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MCLENNAN

(54) **LIGHT EMITTING DIODE (LED) ASSEMBLY AND METHOD OF MANUFACTURING THE SAME**

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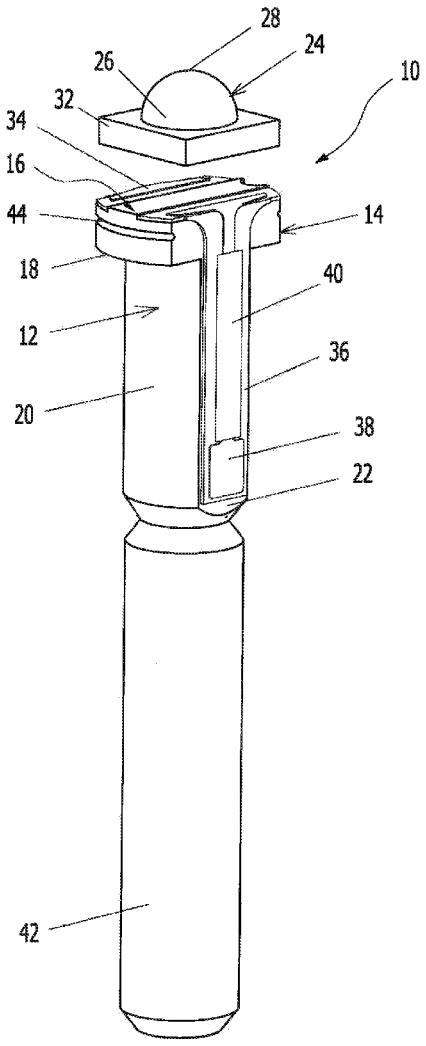
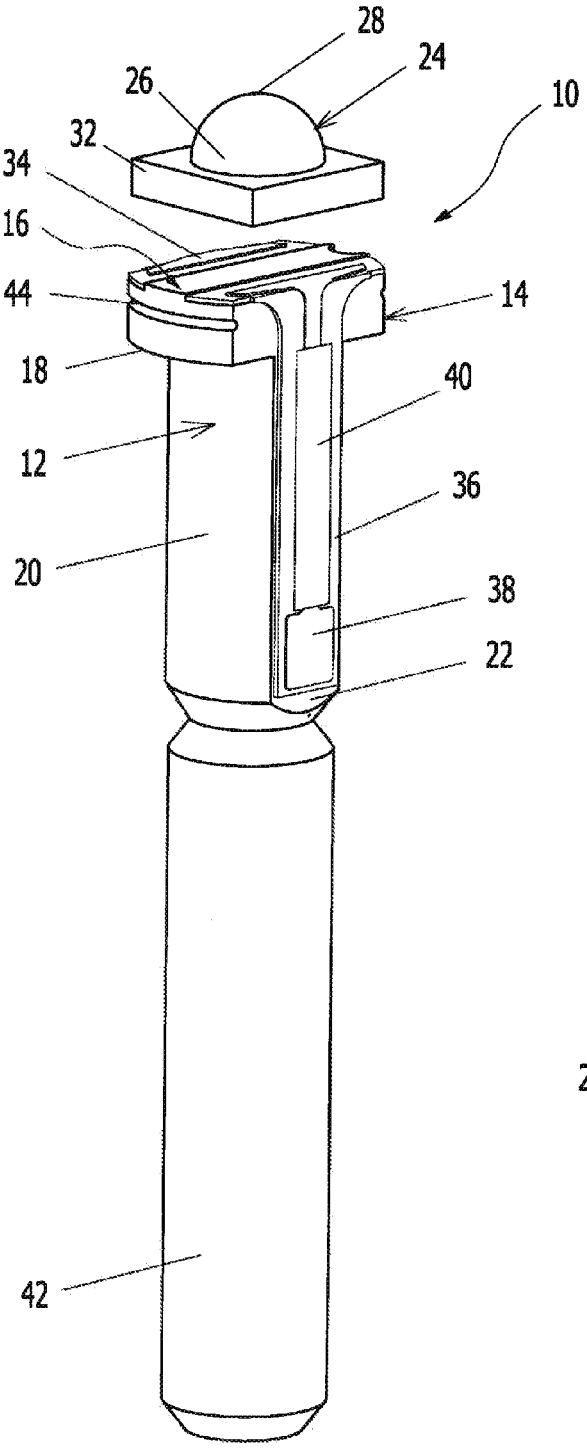
CPC ***F21K 9/00*** (2013.01); ***F21V 29/002*** (2013.01); *F21Y 2101/02* (2013.01)

USPC **362/382**

(57) **ABSTRACT**

The present invention relates to an improved light emitting diode (LED) assembly and method of manufacture which enables the fixing of LED chips to a much broader range of surfaces or objects, amongst other benefits. In particular, the invention relates to a metal core printed circuit board (MCPCB) including on a first surface an LED die, and on a second surface a heat spreader substrate. In a preferred embodiment, the MCPCB is a longitudinal rivet (or screw or the like) whereby the first surface is on the head of the rivet and the second surface extends along its length, the MCPCB rivet being adapted for quick and simple installation to a heat sink and/or PCB or MCPCB.

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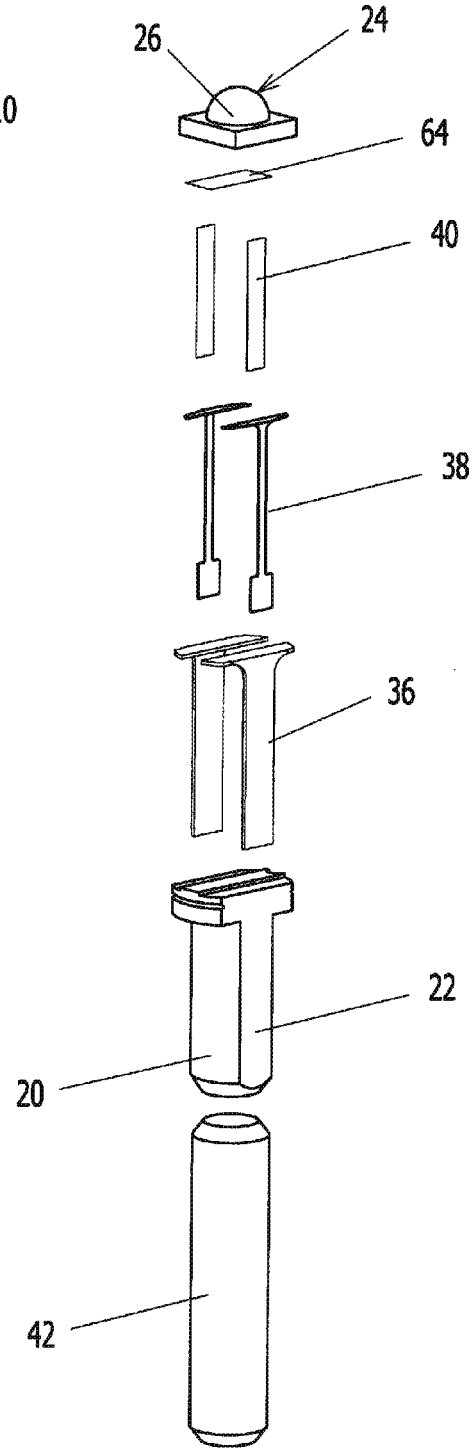
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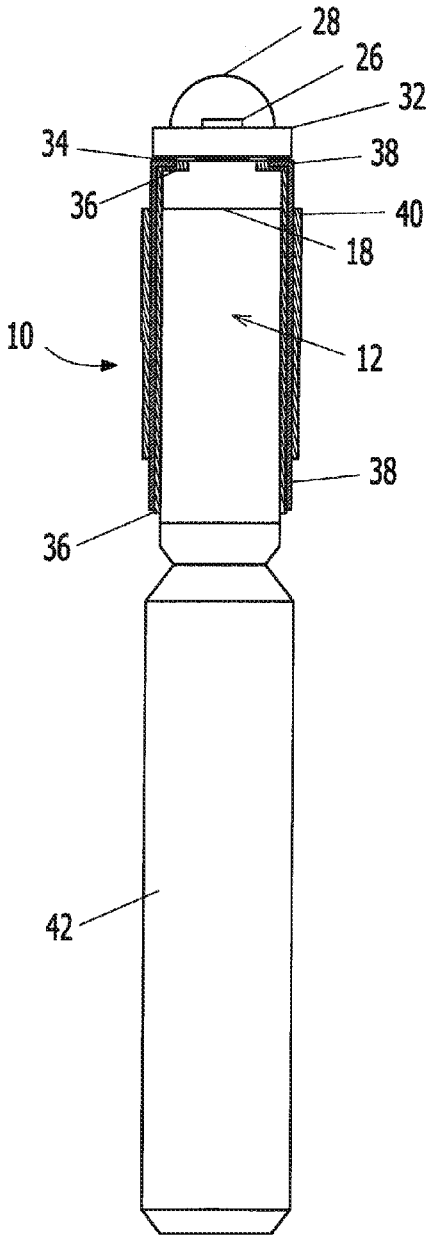
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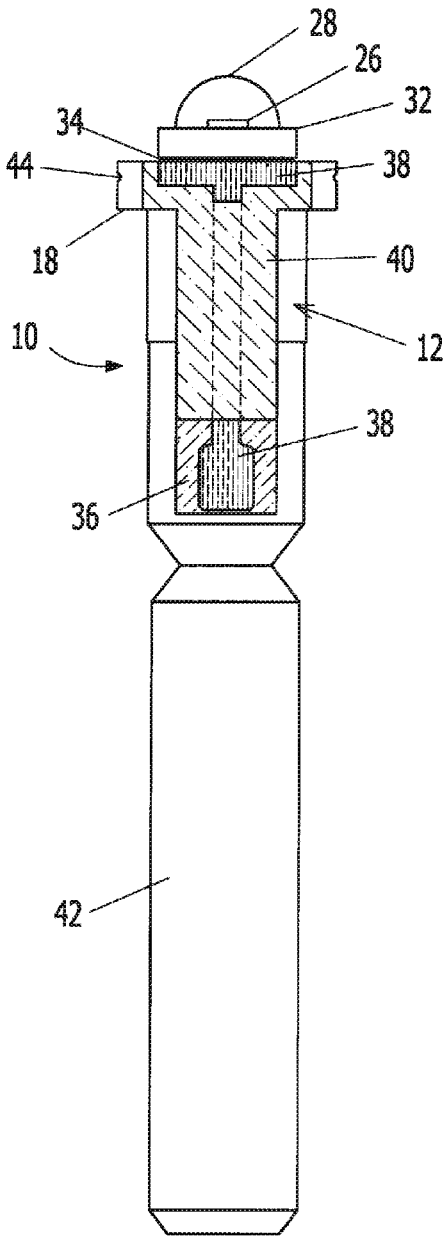
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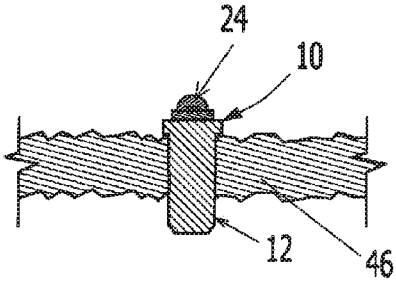

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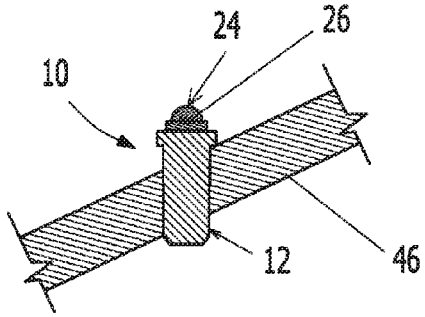

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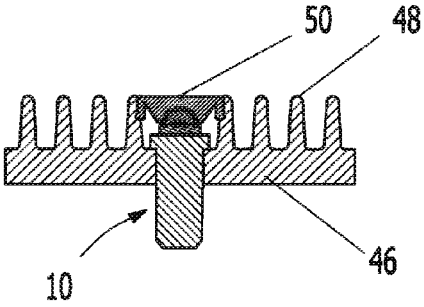

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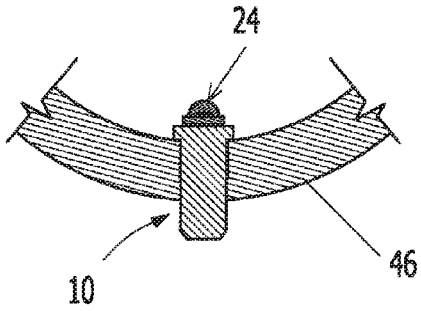

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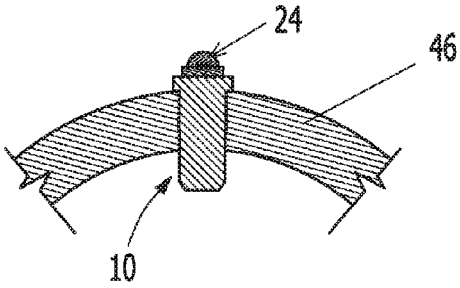

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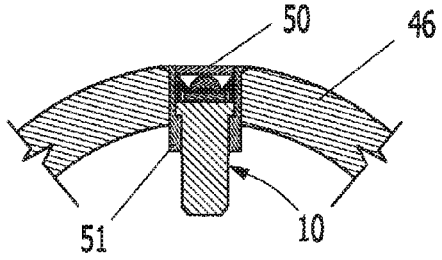

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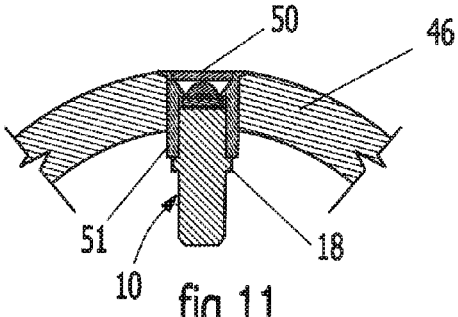

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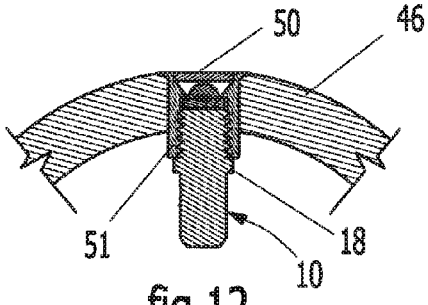

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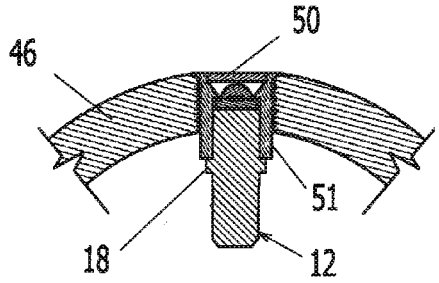

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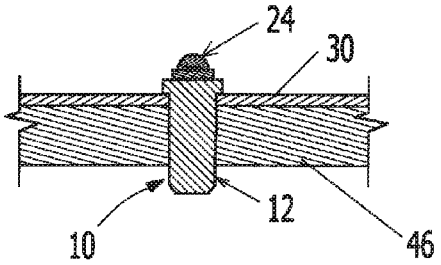

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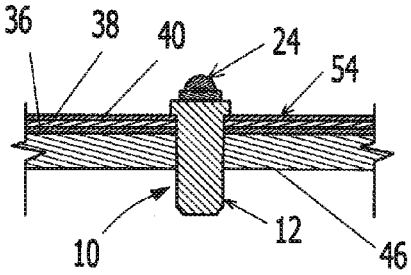

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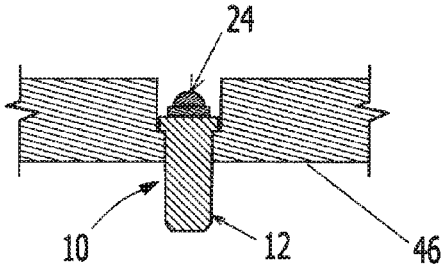

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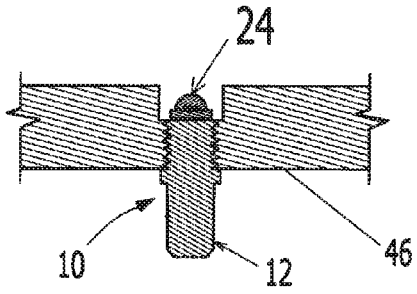

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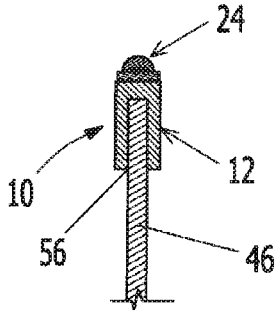

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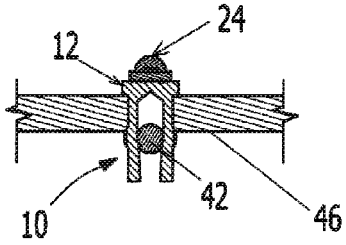

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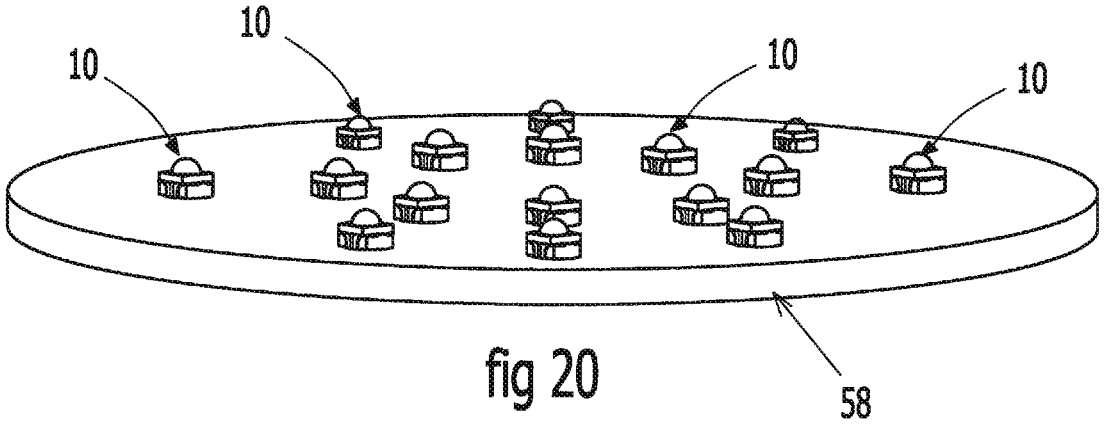

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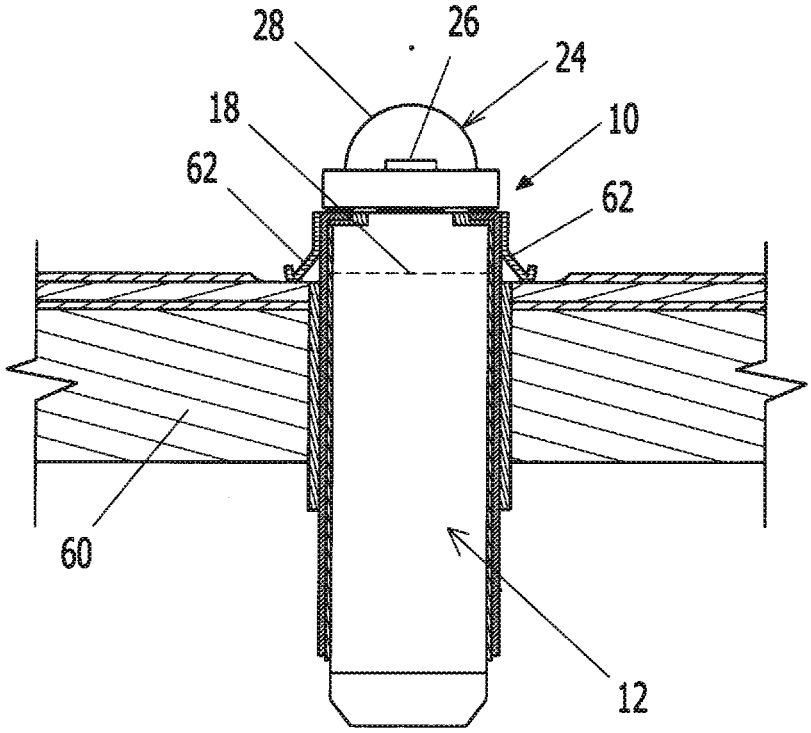

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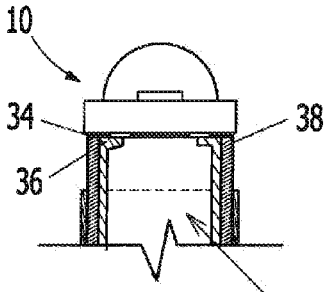

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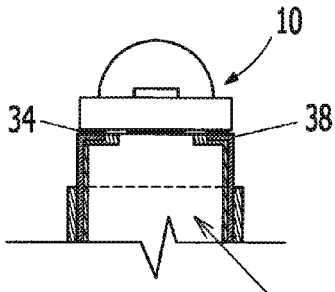

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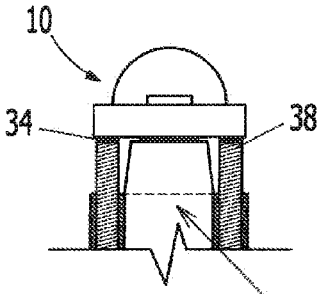

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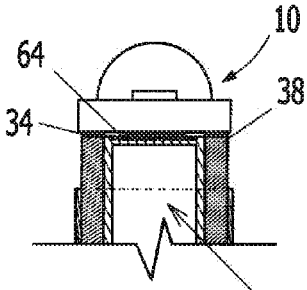

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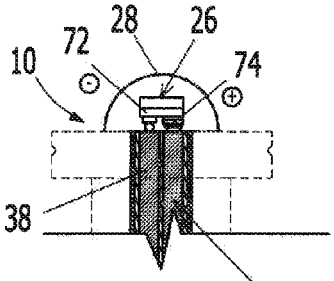

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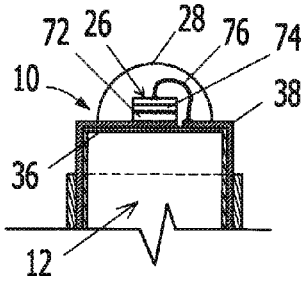

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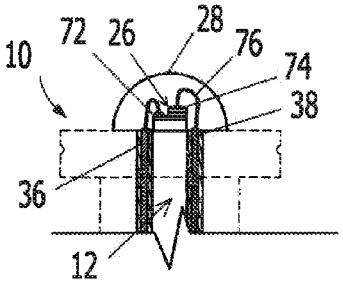

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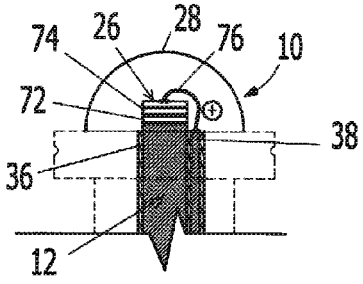

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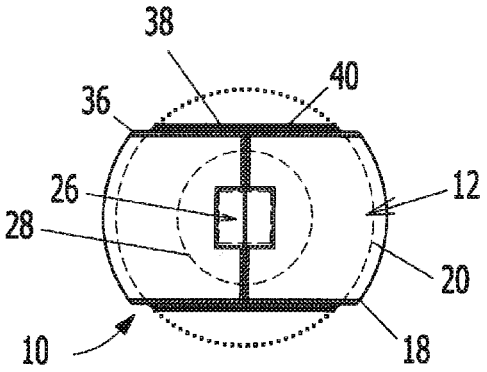

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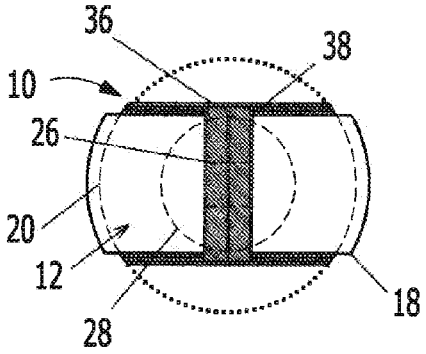

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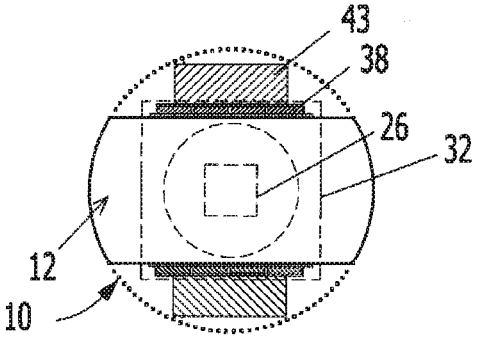

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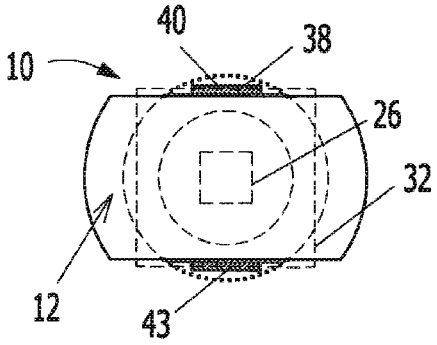

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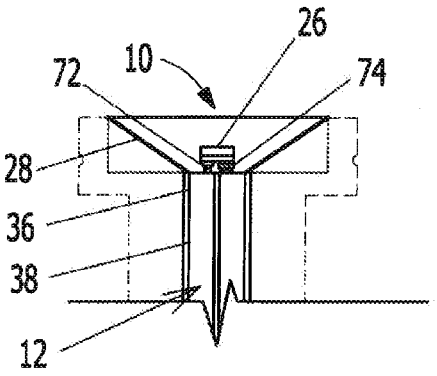

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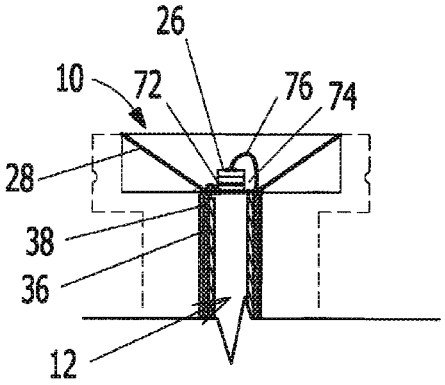

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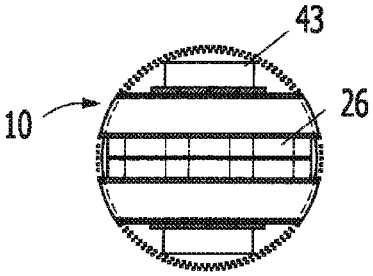

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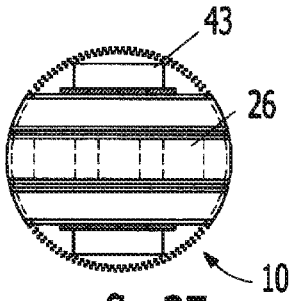

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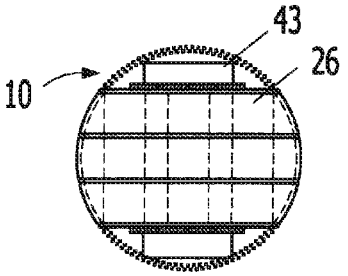

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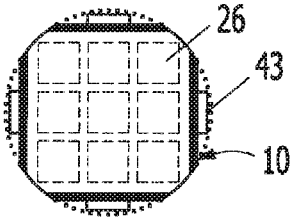

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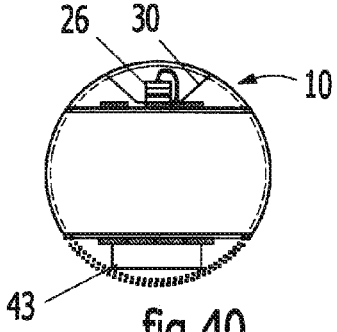

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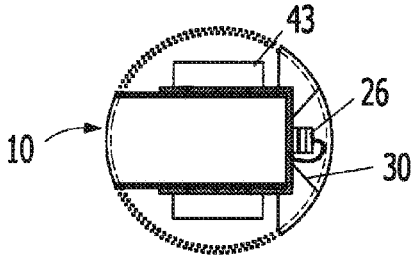

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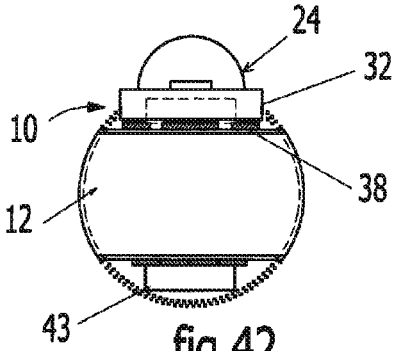

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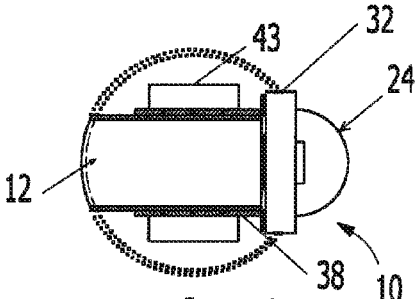

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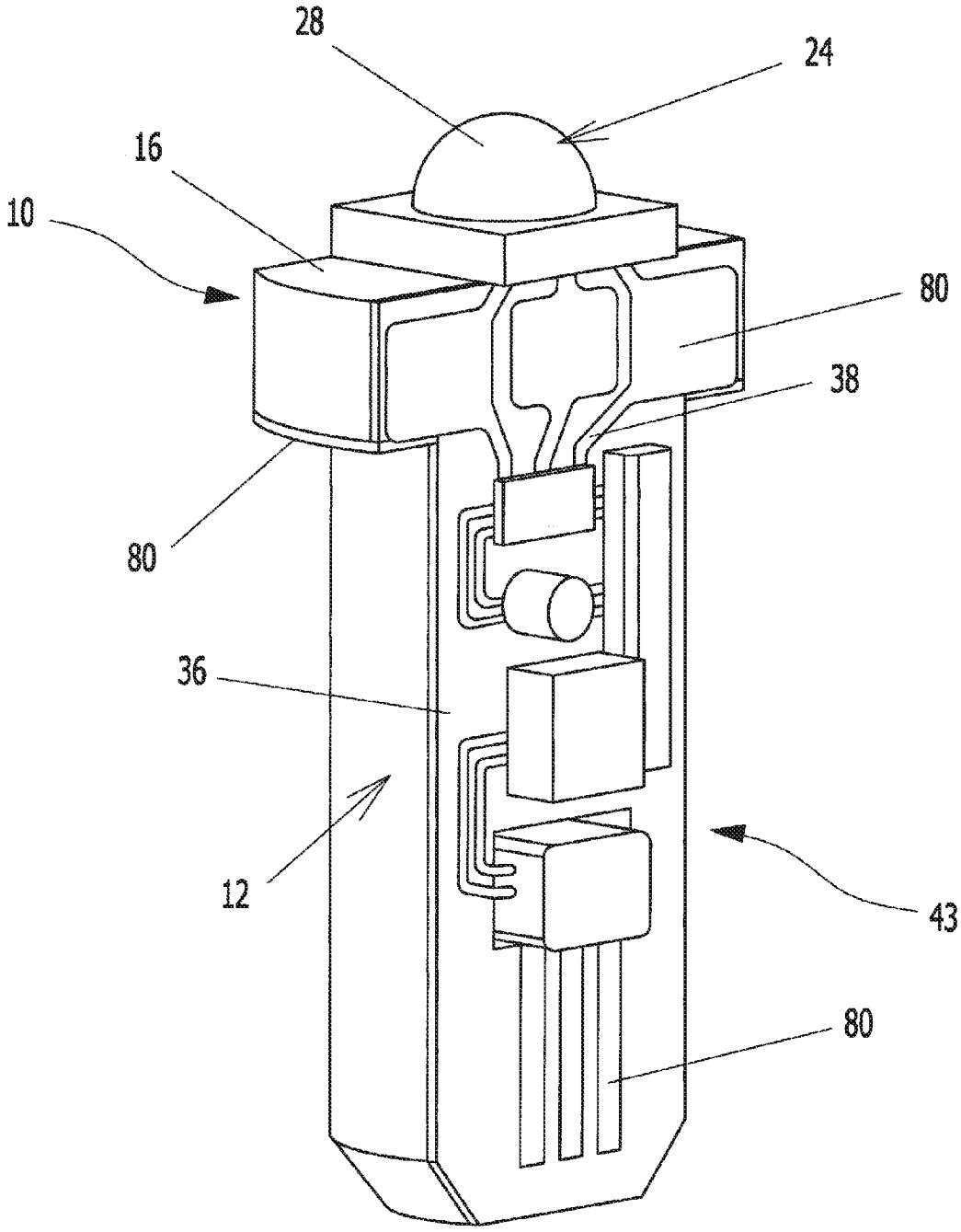

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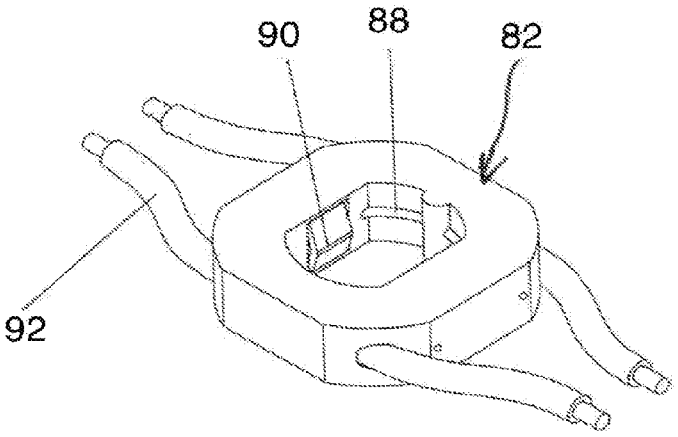

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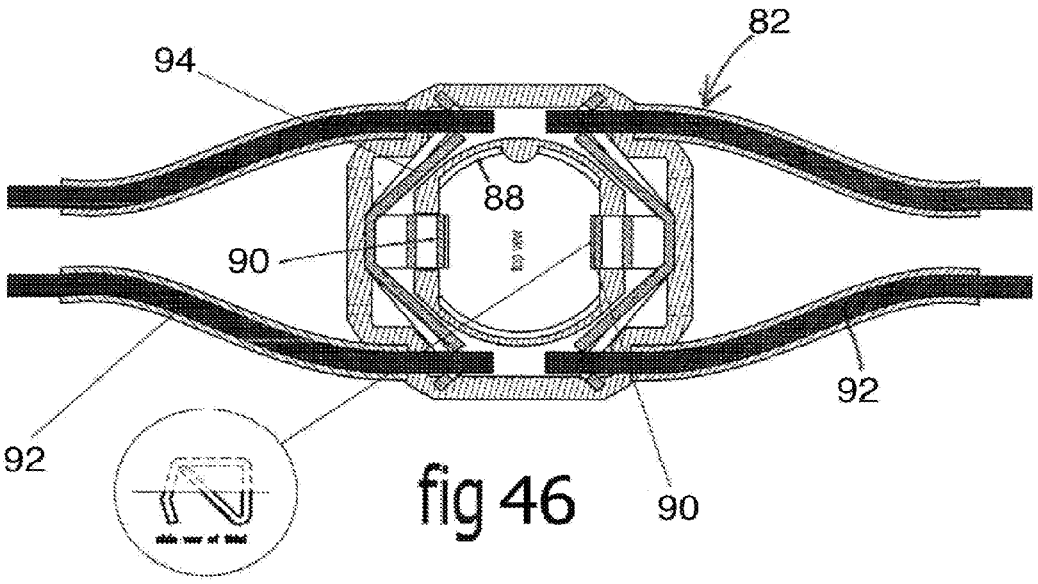

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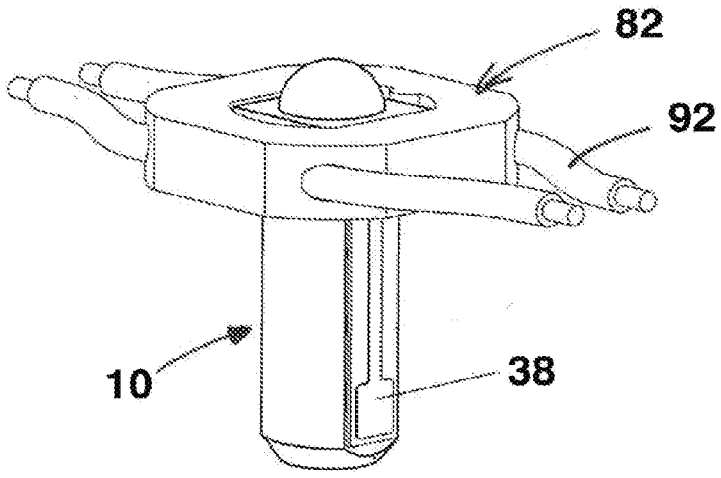

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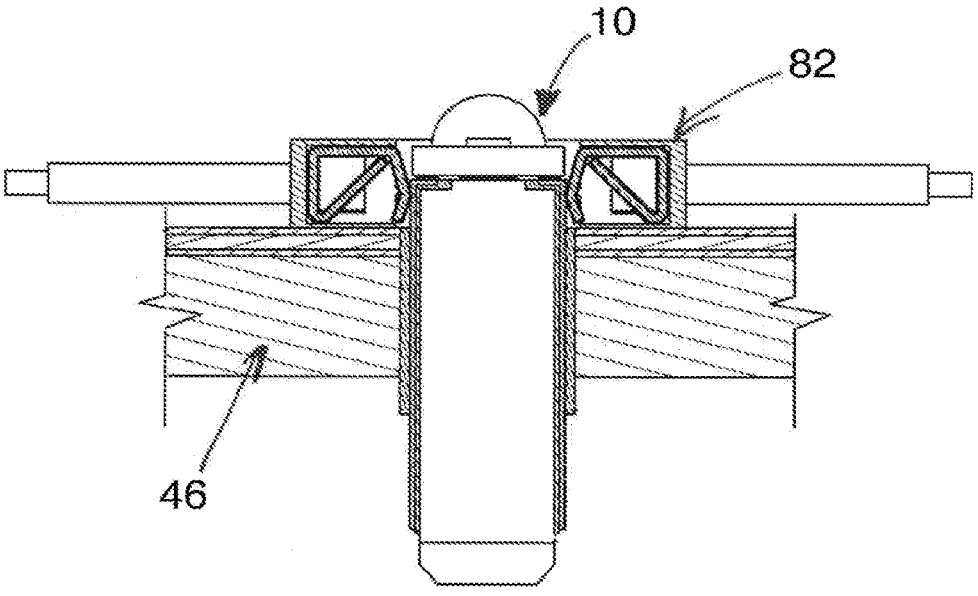

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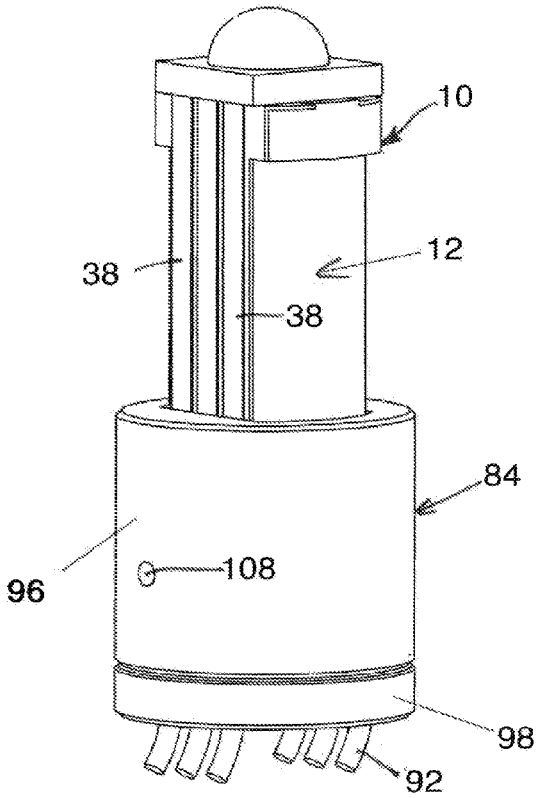

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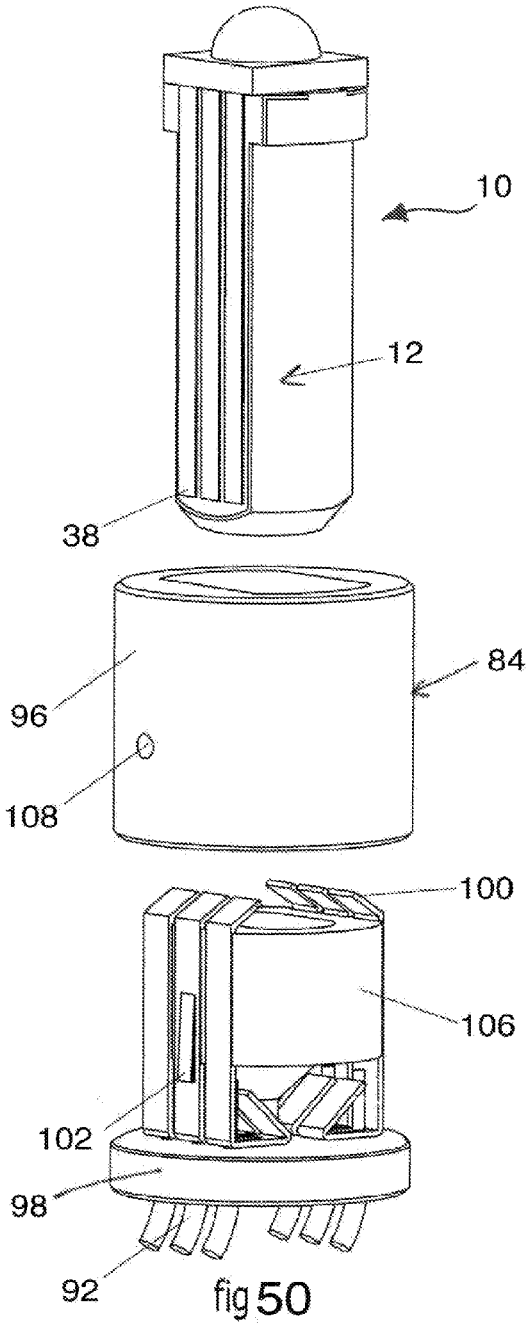

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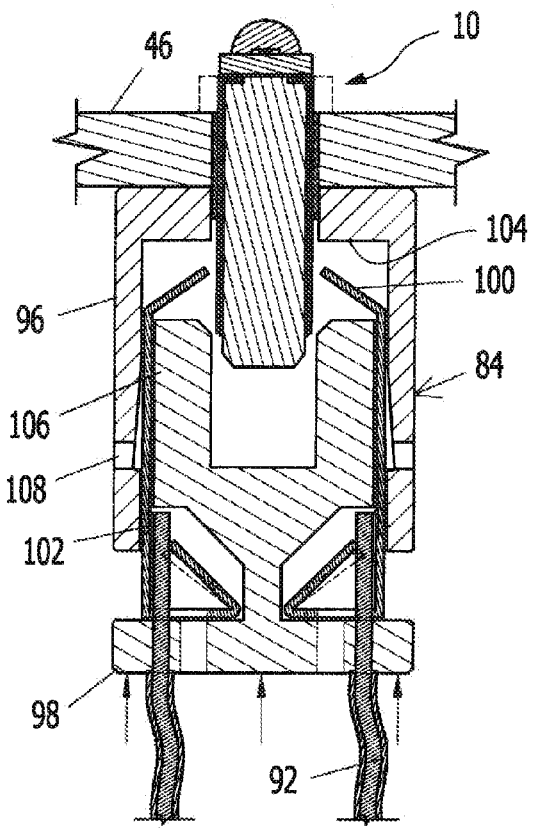
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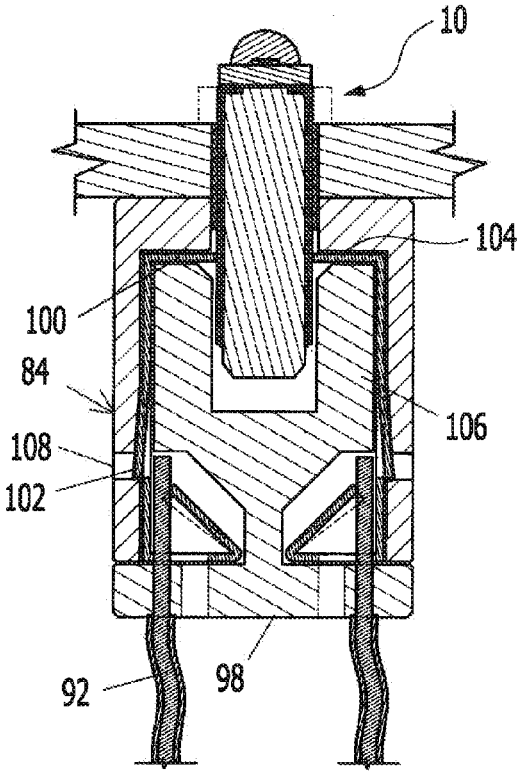
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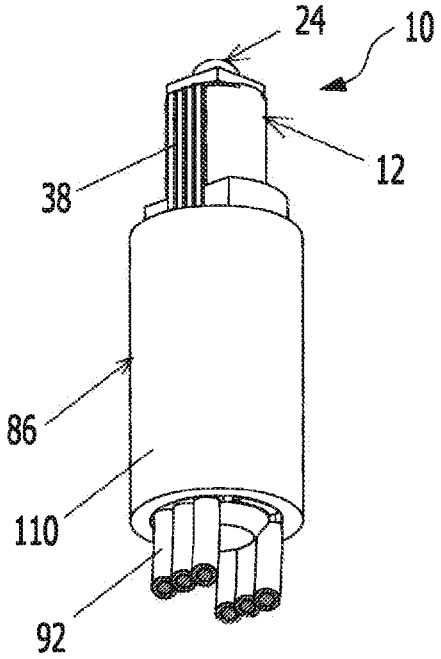

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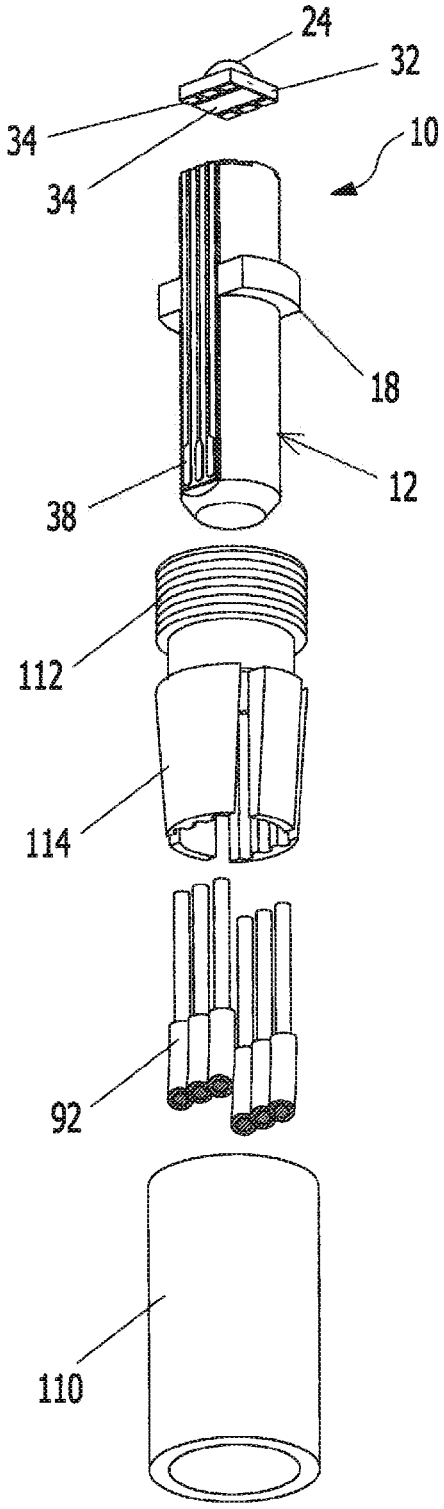

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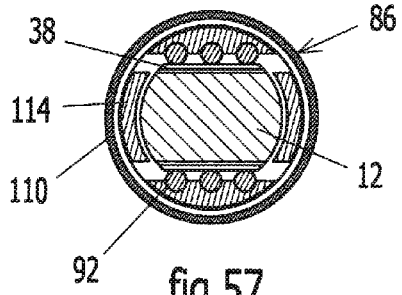

fig 57

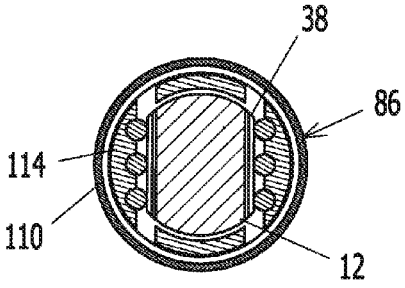

fig 58

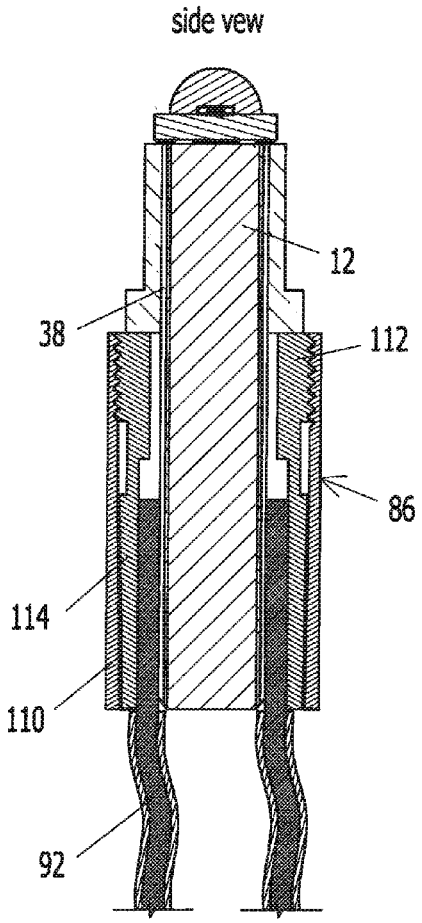

fig 55

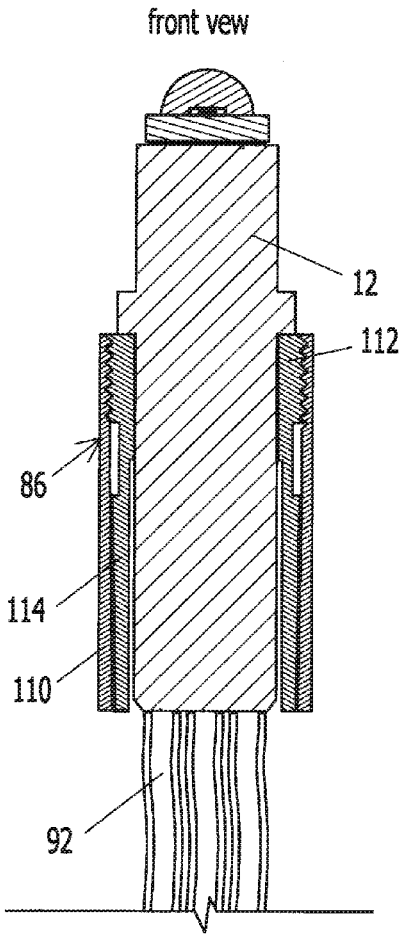

fig 56

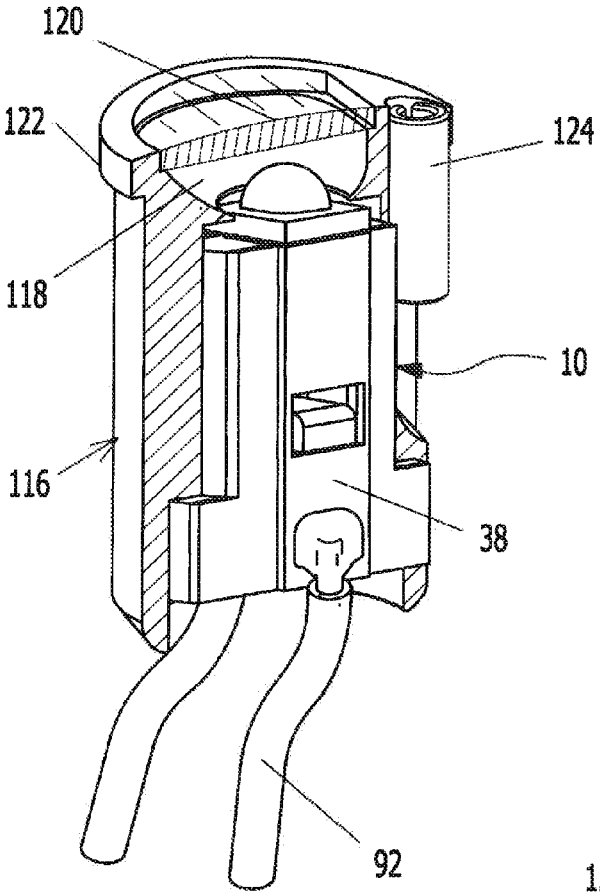

fig 59

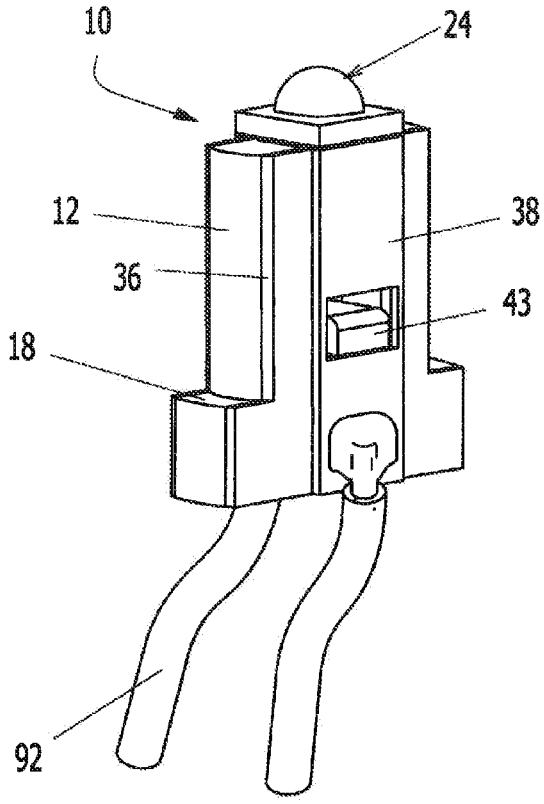

fig 60

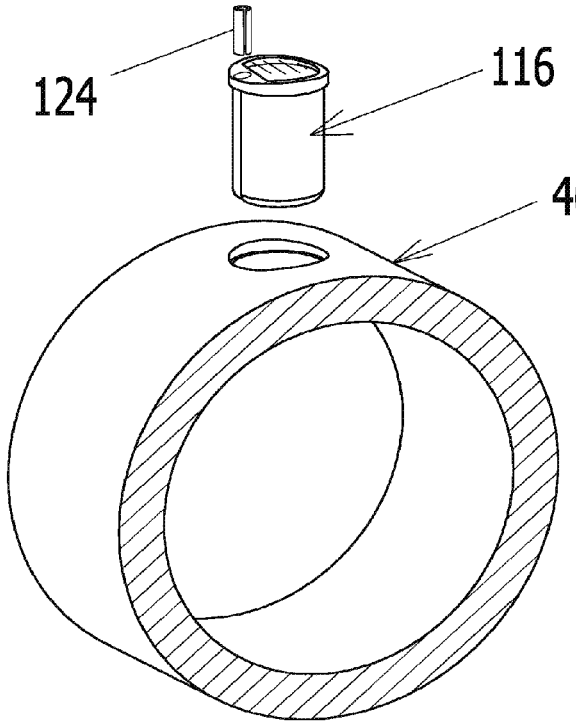

fig 61

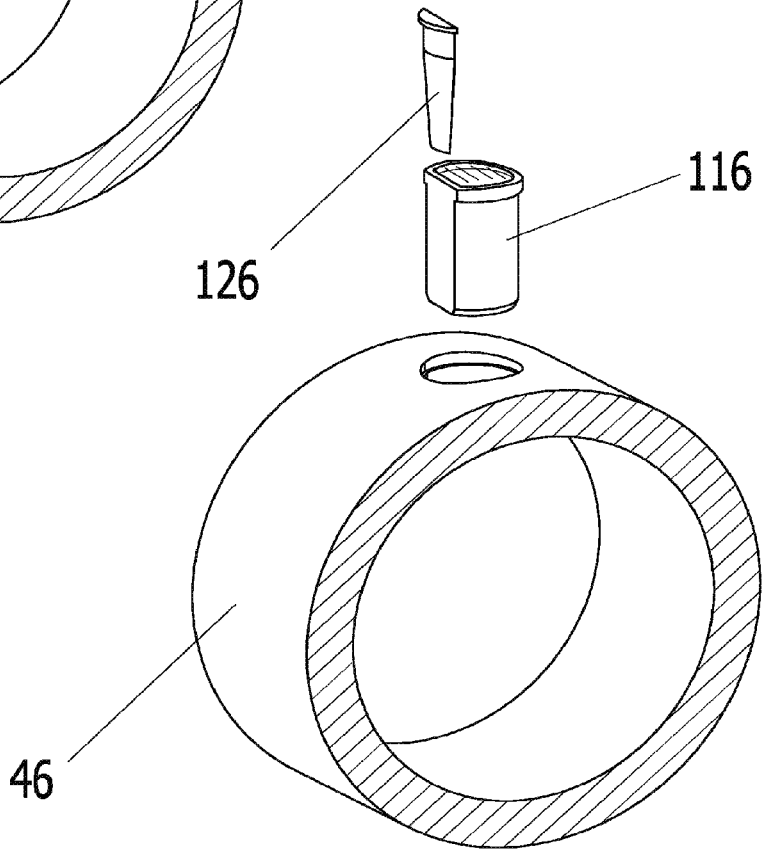

fig 62

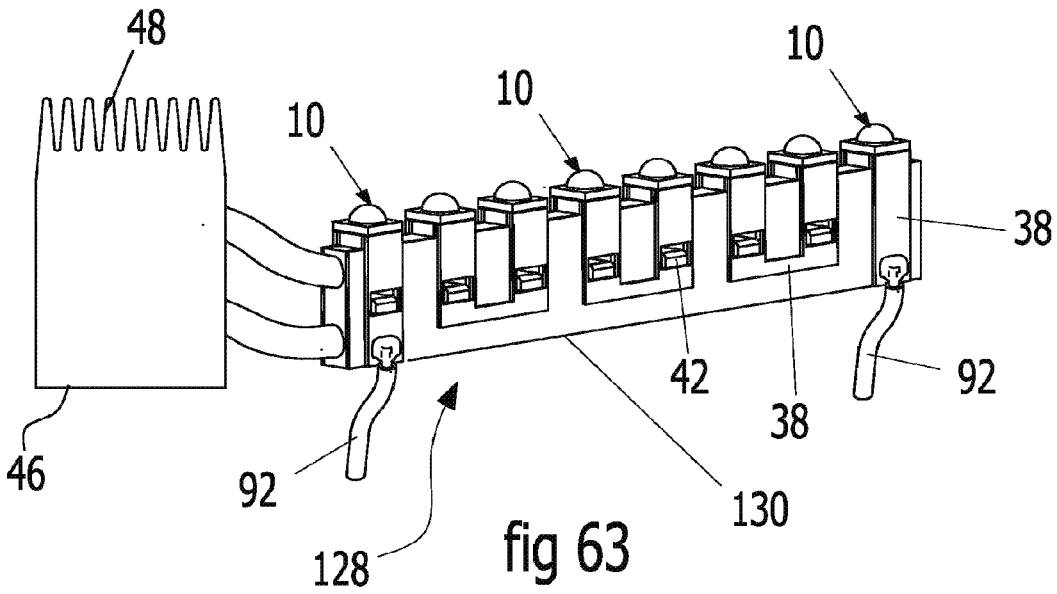

fig 63

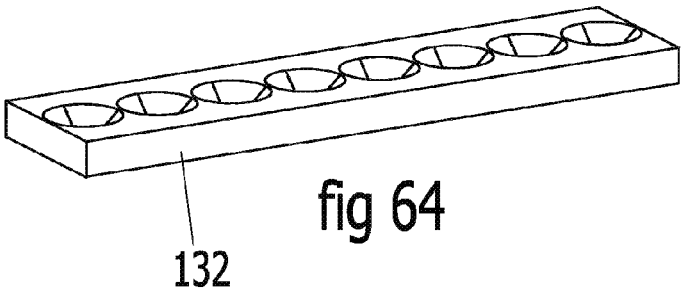

fig 64

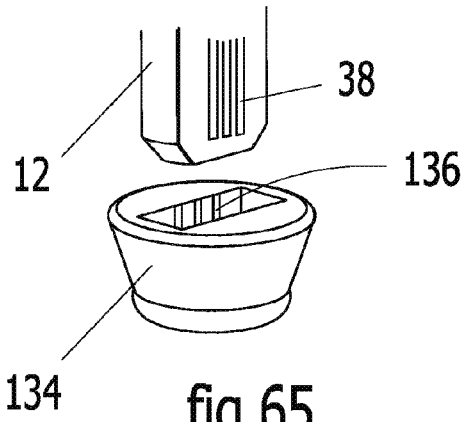

fig 65

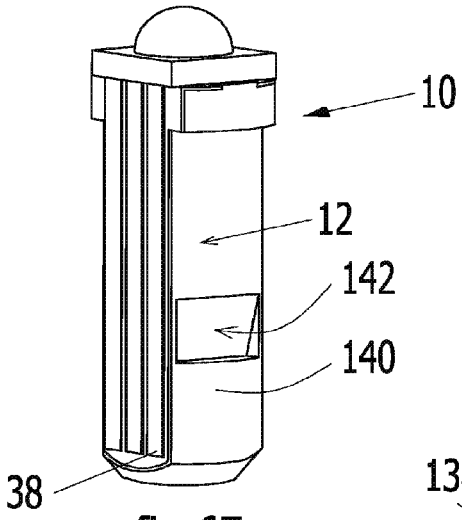

fig 67

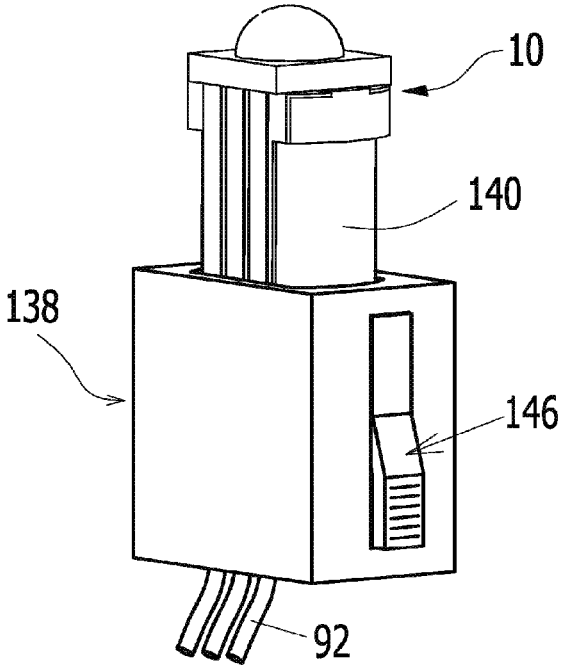

fig 66

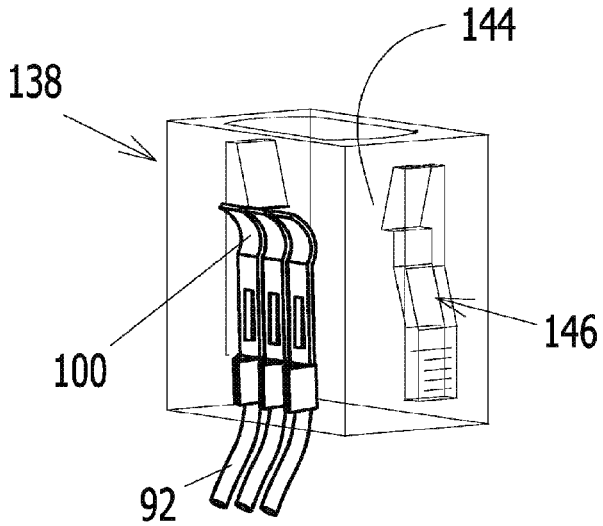

fig 68

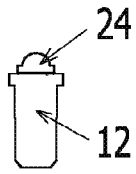

fig 69

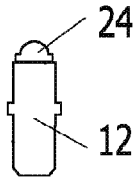

fig 70

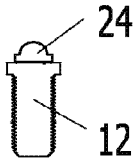

fig 71

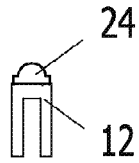

fig 72

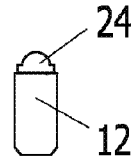

fig 73

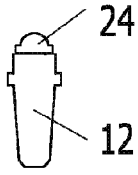

fig 74

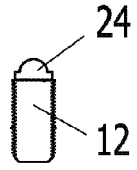

fig 75

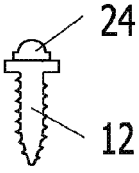

fig 76

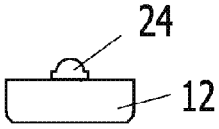

fig 77

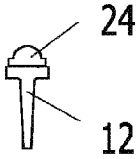

fig 78

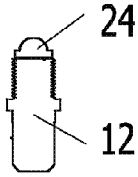

fig 79

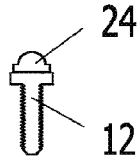

fig 80

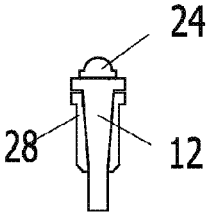

fig 81

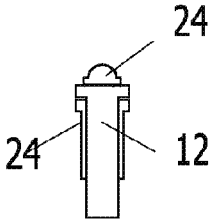

fig 82

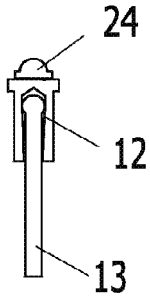

fig 83

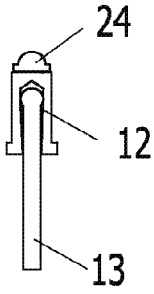

fig 84

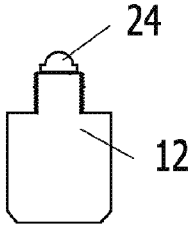

fig 85

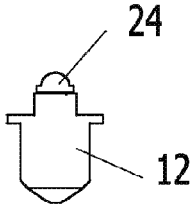

fig 86

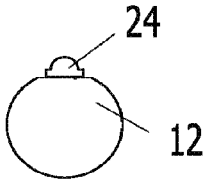

fig 87

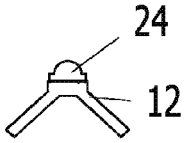

fig 88

LIGHT EMITTING DIODE (LED) ASSEMBLY AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 13/411,759, filed Mar. 5, 2012, which application is a National Stage of PCT Patent Application No. PCT/AU2010/001182, filed Sep. 10, 2010, which in turn claimed priority from Australian Application No. 2009904337, filed Sep. 10, 2009, the disclosures of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to an improved light emitting diode (LED) assembly and method of manufacture which enables the fixing of LED chips to a much broader range of surfaces or objects, amongst other benefits. In particular, the invention relates to a metal core printed circuit board (MCPCB) including on a first surface a LED die, and on a second surface a conductive circuit layer. In a preferred embodiment, the MCPCB is in the shape of a longitudinal rivet (or screw or the like) whereby the first surface is on the head of the rivet and the second surface extends along its length, the MCPCB rivet thus being adapted for quick and simple installation to a heat sink and/or PCB or MCPCB.

BACKGROUND OF THE INVENTION

[0003] The uses for LED's have grown quite considerably over the years, largely due to advances made in increases in their light output. Historically, the low light output from LED's made them impractical for use in applications requiring significant light output, for example, in outdoor applications, but there has been an increase in the employment of LED's as light source replacements in all light situations.

[0004] The apparent light output of a LED depends on a number of factors including the viewing angle of the LED with respect to the optical centre, and the brightness of the LED which itself depends on a number of factors. For example, the brightness can be affected by the amount of current being delivered to a LED, and the junction temperature of the LED. Keeping the junction temperature as low as possible maximises the performance potential of the LED.

[0005] A typical LED system comprises an emitter (which typically houses a LED die or chip, optics, encapsulent, and a heat sink plug), a metal-core printed circuit board (MCPCB), and some form of metal heat sink. One of the factors which affects the junction temperature of the LED and hence its performance is the effectiveness of the "thermal path", that is, the path through which heat is moved away from the back side of the LED chip. Known thermal path designs involve the transfer of heat from the emitter to the MCPCB via a solder (if the emitter is soldered to the MCPCB), and from the MCPCB to the external heat sink (to which the MCPCB is usually mechanically attached), and finally to ambient surroundings.

[0006] An MCPCB is a type of circuit board comprising a metal substrate otherwise known as a heat spreader (typically copper or aluminium) and a dielectric layer which is a non-conductor of current. These boards, as the name suggests, are typically flat panels having a face for housing the LED as well as drive circuitry and components. Such components include, but are not limited to a voltage regulator, a current control and monitoring and feedback circuit, a temperature sensor, a light sensor, a moisture sensor, a dmx driver, a dmx receiver, a motion sensor, a resistor, a microcontroller, a shunt, a bypass controller and/or a communication link. The LED and associated circuitry and components can use up valuable space on circuit board faces. This space could otherwise be used to house more components, including more LED's for example.

[0007] It is becoming increasingly important to maximise efficiency, versatility and the use of confined spaces in LED lighting devices whilst still maintaining the required levels of heat transfer and performance.

[0008] It is therefore an object of the present invention to overcome at least some of the aforementioned problems or to provide the public with a useful alternative.

SUMMARY OF THE INVENTION

[0009] Therefore in one form of the invention there is proposed a heat transfer device characterised by:

[0010] a body including a first surface and a second surface, said first and second surfaces extending in different planes;

[0011] a heat generating means associated with said first surface;

[0012] a means of transferring heat away from said heat generating means, said means of transferring heat being associated with said second surface.

[0013] Preferably said body is shaped in the form of a fastening means such as a rivet or screw, wherein a head portion of the fastening means includes said first surface, and an elongate body portion of the fastening means includes said second surface.

[0014] In preference said first surface and second surface are perpendicularly disposed.

[0015] Preferably said body is in the form of a printed circuit board (PCB).

[0016] In preference said body is in the form of a metal core printed circuit board (MCPCB), wherein said means of transferring heat includes said MCPCB metal core.

[0017] Preferably said means of transferring heat away from said heat generating means includes a heat conductive layer of material extending from said heat generating means on said first surface to said second surface.

[0018] In preference said heat generating means is a light emitting diode (LED).

[0019] In preference said heat conductive layer includes a circuit for transferring current to said LED.

[0020] Preferably said heat conductive layer include electrical components.

[0021] In preference said heat transfer device further includes a heat sink.

[0022] In a further form of the invention there is proposed a LED assembly characterised by:

[0023] a circuit board body including a first and second surface disposed in two different planes; a LED chip associated with said first surface; and a conductive circuit layer associated with said second surface, said conductive circuit layer being electrically connected to said LED chip.

[0024] Preferably said circuit board body includes an elongate shape, said first surface extending along an end of said elongate body, and second surface extending substantially perpendicularly along the length of the body.

[0025] In preference said circuit board body is in the shape of a fastener such as a rivet or screw including a head portion and a body portion having at least one flat surface, said LED

chip being mounted to the head portion, and the circuit board body being mounted along said flat surface.

[0026] Preferably said circuit body is a metal core printed circuit board (MCPCB).

[0027] In preference said assembly further includes a heat sink.

[0028] In a further form of the invention there is proposed a terminal block adapted to house a LED assembly as characterised above.

[0029] In a yet further form of the invention there is proposed a light fixture adapted to house a LED assembly as characterised above.

[0030] In a still further form of the invention there is proposed a light fixture including:

[0031] a LED associated with an upper portion of an MCPCB elongate body; a conductive circuit layer in electrical connection with said LED extending along the length of the MCPCB body; a data/power cable associated with a lower portion of the MCPCB body in electrical connection with said conductive circuit layer; and a heat sink.

[0032] In a further form of the invention there is proposed a method of manufacturing a LED assembly characterised by the step of forming a MCPCB body in the shape of a fastening means such as a rivet or screw including a LED manufactured on a head surface thereof, and a conductive circuit layer in electric connection with said LED and extending along the length of an elongate body portion surface of said fastening means.

[0033] In a still further form of the invention there is proposed a method of manufacturing a LED assembly characterised by the steps of:

[0034] (a) forming a MCPCB body in the shape of an elongate fastening means such as a rivet or screw; (b) manufacturing a LED on an upper face of the elongate fastening means; and (c) manufacturing a conductive circuit layer along a surface extending along the length of the elongate fastening means body.

[0035] In a yet further form of the invention there is proposed a LED assembly manufactured from the steps defined above.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0036] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several implementations of the invention and, together with the description, serve to explain the advantages and principles of the invention. In the drawings:

[0037] FIG. **1** illustrates a partially exploded perspective view of a rivet-type LED assembly in accordance with a first embodiment of the invention;

[0038] FIG. **2** illustrates an exploded perspective view of the LED assembly of FIG. **1**;

[0039] FIG. **3** illustrates a side, partial cross-sectional view of the LED assembly of FIG. **1**;

[0040] FIG. **4** illustrates a front, partial cross-sectional view of the LED assembly of FIG. **1**;

[0041] FIGS. **5** to **19** illustrate front cross-sectional views of various LED assemblies embodying the present invention when fixed to alternately configured heat sinks;

[0042] FIG. **20** illustrates a plurality of LED assemblies fixed to a heat sink wafer in accordance with the present invention;

[0043] FIG. **21** illustrates a side cross-sectional view of the LED assembly of FIG. **1** fixed to another MCPCB;

[0044] FIGS. **22** to **29**, and FIGS. **34** to **35** illustrate side cross-sectional views of rivet-type LED assemblies according to further embodiments of the present invention;

[0045] FIGS. **30** to **33**, and FIGS. **36** to **43** illustrate top cross-sectional views of rivet-type LED assemblies according to still further embodiments of the present invention;

[0046] FIG. **44** illustrates a perspective view of a rivet-type LED assembly including electrical circuit components in accordance with a preferred embodiment of the invention;

[0047] FIG. **45** illustrates a perspective view of a terminal block;

[0048] FIG. **46** illustrates a top cross sectional view of the terminal block of FIG. **45**;

[0049] FIG. **47** illustrates a perspective view of the terminal block of FIG. **45** when affixed to the LED assembly of the present invention;

[0050] FIG. **48** illustrates a side cross sectional view of the terminal block and LED assembly of FIG. **37**;

[0051] FIG. **49** illustrates a perspective view of a RGB terminal block when affixed to a rivet-type LED assembly having an RGB conductive circuit layer;

[0052] FIG. **50** illustrates an exploded perspective view of FIG. **49**;

[0053] FIG. **51** illustrates a side cross sectional view of the LED assembly and terminal block of FIG. **49** in a disengaged state;

[0054] FIG. **52** illustrates a side cross sectional view of the LED assembly and terminal block of FIG. **49** in an engaged state;

[0055] FIG. **53** illustrates a perspective view of an alternate type of RGB terminal block when affixed to a rivet-type LED assembly having an RGB-conductive circuit layer;

[0056] FIG. **54** illustrates an exploded perspective view of FIG. **53**;

[0057] FIG. **55** illustrates a side cross sectional view of the LED assembly and terminal block of FIG. **53**;

[0058] FIG. **56** illustrates a front cross sectional view of the LED assembly and terminal block of FIG. **53**;

[0059] FIGS. **57** and **58** illustrate top cross sectional views of the LED assembly and terminal block of FIG. **53**;

[0060] FIG. **59** illustrates a cutaway perspective view of a LED assembly housed in a puck device;

[0061] FIG. **60** illustrates the LED assembly of FIG. **59** with the puck housing removed;

[0062] FIG. **61** illustrates an exploded perspective view of the LED assembly and puck device of FIG. **59** associated with a hand rail heat sink;

[0063] FIG. **62** illustrates an exploded perspective view of a LED assembly, hand rail heat sink, and puck device according to a further embodiment;

[0064] FIG. **63** illustrates a perspective view of a plurality of LED assemblies connected through a heat pipe and heat sink apparatus;

[0065] FIG. **64** illustrates a perspective view of a reflector for use with the apparatus of FIG. **63**;

[0066] FIG. **65** illustrates a perspective view of a power connecting junction with a LED assembly connected;

[0067] FIG. **66** illustrates a perspective view of a plug including a LED assembly fixed thereto;

[0068] FIG. **67** illustrates a perspective view of the LED assembly of FIG. **66**;

[0069] FIG. **68** illustrates a perspective view of internal components of the plug of FIG. **66**;

[0070] FIGS. **69** to **88** illustrate side views of rivet-type and screw-type LED assemblies according to still further embodiments of the invention;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0071] The following detailed description of the invention refers to the accompanying drawings. Although the description includes exemplary embodiments, other embodiments are possible, and changes may be made to the embodiments described without departing from the spirit and scope of the invention. Wherever possible, the same reference numbers will be used throughout the embodiments and the following description to refer to the same and like parts.

[0072] The present invention relates to a LED assembly which in a broad form comprises a circuit board substrate including at least two surfaces disposed in different planes, a first surface having associated therewith a LED die or chip, and a second surface having associated therewith a conductive circuit layer electrically connected to the LED chip. The skilled addressee would realise that in providing a circuit board with the ability to fix a LED to a surface extending in one plane, and associated circuitry and components to a surface extending in a different plane, the overall dimension or footprint of the LED assembly **10** is reduced compared to using say a flat panel MCPCB. The invention further provides an improved thermal path from the LED to the ambient surroundings, and more versatility in that the circuit board configuration allows it to be any desired shape, for example in the shape of a rivet or screw.

[0073] It is to be understood that whilst the following description refers to the use of a MCPCB, other substrates could equally well be used such as a printed circuit board (PCB) for example. The invention is not intended to be limited to the embodied application only, as the same principles could equally well be applied to any environment involving the transfer of heat in a device.

[0074] FIGS. **1-4** illustrate a rivet-shaped LED assembly **10** including a MCPCB **12** having a head portion **14** with a top face **16** and lower shoulder **18**, and a longitudinal body portion **20** extending outwardly therefrom. The body portion **20** includes a flat surface **22** extending down along at least one side thereof and perpendicular to the top face **16**, although other angles and arrangements are also possible.

[0075] Fixed to the top face **16** is a LED device **24** which is known in the art as a solid-state semiconductor device that converts electrical energy directly into light. On its most basic level, the semiconductor is comprised of two regions, the p-region which contains positive electrical charges, and the n-region which contains negative electrical charges. When voltage is applied and current begins to flow, the electrons move across the n-region into the p-region. The process of an electron moving through the p-n junction releases energy. The dispersion of this energy produces photons with visible wavelengths.

[0076] The LED device **24** includes a LED chip or die **26** which works on the above principle, a LED lens **28** which is a clear plastic cover that covers the LED to direct light, a LED reflector **30** (optional—shown in additional embodiments) which is a mirrored surface for reflecting light, and a LED board **32** which is a small printed circuit board that the LED chip **26** is manufactured on. It will also become apparent that the board **32** is not always necessary. In the embodiment shown, the LED chip **26** is thermally coupled and electrically connected on the rivet-shaped MCPCB top face **16** by way of a solder, using a soldering pad **34**.

[0077] Inverted L-shaped non-conducting layers **36** are fixed to the metal core portion **20** such that the shorter length of each layer extends across the top face **16** and the longer length extends down along the flat surface **22**. This layer forms a fixing membrane between two conducting (or non-conducting) materials or layers, in this case between the conductive metal core portion **20** "heat spreader" and the similarly shaped conductive circuit layers **38** which extend over the non-conducting layers **36**. The conductive circuit layers **38** are typically copper and they form the circuitry layers for the MCPCB **12**. The top face portions of the conductive circuit layers **38** are sometimes referred to as landings or islands to which the LED chips are mounted.

[0078] Also shown is an outer non-conducting layer **40** which is a thin film adapted to cover all the electric components **43** (not shown in FIGS. **1-4**) that are commonly used on a PCB or MCPCB to protect them. This layer **40** is usually a high temperature epoxy or resin or glue which is capable of withstanding heat. The film may be thick where required and this is described in more detail below.

[0079] The rivet stem **42** forms an extension of the rivet-shaped MCPCB **12** and is removed when the rivet is fixed as is known in the art. The head portion **14** of the MCPCB **12** also includes a notch **44** which enables other items to be located and held onto the assembly. The MCPCB shoulder **18** is obviously used to prevent the rivet shaped MCPCB from being pulled through a hole through which the rivet extends, like an aperture associated with a heat sink for example. The shoulder **18** can also be used to accommodate an electrical connection between the rivet and an associated device.

[0080] It is to be understood that the location and electrical requirements of the components that are to be used on the assembly **10** are not limited to the surface **22**. They could be positioned through the MCPCB **12** as shown in FIG. **44**, for example, to save space and/or to enable connection to multi-layered MCPCB or PCB circuitry or heat spreader substrates.

[0081] The skilled addressee would realise that the use of more than one surface of an MCPCB **12** (in this case being the edge or top face **16** of a rivet-shaped MCPCB) for mounting LED chip(s) or LED board(s) saves significant space and results in the overall dimension (diameter) of the assembly to be extremely compact. This is very important in lighting situations in confined spaces.

[0082] In being able to provide MCPCB's in the shape of rivets and screws, the invention enables extremely quick and simple installation of the LED to a heat sink **46** and/or a PCB or MCPCB as only an appropriately dimensioned aperture is required to install the LED, or group of LED's, to the fixture. The invention is not intended to be limited to this fixing method as the shapes could also be made to fit over the edge of such fixtures, or even on their surface. Further still, the MCPCB could be shaped to accommodate heat pipes, thermoelectric coolers, and other components. The MCPCB **12** acts as a thermal mediator between the LED board and the heat sink **46**, providing a larger heat transfer footprint for the LED, as well as assisting in the ease of assembly, for example, associated wiring.

[0083] FIGS. **5-19** illustrate the LED assembly **10** of the present invention, according to several embodiments, having associated therewith a heat sink **46** which those skilled in the

art would know is used to remove heat produced by the LED chip and its components. The heat sink **46** can be connected to the LED assembly a number of different ways and this is evident in the different examples provided. The present invention is not intended to be limited to any one heat sink arrangement. Each embodiment will now be described briefly. Whilst all the heat sinks shown are configured differently, they are each referenced using the same numeral for the purpose of brevity.

[0084] FIG. **5** shows the LED assembly **10** fixed to a rough surface heat sink **46**. FIG. **6** shows the assembly **10** fixed through a heat sink **46** at an angle. FIG. **7** illustrates the assembly **10** sunken into a small space between heat sink fins **48** and includes an additional lens **50** affixed to the fins **48**, demonstrating yet another possible configuration. FIG. **8** shows the LED assembly **10** fixed to an internal radius curved surface heat sink **46**, whilst FIG. **9** shows the LED assembly **10** fixed to an external radius curved heat sink **46**.

[0085] FIGS. **10**, **11**, **12** and **13** illustrate LED assemblies **10** again including rivet-shaped MCPCB's, which are fixed with sleeves **51** to lower the MCPCB into the heat sink (these examples show curved heat sinks, but the use of sleeves should not be limited to this). In the embodiments of FIGS. **11-13**, the shoulder **18** of the MCPCB **12** is located at an opposite end being the lower portion to suit the particular heat sink configuration. The assembly **10** of FIG. **12** includes an MCPCB having a threaded outer surface and so forms a bolt-type MCPCB rather than a rivet-type. FIG. **13** shows an alternately configured sleeve including an outer thread.

[0086] A full description of the way in which each of these components is connected, for example, by threaded connection, or by interference fit, etc., is not provided because it is considered known in the art.

[0087] The assembly **10** of the present invention could also be used to hold together various components as shown in FIGS. **14-15**. In particular, FIG. **14** shows a LED assembly **10** holding together a heat sink **46** and a reflective panel **30**. FIG. **15** illustrates the assembly **10** holding together a heat sink **46** and a printed circuit board **54**.

[0088] FIGS. **16-19** show yet further embodiments in the form of a LED assembly **10**. FIGS. **16** and **17** are fixed to a recessed heat sink **46**. In FIG. **17**, an assembly **10** is threaded to a recessed heat sink **46**. In FIG. **18**, a LED assembly **10** has a rivet-shaped MCPCB **12** with a slot **56** to fit over the heat sink **46**. In FIG. **19** a LED assembly **10** is fixed to a heat sink **46** through the distortion of the rivet, that is, through use of the remaining rivet stem **42**. FIG. **20** illustrates a heat sink wafer **58** including multiple apertures for receiving a plurality of LED assemblies **10**.

[0089] FIG. **21** is similar to FIG. **15** in that it shows a LED assembly **10** housed in another MCPCB **60**. This drawing however demonstrates the use of circuit connection clips **62** which may be added to the rivet-shaped MCPCB **12** to enable circuit connections to the other MCPCB **60**.

[0090] FIGS. **22-25** illustrate how the conductive circuit layer **38** can be configured a number of different ways. For example, FIG. **22** shows the conductive layer **38** extending along the body up to the solder pad **34**, and FIG. **23** shows the conductive layer **38** extending up the body of the MCPCB **12** with a perpendicular bend to align with the solder pad **34**. FIG. **24** shows the conductive layer as a wire (for power or data transporting medium) running alongside the body of the rivet-shaped MCPCB up to the solder pad **34**. FIG. **25** illustrates how an additional solder pad **64** could be employed to create a thermal path from the LED to an aluminium rivet body.

[0091] As mentioned earlier, the LED chip **26** needn't necessarily have an associated LED board **32**. FIGS. **26-31** and FIGS. **34-41** illustrate examples of LED assemblies which are configured like so, that is, without a board **32** and with a LED chip **26**. FIGS. **34** and **35** also have a lens **28** affixed to the rivet **12**. The shape and size of the MCPCB **12** thus eliminates the need for several components because the positive and negative doped chip can be affixed directly to the board **12**.

[0092] FIG. **26** shows an assembly **10** wherein a LED is fixed to a positive **74** and a negative **72** of the conductive circuit layers **38** that run along the length of the MCPCB **12** and which transfer heat directly away from the LED chip **26**. FIG. **27** illustrates how the LED chip **26** could be fixed to a rivet shaped MCPCB **12** with a non-conductive material **36** there between, and a circuit layer **38** extending from the sides of the rivet to a negative doped chip **72** and a positive doped chip **74**. Similarly, FIG. **28** shows a LED assembly **10** including a LED chip **26** fixed to the rivet shaped MCPCB **12** with a non-conductive material **38** there between, but with a circuit layer extending through the rivet **12** to a negative doped chip **72** and positive doped chip **74**. Shown in FIG. **29** is a LED chip **26** fixed to the conductive circuit layer **38** which extends along the length of the MCPCB **12** and can transfer heat directly away from the LED chip **26**. A wire bond **76** is used to provide an electrical connection between the negative doped chip **72** and positive doped chip **74**. FIG. **30** shows a LED assembly **10** including a LED chip **26** affixed to the rivet **12**, and a conductive circuit layer **38** and heat transfer path **20** on the side of the rivet shaped MCPCB **12**. FIG. **31** shows a LED chip **26** mounted directly to electrically conductive heat spreaders **20** forming the conductive circuit layer **38**.

[0093] FIGS. **32**, **33**, **42** and **43** illustrate still further embodiments using a LED board **32**, namely, a LED assembly **10** with electrical components **43** connected to the circuit and a LED assembly **10** with conductive circuit layers **38** extending up the sides of the rivet shaped MCPCB **12**.

[0094] Yet further possible embodiments are shown in FIGS. **36** to **43**. FIGS. **36** *to* **39** show LED assemblies having multiple LED chips **26** mounted, FIGS. **40** *and* **41** illustrate LED assemblies **10** having a LED chip mounted along the side of the rivet shaped MCPCB **12**, and assemblies **10** having a LED board **32** mounted to the side of the rivet are shown in FIGS. **42** and **43**.

[0095] In each of FIGS. **30-43**, the outer non-conducting layer is a thick coating which encapsulates the circuitry and components and fills the shape out from a rectangle to a circle, although other shapes are possible.

[0096] Thus, the conductive layer **38** is used to house the electrical circuit and components **43** that would be used on the MCPCB, and may include a voltage regulator, current control circuit and monitoring and feedback circuit, temperature sensor, a light sensor, a moisture sensor, a dmx driver, a dmx receiver, a motion sensor, a resistor, a microcontroller, a shunt, a bypass controller, a sensor of any type, and/or a communication link. Some of these components are shown in more detail in the LED assembly **10** of FIG. **44**. Also present are power data connection areas **80** to which power or data wires can be connected. The skilled addressee would realise that such an assembly provides a number of advantages, including:

[0097] there is no limitation on where the power or data can be connected to the device as the MCPCB can be designed for any particular area, thus allowing for a broader amount of connection options (for example, the clips **62** shown in FIG. **21** show but one connection option at the top of the rivet **12**);

[0098] any circuitry components including those mentioned above can be placed on the faces of the MCPCB **12**;

[0099] the components can be housed through the device, to save space, to bridge, or to make contact with circuitry on the other side;

[0100] the circuitry is not limited to one layer—it can be multi-layered;

[0101] the circuitry (wiring substrate) can be 3-dimensional;

[0102] the circuitry and the components can be covered in protective epoxy resin sealant, as mentioned earlier, or silicone or the like to water proof and/or insulate the circuitry and components thermally and electrically;

[0103] the sealing of the circuitry and components can be a thin coating just to seal or insulate;

[0104] the sealing can also be a thick coating to encapsulate the circuitry and components to fill the shape out from one shape to another, for example, form a rectangle to a circle as per FIGS. **30-33**; and

[0105] the coating encapsulate can also assist in the formation of threads, shoulders, etc.

[0106] FIGS. **45** to **58** illustrate different terminal block and LED configurations. In particular, the terminal block **82** shown in FIGS. **45** to **48** is for a single light LED, whilst the terminal blocks **84** and **86** shown in FIGS. **49** to **58** are intended for RGB LED assemblies.

[0107] FIG. **45** shows a single light terminal block **82** without the LED assembly **10**, and it can be seen that the device includes ridges **88** to clip the block onto the top of the LED and contacts **90** that connect to the circuit **38** on the rivet **12** as in FIG. **1**. The earlier described notch **44** on rivet shaped MCPCB **12** is adapted to engage the ridges **88** to secure the LED assembly in the terminal block **82**. The terminal block **82** includes power/data cables **92** as is known in the art. FIG. **46** shows in detail how the contacts **90** and **94** are moveable so as to cause contact between conductive circuit layer **38** (not shown) and the power/data cables **92** when the assembly **10** engages the block **82**. FIG. **47** illustrates these components when assembled. FIG. **48** shows the assembled components affixed to a heat sink **46**.

[0108] FIG. **49** shows a RGB LED assembly having three distinct circuit layers **38** housed on opposed sides of an RGB terminal block **84**. As shown more clearly in FIGS. **50** to **52**, the RGB terminal block **84** includes an outer housing **96** and a base **98** which supports clamping tabs **100** adapted to contact the three circuit layers **38** when the components are engaged. The clamping tabs **100** are in contact with respective data/power cables **92** at their lower ends. When the housing **96** is pushed down over the clamping tabs **100** towards the base **98**, a biased sleeve **102** associated with one of the clamping tabs **100** is pushed outwards, until the housing **96** is fully inserted and the sleeve **102** is able to snap back outwards again thereby locking the housing **96** in place. When the housing and the base are engaged like so, an internal shoulder **104** of the housing presses down against the top of the clamping tabs, and in combined action with inner housing **106** causes them to make contact with the circuit layers **38** (as shown clearly in FIG. **52**). To disengage the housing, one simply needs to press the biased sleeve **102** using an appropriate tool through the aperture **108** in the side of the housing. FIGS. **51** and **52** also illustrate the use of a heat sink **46**.

[0109] The terminal block embodiment shown in FIGS. **53** to **58** works on the same principles as the above described embodiments in that when the terminal block **86** is fully engaged with the LED assembly, an electrical connection is formed between the cables **92** and the circuit layers **38**, and when disengaged, the connection is broken. The difference resides in the way in which this connection occurs. In this embodiment, the block **86** includes an outer housing **110** and an inner housing **112** which are engageable by threaded connection, the outer housing **110** including inner converging walls at a lower portion thereof and the inner housing **112** including inwardly moveable panel sleeves **114**. These components are configured such that as the inner housing **112** is screwed into the outer housing, the converging walls cause the sleeves to move inwardly and thereby cause the cables housed therein to also move inwardly and make contact with the conductive layers **38** of the inserted rivet shaped MCPCB **12**. As is also shown, the LED board **32** includes seven solder pads **34** which correspond with the six circuit layers **38** and one heat path, and the shoulder **18** is shifted further down along the body of the rivet MCPCB **12**.

[0110] FIGS. **59** to **62** illustrate yet another way the LED assembly **10** could be used. The LED assembly **10** is housed in a puck **116** as shown in FIG. **59**. In the embodiments shown, the puck **116** is in the form of a light device including a reflector **118** and a reflector cover **120** as shown in FIG. **59**. The LED assembly **10**, which is shown on its own in FIG. **60**, can be secured in the puck **116** by any known means including in the configuration shown in the drawings. The puck is able to be inserted into various shaped heat sinks, including the handrail **46** shown in FIGS. **61** and **62**, but not limited thereto. The shoulder **122** on the lighting device helps to locate the device in the wall of the pipe **46**.

[0111] There is shown two means of fixing the device into the pipe. The first is shown in FIGS. **59** to **61** and is in the form of a compressible rollpin **124** adapted to push between the puck and the wall of the pipe to hold it in place. The roll pin **124** is pushed flush with the top face of the puck. The second means is shown in FIG. **62** and utilises a wedge **126** which pushes between the puck and the wall of the pipe to hold it in place, completing the cylindrical shape of the puck when pushed flushed to the puck face.

[0112] FIG. **63** illustrates an apparatus **128** including a plurality of LED assemblies **10**, a heat pipe **130**, and a heat sink **46**. The heat sink **46** is to remove the heat at a distance from the LED assemblies **10**. The heat pipe **130** has a fluid in it which interacts with the LED assemblies in a manner which causes heat to be absorbed by the fluid, the heated fluid then being cycled to the heat sink to thereby flush heat away from the LED assemblies. A reflector **132** suitable for use with the apparatus of FIG. **63** is shown in FIG. **64**. The reflector can be used to focus the light from the LED assembly and insulate the radiant heat which emanates from the LED assemblies.

[0113] FIG. **65** illustrates a yet further embodiment in the form of a power connecting junction **134** adapted to clip on to the bottom of a MCPCB rivets **12**, the junction including along an inner surface conductive layers **136** adapted to contact the conductive layers **38** along the rivet **12** to complete/connect a circuit.

[0114] FIGS. **66** to **68** illustrate yet another way a LED assembly **10** of the present invention could be fixed inside a terminal block **138**. In this embodiment, a MCPCB rivet **12**,

includes on one of its faces **140** a notch **142** which is engageable by an internal plug **144** associated with an upper portion of tab **146**. The skilled addressee would realise that because the plug **144** is biased into a position such that it extends inside notch **142**, it will engage the notch **142** when the assembly **10** is inserted sufficiently deeply inside the block **138**. To then release the assembly **10**, one would simply press the lower portion of the tab **146** which is configured such that in doing so, the upper portion and hence the plug **144** shifts outwardly and disengages the notch **142**. As per previous embodiments, the terminal block includes internal clamping tabs **100** which engage the conductive layers **38** of the rivet shaped MCPCB **12** once inserted.

[0115] Finally, FIGS. **69** to **88** illustrate examples of possible shapes of LED assemblies including MCPCB's in the shape of rivets, screws, and other mechanical fasteners. For the purpose of brevity, these are not each described in detail.

[0116] The present invention is not intended to be limited use of just a light emitting diode (LED), silicon-based LED, silicon sub-mounted LED, or a LED made of any type of material. It could equally well be a solid state laser, an organic light-emitting diode, a polymer light-emitting diode, or another solid state light emitting device. It could also be a non-solid state light emitting device, for example, a non-solid state laser, a gaseous discharge light source (e.g., high-intensity discharge), an electric arc light source (e.g., arc lamp), or any other component that would benefit from this system.

[0117] The MCPCB rivet shaped body **12** is preferably made from sheet copper punched to shape, however, other materials and/or processes could also be used, including silver, aluminium, or any good thermal conductive material. The manufacturing processes could consist of, but is not limited to, bar machining, forging, or the use of pressure die cast processes.

[0118] Further advantages and improvements may very well be made to the present invention without deviating from its scope. Although the invention has been shown and described in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope and spirit of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices and apparatus.

[0119] In any claims that follow and in the summary of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprising" is used in the sense of "including", i.e. the features specified may be associated with further features in various embodiments of the invention.

1. A Light Emitting Diode (LED) assembly comprising:
a LED device; and
a metal core printed circuit board (MCPCB) comprising a body with a core extending to a first end edge; wherein the LED device is mounted on the first end edge of the MCPCB and the LED device is in thermal contact with the first end edge of the MCPCB.

2. The LED assembly of claim **1**, wherein the LED device comprises an LED chip, and wherein the LED chip is in thermal contact with the first end edge of the MCPCB.

3. The LED assembly of claim **2**, wherein:
the MCPCB further comprises first and second circuit connection points; the LED chip further comprises first and second doped chips; and
the first doped chip is wire bonded to the first circuit connection point and the second doped chip is wire bonded to the second circuit connection point.

4. The LED assembly of claim **3** wherein the MCPCB further comprises at least two external circuitry connection points.

5. The LED assembly of claim **1**, wherein the LED device comprises an LED chip mounted on a printed circuit board (PCB), and wherein the PCB is in thermal contact with the first end edge of the MCPCB.

6. The LED assembly of claim **5**, wherein:
the MCPCB further comprises first and second circuit connection points;
the PCB further comprises first and second circuit connection points; and
the first circuit connection point of the PCB is soldered to the first circuit connection point of the MCPCB and the second circuit connection point of the PCB is soldered to the second circuit connection point of the MCPCB.

7. The LED assembly of claim **6** wherein the MCPCB further comprises at least two external circuitry connection points.

8. The LED assembly of claim **1**, wherein the width of the core of the MCPCB is the same as the width of the thermal footprint of the LED device.

9. The LED assembly of claim **1**, wherein width of the core of the MCPCB is greater than the width of the thermal footprint of the LED device.

10. The LED assembly of claim **1**, wherein the body of the MCPCB is elongate and in the shape of a rivet.

11. The LED assembly of claim **10**, wherein the MCPCB further comprises a shoulder.

12. The LED assembly of claim **10**, wherein the MCPCB further comprises a front circuit layer extending along a front side of the MCPCB.

13. The LED assembly of claim **12**, wherein the MCPCB further comprises electronic circuitry.

14. The LED assembly of claim **10**, wherein the MCPCB further comprises a rear circuit layer extending along a rear side of the MCPCB.

15. The LED assembly of claim **1**, wherein the body of the MCPCB is elongate and further comprises first and second threaded side edges.

16. The LED assembly of claim **15**, wherein the MCPCB further comprises a shoulder.

17. The LED assembly of claim **15**, wherein the MCPCB further comprises a front circuit layer extending along a front side of the MCPCB.

18. The LED assembly of claim **17**, wherein the MCPCB further comprises electronic circuitry.

19. The LED assembly of claim **10**, wherein the MCPCB further comprises a rear circuit layer extending along a rear side of the MCPCB.

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