[**pushbufton**]** *pushbutton* switch **320**, by pressing and holding switch S**1** **320** for a given time, by pressing switch S**1**, **320** two or more times within a given time or times, or any combination of the foregoing, or any other desired switch sequence. Capacitor C**2** may reduce unwanted signals generated when switch contacts S**1** open and/or close.

Circuit **500** includes various electronic components that are disposed on electronic circuit board **300**, on electronic circuit board **400**, in LED assembly **200**, and on heat sink **100**. Battery B is an electrical power source that provides electrical power for selectively energizing LED **210** responsive to the other components of circuit **500** and is connected to circuit **500** via contact springs **420** on circuit board **400**. Optionally, a fuse F**1** may be provided, *e.g., in series with battery B,* e.g., on circuit board **400**, to limit the current that may flow under fault conditions, but fuse F**1** always must allow a greater current level than the highest current that flows under normal operation.

Connection between circuit boards **300** and **400** is via conductors **430** and relatively high current normally flows through the path including *fuse F1,* conductors **340**, LED **210**, control transistor Q**1**, **330** and current sensing resistor R**4**. Current sensing resistor R**4** may cooperate with integrated circuit U**1** by providing to pin PB**1** thereof a feedback signal representative of the current flowing through LED **210** to control the value of current flowing in FET **[210]** *Q1, 330* with resistor R**4** providing a feedback signal via resistor R**7** to pin **6**, PB**1**, of circuit U**1** via resistor R**7** and circuit U**1** providing a correction signal, PWM OUT, via resistors R**6** and R**8** to drive control transistor Q**1**, with capacitor C**1** providing low-pass filtering. The signal from pin **6**, PWM OUT, of circuit U**1** may be a pulse width modulated (PWM) signal that is low pass filtered by resistors R**6**, R**8** and capacitor C**1** to provide an appropriate drive signal for controlling transistor Q**1**. It is noted that control transistor Q**1**, a MOSFET transistor, is an example of a control device **330** for controlling the current flowing through LED **210** and device **330** is preferably mounted on electronic circuit board **300** proximate to the location attached to heat sink **100** by fastener **305**.

Integrated circuit U**1** provides a voltage at pin PB**2**, REF EN, that is at least in part responsive to the selected operating condition for establishing a reference potential for controlling the current flowing through LED **210**. The voltage from pin PB**2**, REF EN, of circuit U**1** is reduced by a first voltage divider including resistor R**12** and diode D**3**, and the voltage across diode D**3** is further reduced by the voltage divider formed by resistors R**1** and R**12** and is provided via resistor R**9** to circuit U**1** at pin PB**0**, +COMP, thereof as a reference for a feedback loop controlling current flowing through LED **210** using a feedback signal from resistor R**4** as described above.

Power from battery B is provided to pin Vcc of integrated circuit U**1** via resistor R**3**, diode D**1**, and is filtered to remove transient voltage changes, if any, by capacitor C**3** having substantial capacitance. Integrated circuit U**1** receives at pin Vcc either the voltage of battery B (less a small voltage drop across resistor R**3** and diode D**1**) or a controlled predetermined voltage, e.g., 3.0 volts, controlled by reference diode D**2**.

When light **10**, **10'** is in certain operating conditions, e.g., conditions wherein the frequency of an oscillator internal to circuit U**1** is desired to be operated at a relatively precise frequency such as a mode involving timing, pin PB**4**, 3.0V ENABLE, of integrated circuit pulls down towards ground GND potential (a LOW output condition) so that reference diode D**2** is essentially connected between pins Vcc and GND of circuit U**1** and is turned ON, thereby to control the Vcc voltage applied to circuit U**1** to the predetermined voltage produced by voltage reference diode D**2** at the enable input to circuit U**1**, e.g., 3.0 volts. Diode D**2** receives feedback of a

predetermined fraction of the voltage of Vcc via resistors R**1**, R**5** thereby to establish the value of the predetermined voltage, e.g., 3.0 volts, that it provides. The relatively precise reference voltage thus provided by reference diode D**2** helps to stabilize operation of microprocessor U**1**, e.g., as the voltage from battery B varies over its operating life. Under this condition, the voltage drop across resistor R**3** may be a substantial portion of the voltage of battery B.

Under other operating conditions, e.g., conditions wherein the frequency of an oscillator internal to circuit U**1** is not important or wherein it may be desirable to save the power consumed by diode D**2** when it is providing the predetermined voltage, pin PB**4**, 3.0V ENABLE, of integrated circuit is released to pull up towards Vcc potential (a HIGH output condition) so that reference diode D**2** is essentially disconnected from pin GND of circuit U**1** thereby to not function to control the Vcc voltage applied to circuit U**1**, whereby circuit U**1** receives a supply voltage Vcc that is close to battery B voltage.

In the illustrated example embodiment of circuit **500**, LED **210** is preferably a type LXHL-PW09 white LED as above, MOSFET transistor Q**1** is preferably a type NTD40N03 available from ON Semiconductor located in Phoenix, Ariz., integrated circuit U**1** is preferably a type ATTINY11 microprocessor that is available from Atmel Corporation located in San Jose, Calif., and reference diode D**2** is a type TL432ACDBZR available from Texas Instruments located in Dallas, Tex.

A light **10**, **10'** may comprise a light emitting diode **210** selectively energizable for producing light; an electronic circuit **300**, **500** for selectively energizing light emitting diode **210**; a heat sink **100** of a thermally conductive material, wherein light emitting diode **210** is thermally bonded to heat sink **100**, wherein electronic circuit **300**, **500** is attached to heat sink **100**; and a case **20** for receiving heat sink **100**, light emitting diode **210**, electronic circuit **300**, **500**, and a source B of electrical power. Electronic circuit **300**, **500** may be disposed on an electronic circuit board **300**, **310** that is attached to heat sink **100**. Electronic circuit board **310** may include vias and/or a conductor for increasing the thermal conductivity of electronic circuit board **310** proximate a location at which electronic circuit board **310** is attached to heat sink **100**. Electronic circuit **300**, **500** may include an electronic component **330** for selectively controlling the energizing of light emitting diode **210**, wherein electronic component **330** is disposed on electronic circuit board **310** proximate the location at which electronic circuit board **300**, **310** is attached to heat sink **100**. Electronic circuit board **300**, **310** may be attached to heat sink **100** without thermally conductive bonding material. Heat sink **100** may maintain light emitting diode **210** and electronic circuit **300**, **310** at a temperature less than 200° C. in an ambient 40° C. environment under normal operation and under a fault condition. Heat sink **100** may be of a thermally conductive material comprising a first generally rectangular planar member **110** for supporting light emitting diode **210** and a second generally rectangular member **120** integrally joined to first generally rectangular member **110** and for supporting electronic circuit **300**, **500**, and may further include two optional opposing elongated members **130** each integrally joined to first and second rectangular planar members **110**, **120** proximate opposing edges thereof. Heat sink **100** may have at least two spaced apart alignment features **116** for positioning light emitting diode **210** on a predetermined region of heat sink **100** for bonding light emitting diode **210** thereto. Electronic circuit **300**, **500** for energizing light emitting diode **210** may receive a voltage from a source B of electrical power and may provide a predetermined current to light emitting diode **210**, and may increase the voltage from the source B of electrical power if necessary to provide the predetermined current.

A light **10**, **10'** may comprise a heat sink **100** of a thermally conductive material comprising a first generally rectangular planar member **110** and a second generally rectangular member **120** integrally joined to first generally rectangular member **110**; a light emitting diode **210** attached to a broad surface of first generally rectangular planar member **110** of heat sink **100**; an electronic circuit board **300** comprising circuitry **500** for energizing light emitting diode **210**, and wherein electronic circuit board **300** is attached to second generally rectangular planar member **120**. Light **10** may comprise a case **20** for receiving heat sink **100**, light emitting diode **210**, electronic circuit board **300**, and a source B of electrical power. Light emitting diode **210** may be bonded to a central region of the broad surface of first generally rectangular member **110** of heat sink **100** by a thermally conductive adhesive. Light **10**, **10'** may further comprise a second electronic circuit board **220**, **220'**, **220"** for receiving light emitting diode **210** and having conductive areas **202**, **204** thereon, wherein light emitting diode **210** is bonded to the central region of broad surface **112** of first generally rectangular member **110** of heat sink **100** through second electronic circuit board **220**, **220'**, **220"** and wherein electrical contacts **212**, **214** of light emitting diode **210** are electrically connected to the conductive areas **202**, **204** of second electronic circuit board **220**, **220'**, **220"**. Electronic circuit board **220**, **220'**, **220"** may have a central opening **206** therein for receiving light emitting diode **210** or may have a contact area **208'**, **208"** for receiving LED **210** or may have a contact area **208"** including conductive vias, openings, holes, plated holes, plated through holes, plated full plated through holes, and/or other openings **206"** for receiving LED **210**, or may have a combination thereof. First generally rectangular member **110** of heat sink **100** may have at least two spaced apart alignment features **116** for positioning light emitting diode **210** on a central region of a broad surface **112** of first generally rectangular member **110** of heat sink **100** for bonding light emitting diode **210** to heat sink **100**. Electronic circuit board **300** may be supported at one end by a fastener **305** engaging second generally rectangular member **120** of heat sink **100**. An electronic component **330** for controlling the energization of light emitting diode **210** may be disposed on electronic circuit board **300**, **310** proximate fastener **305**. Electronic circuit board **300**, **310** may be attached to heat sink **100** without thermally conductive bonding material. Heat sink **100** may be fabricated from a single piece of a thermally conductive material, e.g., by machining, by casting, by die casting, by molding, or by forging the single piece of a thermally conductive material. First generally rectangular planar member **110** and second generally rectangular member **120** may be fabricated separately from thermally conductive material, e.g., each of first generally rectangular planar member **110** and second generally rectangular member **120** of heat sink **100** may be fabricated by machining, by casting, by die casting, by molding, by forging, or by any combination thereof, and first and second generally rectangular planar members **110**, **120** may be integrally joined by welding, by brazing, by soldering, by a permanent adhesive, by a permanent thermally conductive adhesive, or by any combination thereof. Circuitry **500** for energizing light emitting diode **100** may receive a voltage from the source B of electrical power and may provide a predetermined current to light emitting diode **210**, and may increase the voltage from the source B of electrical power if necessary to provide the predetermined current. Light **10**, **10'** may further comprise a second electronic circuit board **400**, **410** including terminals

420 for making electrical connection to a battery B, wherein second electronic circuit board **400**, **410** may be attached to heat sink **100** juxtaposed from electronic circuit board **300**, **310** and proximate an edge of first generally rectangular member **110**. Heat sink **100** may maintain light emitting diode **210** and energizing circuitry **500** of electronic circuit board **300**, **310** at a temperature less than 200° C. in normal operation and under a fault condition. First generally rectangular member **110** of heat sink **100** may be thicker in a central region **112** whereat light emitting diode **210** is attached thereto than in a surrounding region.

A light **10**, **10'** may comprise a heat sink **100** of a thermally conductive material, heat sink **100** comprising a first generally rectangular planar member **110** defining four edges and two opposing broad surfaces, two opposing elongated members **130** each [integrallyjoined] *integrally joined* to first rectangular planar member **100** proximate two opposing edges thereof, and a second generally rectangular member **120** integrally joined at opposing ends thereof to the two elongated members **130** and integrally joined to first generally rectangular member **110**; a light emitting diode **210** bonded by a thermally conductive adhesive to a central region **112** of a broad surface of first generally rectangular planar member **110** of heat sink **100** between the two elongated members **130** thereof; wherein heat sink **100** has at least two spaced apart alignment features **116** for positioning light emitting diode **210** on the central region **112** of the broad surface of first generally rectangular member **110** of heat sink **100** for the bonding of light emitting diode **210** thereto; a first electronic circuit board **300**, **310** adjacent second generally rectangular member **120** of heat sink **100** comprising circuitry **500** for energizing light emitting diode **210**, wherein first electronic circuit board **300**, **310** is supported at one end by a fastener **305** engaging second generally rectangular member **120** of heat sink **100**; and a second electronic circuit board **220**, **220'**, **220"** supporting light emitting diode **210**, wherein electrical contacts **212**, **214** of light emitting diode **210** are electrically connected to respective conductive areas **202**, **204** of second electronic circuit board **220**, **220'**, **220"** and to first electronic circuit board **300**, **310**. An electronic component **330** for controlling the energization of light emitting diode **210** may be disposed on first electronic circuit board **300**, **310** proximate fastener **305**. First electronic circuit board **300**, **310** may be attached to heat sink **100** without thermally conductive bonding material. Heat sink **100** may be fabricated from a single piece of a thermally conductive material, e.g., by machining, by casting, by die casting, by molding, or by forging the single piece of a thermally conductive material. First generally rectangular planar member **110**, the two opposing elongated members **130** and second generally rectangular member **120** may be fabricated separately from thermally conductive material, wherein each of first generally rectangular planar member **110**, the two opposing elongated members **130** and second generally rectangular member **120** of heat sink **100** may be fabricated by machining, by casting, by die casting, by molding, by forging, or by any combination thereof, and wherein first and second generally rectangular planar members **110**, **120** and the two elongated members **130** may be integrally joined by welding, by brazing, by soldering, by a permanent adhesive, by a permanent thermally conductive adhesive, or by any combination thereof. Circuitry **500** for energizing light emitting diode **210** may receive a voltage from the source B of electrical power and may provide a predetermined current to light emitting diode **210**, and may provide a voltage greater than the voltage from the source B of electrical power when necessary to provide the predetermined current. Light **10**, **10'** may further comprise a third electronic circuit board **400**, **410** including terminals **420** for making electrical connection to a battery B, wherein third electronic circuit board **400**, **410** may be attached to heat sink **100** between the two elongated members **130** thereof juxtaposed from first electronic circuit board **300**, **310** and proximate an edge of first generally rectangular member **110**. Heat sink **100** may maintain light emitting diode **210** and the energizing circuitry **500** of electronic circuit board **300**, **310** at a temperature less than 200° C. in normal operation and under a fault condition. The second electronic circuit board **220**, **220'**, **220"** supporting said light emitting diode may comprise: second circuit board **220** having an opening **206** therethrough in which light emitting diode **210** is disposed; or second circuit board **200'**, **220"** having a contact area **208'**, **208"** thereon to which light emitting diode **210** is attached; or second circuit board **220"** having a contact area **208"** thereon to which light emitting diode **210** is attached, wherein contact area **208"** includes a plurality of openings **206"**, of holes **206"**, of conductive vias **206"**, of plated-through holes **206"**, of plated full plated-through holes **206"**, and/or of solder filled holes **206"**, in second circuit board **220**, **220'**, **220"**.

A light **10** may comprise a heat sink **100** of a thermally conductive material, a light emitting diode **210** selectively energizable for producing light, wherein light emitting diode **210** is thermally bonded to heat sink **100**, an electronic circuit **300**, **500** for selectively energizing light emitting diode **210**, wherein electronic circuit **300**, **500** has an attachment location at which it is attached to heat sink **100**, electronic circuit **300**, **500** further including means for reducing thermal resistance between a heat generating component **330** thereof and the attachment location thereof; and a case **20** for receiving heat sink **100**, light emitting diode **210**, electronic circuit **300**, **500**, and a source B of electrical power. Electronic circuit **300**, **500** for selectively energizing light emitting diode **210** may be disposed on an electronic circuit board **300**, **310** that is attached to heat sink **100**. Electronic circuit board **310** may include vias and/or a conductor for increasing the thermal conductivity of electronic circuit board **310** proximate a location at which electronic circuit board **310** is attached to heat sink **100**. Electronic circuit **300**, **500** may include an electronic component **330** for selectively controlling the energizing of light emitting diode **210**, wherein electronic component **330** is disposed on electronic circuit board **310** proximate the location at which electronic circuit board **310** is attached to heat sink **100**. Electronic circuit board **310** may be attached to heat sink **100** without thermally conductive bonding material. Means for reducing thermal resistance between the heat generating component **330** and the attachment location may include a substantial electrical conductor area, a thicker electrical conductor, one or more conductive vias, or any combination thereof, proximate to the attachment location of electronic circuit **300**, **500**. Heat sink **100** may maintain light emitting diode **210** and electronic circuit **300**, **500** at a temperature less than 200° C. in an ambient 40° C. environment under normal operation and under a fault condition. Electronic circuit **300**, **500** may include a pair of contact springs **420** extending away from heat sink **100** for making electrical contact with the source B of electrical power. Heat sink **100** of a thermally conductive material may comprise a first generally rectangular planar member **110** for supporting light emitting diode **210**, and a second generally rectangular member **120** integrally joined to the first generally rectangular member **110** and for supporting electronic circuit **300**, **500**. Heat sink **100** may have at least two spaced apart alignment features **116** for positioning light emitting diode **210** on a predetermined region of heat sink **100** for bonding light emitting diode **210** thereto. Electronic circuit **300**, **500** for

selectively energizing light emitting diode **210** may receive a voltage from the source B of electrical power and may provide a predetermined current to light emitting diode **210**, and may increase the voltage from the source B of electrical power if necessary to provide the predetermined current.

A light **10** may comprise a heat sink **100** of a thermally conductive material, a light emitting diode **210** selectively energizable for producing light, wherein light emitting diode **210** is thermally bonded to heat sink **100**, an electronic circuit **300**, **500** for selectively energizing light emitting diode **210**, wherein electronic circuit **300**, **500** has an attachment location at which it is attached to heat sink **100**, electronic circuit **300**, **500** further including a pair of contact springs **420** extending in a direction away from heat sink **100** for contacting a source B of electrical power, and a case for receiving heat sink **100**, light emitting diode **210**, electronic circuit **300**, **500**, and source B of electrical power. Electronic circuit **300**, **500** for selectively energizing light emitting diode **210** may be disposed on an electronic circuit board **310** that is attached to heat sink **100**, and electronic circuit board **310** may include vias and/or a conductor for increasing the thermal conductivity of electronic circuit board **310** proximate a location at which electronic circuit board **310** is attached to heat sink **100**. Electronic circuit **300**, **500** may include an electronic component **330** for selectively controlling the energizing of light emitting diode **210**, wherein electronic component **330** may be disposed on electronic circuit board **310** proximate the location at which electronic circuit board **310** is attached to heat sink **100**. Electronic circuit board **310** may be attached to heat sink **100** without thermally conductive bonding material. Electronic circuit **300**, **500** may include a substantial electrical conductor area, a thicker electrical conductor, one or more conductive vias, or any combination thereof, proximate to an attachment location of electronic circuit **300**, **500** for reducing the thermal resistance between a heat generating component **330** thereof and the attachment location thereof. Heat sink **100** may maintain light emitting diode **210** and electronic circuit **300**, **500** at a temperature less than 200° C. in an ambient 40° C. environment under normal operation and under a fault condition. Pair of contact springs **420** may include coiled spring-like structures of electrically conductive wire extending away from heat sink **100** for making electrical contact with terminals of the source B of electrical power. Heat sink **100** of a thermally conductive material may comprise: a first generally rectangular planar member **110** for supporting light emitting diode **210**, and a second generally rectangular member **120** integrally joined to the first generally rectangular member **110** and for supporting electronic circuit **300**, **500**. Heat sink **100** may have at least two spaced apart alignment features **116** for positioning light emitting diode **210** on a predetermined region of heat sink **100** for bonding light emitting diode **210** thereto. Electronic circuit **300**, **500** for selectively energizing light emitting diode **210** may receive a voltage from the source B of electrical power and may provide a predetermined current to light emitting diode **210**. Electronic circuit **300**, **500** for selectively energizing light emitting diode **210** may increase the voltage from the source B of electrical power if necessary to provide the predetermined current.

As used herein, the term "about" means that dimensions, sizes, formulations, parameters, shapes and other quantities and characteristics are not and need not be exact, but may be approximate and/or larger or smaller, as desired, reflecting tolerances, conversion factors, rounding off, measurement error and the like, and other factors known to those of skill in the art. In general, a dimension, size, formulation, parameter, shape or other quantity or characteristic is "about" or "approximate" whether or not expressly stated to be such. It is noted that embodiments of very different sizes, shapes and dimensions may employ the described arrangements.

Another example embodiment of a light and heat sink arrangement may be found in U.S. patent application Ser. No. 11/394,633 filed Mar. 31, 2006, which is hereby incorporated herein by reference in its entirety.

While the present invention has been described in terms of the foregoing example embodiments, variations within the scope and spirit of the present invention as defined by the claims following will be apparent to those skilled in the art. For example, while LED assembly **200** may include LED **210** being attached to an electronic circuit board **220**, **220'**, **220"** for convenient assembly, conductors **340** could be directly connected to LED **210** which would be directly bonded to heat sink **100**.

The substantial electrical conductor area, thicker electrical conductor, conductive vias, or another arrangement, of circuit substrate **310** proximate to the location thereon where fastener **305** attaches circuit board **300** to heat sink **100** may be electrically insulated from electronic circuit **300**, **500** and/or from fastener **305** and/or from heat sink **100**, or may not be insulated from electronic circuit **300**, **500** and/or from fastener **305** and/or from heat sink **100**, any of which arrangements can be compatible with the function of reducing the thermal resistance between control component **330** and heat sink **100**.

Further, alignment features such as alignment holes **116** of heat sink **100** could be alignment projections, such as posts or lugs, that engage complementary alignment features, e.g., holes or recesses, of the alignment tool.

In addition to the example electronic circuit illustrated in FIG. **5**, other electronic circuits could be employed, including a simple circuit wherein switch **320** operates to directly apply and remove power from LED **210** or does so by directly causing a control device **330**, e.g. a MOSFET transistor, to selectively become conductive and non-conductive. Control device could be controlled by a toggle type flip flop that changes state in response to closures of contacts S**1**, **320**. Further, control device **330** could be a simple electronic switching device or may be used to regulate or control current flowing through LED **210** or may be used to transform and or condition power from the power source to a voltage and/or current suitable for LED **210**, either for continuous, variable or intermittent operation.

Finally, numerical values stated are typical or example values, are not limiting values, and do not preclude substantially larger and/or substantially smaller values. Values in any given embodiment may be substantially larger and/or may be substantially smaller than the example or typical values stated.

What is claimed is:

1. A *portable* light comprising:

a heat sink of a thermally conductive material comprising a first generally rectangular planar member, and a second generally rectangular member integrally joined to the first generally rectangular member;

a light emitting diode attached to a broad surface of the first generally rectangular planar member of said heat sink;

an electronic circuit board comprising circuitry for controlling the energizing of said light emitting diode, wherein said electronic circuit board is attached to the second generally rectangular planar member,

the circuitry of said electronic circuit board including an electronic component that generates heat when energizing said light emitting diode and generates greater heat under a fault condition, wherein said electronic compo-

nent is thermally coupled by said electronic circuit board to the second generally rectangular planar member of said heat sink to prevent the temperature of said electronic component from increasing excessively under the fault condition; and

a case for receiving said heat sink, said light emitting diode, said electronic circuit board, and a source of electrical power.

2. The *portable* light of claim **1** wherein said light emitting diode is bonded to a central region of the broad surface of the first generally rectangular member of said heat sink by a thermally conductive adhesive.

3. The *portable* light of claim **1** further comprising a second electronic circuit board for receiving said light emitting diode and having conductive areas thereon, wherein said light emitting diode is bonded to the central region of the broad surface of the first generally rectangular member of said heat sink through said second electronic circuit board and wherein the electrical contacts of said light emitting diode are electrically connected to the conductive areas of said second electronic circuit board.

4. The *portable* light of claim **1** wherein the first generally rectangular member of said heat sink has at least two spaced apart alignment features for positioning said light emitting diode on a central region of a broad surface of the first generally rectangular member of said heat sink for bonding said light emitting diode to said heat sink.

5. The *portable* light of claim **1** wherein said electronic circuit board is supported at one end by a fastener engaging the second generally rectangular member of said heat sink.

6. The *portable* light of claim **5** **[**further comprising an**]** *wherein the* electronic component *is* for controlling the energization of said light emitting diode, wherein said electronic component is disposed on said electronic circuit board proximate said fastener.

7. The *portable* light of claim **6** wherein said electronic circuit board includes a substantial electrical conductor area, a thicker electrical conductor, one or more conductive vias, or any combination thereof, proximate said fastener for reducing thermal resistance between said electronic component and the fastener.

8. The *portable* light of claim **1** wherein said electronic circuit board is attached to said heat sink without thermally conductive bonding material.

9. The *portable* light of claim **1** wherein said heat sink is fabricated from a single piece of a thermally conductive material.

10. The *portable* light of claim **9** wherein said heat sink is fabricated by machining, by casting, by die casting, by molding, or by forging the single piece of a thermally conductive material.

11. The *portable* light of claim **1** wherein the first generally rectangular planar member and the second generally rectangular member are fabricated separately from thermally conductive material, and wherein the first and second generally rectangular planar members are integrally joined by welding, by brazing, by soldering, by a permanent adhesive, by a permanent thermally conductive adhesive, or by any combination thereof.

12. The *portable* light of claim **11** wherein each of the first generally rectangular planar member and the second generally rectangular member of said heat sink is fabricated by machining, by casting, by die casting, by molding, by forging, or by any combination thereof.

13. The *portable* light of claim **1** wherein said circuitry for energizing said light emitting diode receives a voltage from the source of electrical power and provides a predetermined current to said light emitting diode, and increases the voltage from the source of electrical power if necessary to provide the predetermined current.

14. The *portable* light of claim **1** further comprising a pair of contact springs extending away from said heat sink for electrically connecting said electronic circuit board to the source of electrical power.

15. The *portable* light of claim **1** further comprising a second electronic circuit board including terminals for making electrical connection to a battery, wherein said second electronic circuit board is attached to said heat sink juxtaposed from said electronic circuit board and proximate an edge of the first generally rectangular member.

16. The *portable* light of claim **1** wherein said heat sink maintains said light emitting diode and the energizing circuitry of said electronic circuit board at a temperature less than 200° C. in normal operation and under a fault condition.

17. The *portable* light of claim **1** wherein the first generally rectangular member of said heat sink is thicker in a central region whereat said light emitting diode is attached thereto than in a surrounding region.

18. A light comprising:

a heat sink of a thermally conductive material, said heat sink comprising a first generally rectangular planar member defining four edges and two opposing broad surfaces, two opposing elongated members each integrally joined to the first rectangular planar member proximate two opposing edges thereof, and a second generally rectangular member integrally joined at opposing ends thereof to the two elongated members and integrally joined to the first generally rectangular member;

a light emitting diode attached to a broad surface of the first generally rectangular planar member of said heat sink between the two elongated members thereof;

an electronic circuit board comprising circuitry for energizing said light emitting diode, wherein said electronic circuit board is attached to the second generally rectangular planar member between the two opposing elongated members; and

a case for receiving said heat sink, said light emitting diode, said electronic circuit board, and a source of electrical power.

19. The light of claim **18** wherein said light emitting diode is bonded to a central region of the broad surface of the first generally rectangular member of said heat sink by a thermally conductive adhesive.

20. The light of claim **18** further comprising a second electronic circuit board for receiving said light emitting diode and having conductive areas thereon, wherein said light emitting diode is bonded to the central region of the broad surface of the first generally rectangular member of said heat sink through said second electronic circuit board and wherein the electrical contacts of said light emitting diode are electrically connected to the conductive areas of said second electronic circuit board.

21. The light of claim **18** wherein the first generally rectangular member of said heat sink has at least two spaced apart alignment features for positioning said light emitting diode on a central region of a broad surface of the first generally rectangular member of said heat sink for bonding said light emitting diode to said heat sink.

22. The light of claim **18** wherein said electronic circuit board is supported at one end by a groove in a first one of the two elongated members of said heat sink and at an opposite end by a fastener engaging the second generally rectangular member of said heat sink.

23. The light of claim 22 further comprising an electronic component for controlling the energization of said light emitting diode, wherein said electronic component is disposed on said electronic circuit board proximate said fastener.

24. The light of claim 23 wherein said electronic circuit board includes a substantial electrical conductor area, a thicker electrical conductor, one or more conductive vias, or any combination thereof, proximate said fastener for reducing thermal resistance between said electronic component and said fastener.

25. The light of claim 18 wherein said electronic circuit board is attached to said heat sink without thermally conductive bonding material.

26. The light of claim 18 wherein said heat sink is fabricated from a single piece of a thermally conductive material.

27. The light of claim 26 wherein said heat sink is fabricated by machining, by casting, by die casting, by molding, or by forging the single piece of a thermally conductive material.

28. The light of claim 18 wherein the first generally rectangular planar member, the two opposing elongated members and the second generally rectangular member are fabricated separately from thermally conductive material, and wherein the first and second generally rectangular planar members and the two elongated members are integrally joined by welding, by brazing, by soldering, by a permanent adhesive, by a permanent thermally conductive adhesive, or by any combination thereof.

29. The light of claim 28 wherein each of the first generally rectangular planar member, the two opposing elongated members and the second generally rectangular member of said heat sink is fabricated by machining, by casting, by die casting, by molding, by forging, or by any combination thereof.

30. The light of claim 18 wherein said circuitry for energizing said light emitting diode receives a voltage from the source of electrical power and provides a predetermined current to said light emitting diode, and increases the voltage from the source of electrical power if necessary to provide the predetermined current.

31. The light of claim 18 further comprising a pair of contact springs extending away from said heat sink for electrically connecting said electronic circuit board to a source of electrical power.

32. The light of claim 18 further comprising a second electronic circuit board including terminals for making electrical connection to a battery, wherein said second electronic circuit board is attached to said heat sink between the two elongated members thereof juxtaposed from said electronic circuit board and proximate an edge of the first generally rectangular member.

33. The light of claim 18 wherein said heat sink maintains said light emitting diode and the energizing circuitry of said electronic circuit board at a temperature less than 200° C. in normal operation and under a fault condition.

34. The light of claim 18 wherein the first generally rectangular member of said heat sink is thicker in a central region whereat said light emitting diode is attached thereto than in a surrounding region.

35. A *portable* light comprising:

a heat sink of a thermally conductive material;

a light emitting diode selectively energizable for producing light, wherein said light emitting diode is thermally coupled to said heat sink;

an electronic circuit for selectively energizing said light emitting diode, wherein said electronic circuit includes an electronic circuit board having an attachment location at which it is attached to said heat sink,

said electronic circuit including an electronic component for selectively controlling the energizing of said light emitting diode, wherein said electronic component generates heat and is disposed on said electronic circuit board proximate the location at which said electronic circuit board is attached to said heat sink,

said electronic circuit board further including a conductive element that reduces the thermal resistance between the heat generating component and the attachment location thereof,

wherein the electronic component generates greater heat under a fault condition, and wherein said electronic component is thermally coupled by the conductive element of said electronic circuit board to said heat sink to prevent the temperature of said electronic component from increasing excessively under the fault condition; and

a case for receiving said heat sink, said light emitting diode, said electronic circuit, and a source of electrical power.

36. The *portable* light of claim 35 wherein said electronic circuit board includes vias and/or a conductor for increasing a thermal conductivity of said electronic circuit board proximate the location at which said electronic circuit board is attached to said heat sink.

37. The *portable* light of claim 35 wherein said electronic circuit board is attached to said heat sink without thermally conductive bonding material.

38. The *portable* light of claim 35 wherein said **[**said**]** conductive element that reduces the thermal resistance between the heat generating component and the attachment location includes a substantial electrical conductor area, a thicker electrical conductor, one or more conductive vias, or any combination thereof, proximate to the attachment location of said electronic circuit.

39. The *portable* light of claim 35 wherein said heat sink maintains said light emitting diode and said electronic circuit at a temperature less than 200° C. in an ambient 40° C. environment under normal operation and under a fault condition.

40. The *portable* light of claim 35 wherein said electronic circuit includes a pair of contact springs extending away from said heat sink for making electrical contact with the source of electrical power.

41. The *portable* light of claim 35 wherein said heat sink of a thermally conductive material comprises: a first generally rectangular planar member for supporting said light emitting diode, and a second generally rectangular member integrally joined to the first generally rectangular member and for supporting said electronic circuit.

42. The *portable* light of claim 35 wherein said heat sink has at least two spaced apart alignment features for positioning said light emitting diode on a predetermined region of said heat sink for bonding said light emitting diode thereto.

43. The *portable* light of claim 35 wherein said electronic circuit for selectively energizing said light emitting diode receives a voltage from the source of electrical power and provides a predetermined current to said light emitting diode.

44. The *portable* light of claim 43 wherein said electronic circuit for selectively energizing said light emitting diode increases the voltage from the source of electrical power if necessary to provide the predetermined current.

45. A *portable* light comprising:

a heat sink of a thermally conductive material;

a light emitting diode selectively energizable for producing light, wherein said light emitting diode is thermally coupled to said heat sink;

an electronic circuit for selectively energizing said light emitting diode, wherein said electronic circuit includes an electronic circuit board having an attachment location at which it is attached to said heat sink,

said electronic circuit further including a pair of *electrical* contact springs *supported by and* extending away from said heat sink in the same direction for *electrically* contacting *the terminals of* a source of electrical power; and

a case for receiving said heat sink, said light emitting diode, said electronic circuit, and the source of electrical power.

46. The *portable* light of claim **45** wherein said electronic circuit board includes vias and/or a conductor for increasing a thermal conductivity of said electronic circuit board proximate a location at which said electronic circuit board is attached to said heat sink.

47. The *portable* light of claim **45** wherein said electronic circuit includes an electronic component for selectively controlling the energizing of said light emitting diode, wherein said electronic component is disposed on said electronic circuit board proximate the location at which said electronic circuit board is attached to said heat sink.

48. The *portable* light of claim **45** wherein said electronic circuit board is attached to said heat sink without thermally conductive bonding material.

49. The *portable* light of claim **45** wherein said electronic circuit includes a substantial electrical conductor area, a thicker electrical conductor, one or more conductive vias, or any combination thereof, proximate to an attachment location of said electronic circuit for reducing the thermal resistance between a heat generating component thereof and the attachment location thereof.

50. The *portable* light of claim **45** wherein said heat sink maintains said light emitting diode and said electronic circuit at a temperature less than 200° C. in an ambient 40° C. environment under normal operation and under a fault condition.

51. The *portable* light of claim **45** wherein said pair of contact springs include coiled spring-like structures of electrically conductive wire extending away from said heat sink for making electrical contact with terminals of the source of electrical power.

52. The *portable* light of claim **45** wherein said heat sink of a thermally conductive material comprises: a first generally rectangular planar member for supporting said light emitting diode, and a second generally rectangular member integrally joined to the first generally rectangular member and for supporting said electronic circuit.

53. The *portable* light of claim **45** wherein said heat sink has at least two spaced apart alignment features for positioning said light emitting diode on a predetermined region of said heat sink for bonding said light emitting diode thereto.

54. The *portable* light of claim **45** wherein said electronic circuit for selectively energizing said light emitting diode receives a voltage from the source of electrical power and provides a predetermined current to said light emitting diode.

55. The *portable* light of claim **54** wherein said electronic circuit for selectively energizing said light emitting diode increases the voltage from the source of electrical power if necessary to provide the predetermined current.

56. A light comprising:

a heat sink of a thermally conductive material, said heat sink comprising a first generally rectangular planar member defining four edges and two opposing broad surfaces, two opposing elongated members each integrally joined to the first rectangular planar member proximate two opposing edges thereof, and a second generally rectangular member integrally joined at opposing ends thereof to the two elongated members and integrally joined to the first generally rectangular member;

a light emitting diode bonded by a thermally conductive adhesive to a central region of a broad surface of the first generally rectangular planar member of said heat sink between the two elongated members thereof;

wherein said heat sink has at least two spaced apart alignment features for positioning said light emitting diode on the central region of the broad surface of the first generally rectangular member of said heat sink for the bonding of said light emitting diode thereto;

a first electronic circuit board adjacent the second generally rectangular member of said heat sink comprising circuitry for energizing said light emitting diode, wherein said first electronic circuit board is supported at one end by a fastener engaging the second generally rectangular member of said heat sink;

a second electronic circuit board supporting said light emitting diode, wherein electrical contacts of said light emitting diode are electrically connected to respective conductive areas of said second electronic circuit board and to said first electronic circuit board; and

a case for receiving said heat sink, said light emitting diode, said first and second electronic circuit boards, and a source of electrical power.

57. The light of claim **56** wherein an electronic component for controlling the energization of said light emitting diode is disposed on said first electronic circuit board proximate said fastener.

58. The light of claim **56** wherein said first electronic circuit board includes a substantial electrical conductor area, a thicker electrical conductor, one or more conductive vias, or any combination thereof, proximate to said fastener for reducing thermal resistance between the circuitry for energizing said light emitting diode and said fastener.

59. The light of claim **56** wherein said first electronic circuit board is attached to said heat sink without thermally conductive bonding material.

60. The light of claim **56** wherein said heat sink is fabricated from a single piece of a thermally conductive material.

61. The light of claim **60** wherein said heat sink is fabricated by machining, by casting, by die casting, by molding, or by forging the single piece of a thermally conductive material.

62. The light of claim **56** wherein the first generally rectangular planar member, the two opposing elongated members and the second generally rectangular member are fabricated separately from thermally conductive material, and wherein the first and second generally rectangular planar members and the two elongated members are integrally joined by welding, by brazing, by soldering, by a permanent adhesive, by a permanent thermally conductive adhesive, or by any combination thereof.

63. The light of claim **62** wherein each of the first generally rectangular planar member, the two opposing elongated members and the second generally rectangular member of said heat sink is fabricated by machining, by casting, by die casting, by molding, by forging, or by any combination thereof.

64. The light of claim **56** wherein said circuitry for energizing said light emitting diode receives a voltage from the source of electrical power and provides a predetermined current to said light emitting diode, and provides a voltage greater than the voltage from the source of electrical power when necessary to provide the predetermined current.

65. The light of claim **56** further comprising a pair of contact springs extending away from said heat sink for electrically connecting said first electronic circuit board to a source of electrical power.

66. The light of claim **56** further comprising a third electronic circuit board including terminals for making electrical connection to a battery, wherein said third electronic circuit board is attached to said heat sink between the two elongated members thereof juxtaposed from said first electronic circuit board and proximate an edge of the first generally rectangular member.

67. The light of claim **56** wherein said heat sink maintains said light emitting diode and the energizing circuitry of said electronic circuit board at a temperature less than 200° C. in normal operation and under a fault condition.

68. The light of claim **56** wherein said second electronic circuit board supporting said light emitting diode comprises:

said second circuit board having an opening therethrough in which said light emitting diode is disposed; or

said second circuit board having a contact area thereon to which said light emitting diode is attached; or

said second circuit board having a contact area thereon to which said light emitting diode is attached, wherein the contact area includes a plurality of openings, of holes, of conductive vias, of plated-through holes, of plated full plated-through holes, and/or of solder filled holes, in said second circuit board.

69. The portable light of claim 1 further comprising:

a fuse connected in series with the source of electrical power and said light source; or

a fuse connected in series with the source of electrical power and said electronic circuit board; or

a fuse connected in series with the source of electrical power and with said light source and said electronic circuit board.

70. The portable light of claim 1 further comprising:

a fuse and a resistor connected in series with the source of electrical power and said light source.

71. The portable light of claim 1 further comprising a switch and a processor responsive to said switch for controlling the energizing of said light emitting diode.

72. The portable light of claim 71 wherein said switch controls energizing of said light emitting diode to operating modes including some or all of momentary ON, continuous ON, OFF, safe, dimmed, cyclical dimming, flashing, blinking, and/or timed ON.

73. The portable light of claim 1 wherein said light emitting diode is disposed in an opening in a circuit board for being thermally bonded directly to said heat sink.

74. The portable light of claim 18 wherein said light emitting diode is disposed in an opening in a circuit board for being thermally bonded directly to said heat sink.

75. The portable light of claim 35 wherein said light emitting diode is disposed in an opening in a circuit board for being thermally bonded directly to said heat sink.

76. The portable light of claim 45 further comprising:

a fuse connected in series with the source of electrical power and said light source; or

a fuse connected in series with the source of electrical power and said electronic circuit board; or

a fuse connected in series with the source of electrical power and with said light source and said electronic circuit board.

77. The portable light of claim 45 further comprising:

a fuse and a resistor connected in series with the source of electrical power and said light source.

78. The portable light of claim 45 further comprising a switch and a processor responsive to said switch for controlling the energizing of said light emitting diode.

79. The portable light of claim 78 wherein said switch controls energizing of said light emitting diode to operating modes including some or all of momentary ON, continuous ON, OFF, safe, dimmed, cyclical dimming, flashing, blinking, and/or timed ON.

80. The portable light of claim 45 wherein said light emitting diode is disposed in an opening in a circuit board for being thermally bonded directly to said heat sink.

81. A portable light comprising:

a heat sink of a thermally conductive material;

a light emitting diode selectively energizable for producing light, wherein said light emitting diode is thermally coupled to said heat sink;

an electronic circuit for selectively energizing said light emitting diode, wherein said electronic circuit has an attachment location at which it is attached to said heat sink,

said electronic circuit further including a switch and a processor responsive to said switch for controlling the energizing of said light emitting diode;

said electronic circuit further including a fuse connected in series with a source of electrical power and said light source;

said electronic circuit further including an electronic component that generates heat when energizing said light emitting diode and generates greater heat under a fault condition, wherein said electronic component is thermally coupled via the attachment location of said electronic circuit to said heat sink to prevent the temperature of said electronic component from increasing excessively under the fault condition; and

a case for receiving said heat sink, said light emitting diode, said electronic circuit, and the source of electrical power.

82. The portable light of claim 81 further comprising:

a resistor connected in series with the source of electrical power and said fuse.

83. The portable light of claim 81 wherein said light emitting diode is disposed in an opening in a circuit board for being thermally bonded directly to said heat sink.

84. A portable light comprising:

a heat sink of a thermally conductive material;

a light emitting diode selectively energizable for producing light, wherein said light emitting diode is thermally coupled to said heat sink;

an electronic circuit for selectively energizing said light emitting diode, wherein said electronic circuit has an attachment location at which it is attached to said heat sink,

said electronic circuit further including a switch and a processor responsive to said switch for controlling the energizing of said light emitting diode;

said electronic circuit further including a fuse connected in series with a source of electrical power and said light source;

said electronic circuit further including an electronic component that generates heat when energizing said light emitting diode and generates greater heat under a fault condition, wherein said electronic component is thermally coupled via the attachment location of said electronic circuit to said heat sink to prevent the temperature of said electronic component from increasing excessively under the fault condition; and

a case for receiving said heat sink, said light emitting diode, said electronic circuit, and the source of electrical power;

wherein said electronic circuit further includes:

a pair of contact springs extending away from said heat sink in the same direction for contacting the source of electrical power; or

an electronic circuit board providing the attachment location; or

a pair of contact springs extending away from said heat sink in the same direction for contacting the source of electrical power and an electronic circuit board providing the attachment location.

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