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F21V 23/00 *(2015.01)* ***F21V 29/502*** *(2015.01)*

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Remarks:
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(54) **IMPROVED DOWNLIGHT**

(57) A downlight assembly comprising:-
(i) a fire rated housing made from material with a melting point in excess of 900° C, said housing comprising a substantially tubular body having a front side and a rear side and at least one side wall and a rear end wall closing the rear of the housing;
(ii) a solid state lighting element mounted in thermal contact with the rear end wall of the housing;characterised in that the downlight assembly is devoid of a separate conventional heat sink.

The invention includes fire rated downlight assemblies of the construction described, as well as downlight assemblies incorporating small ventilation holes.

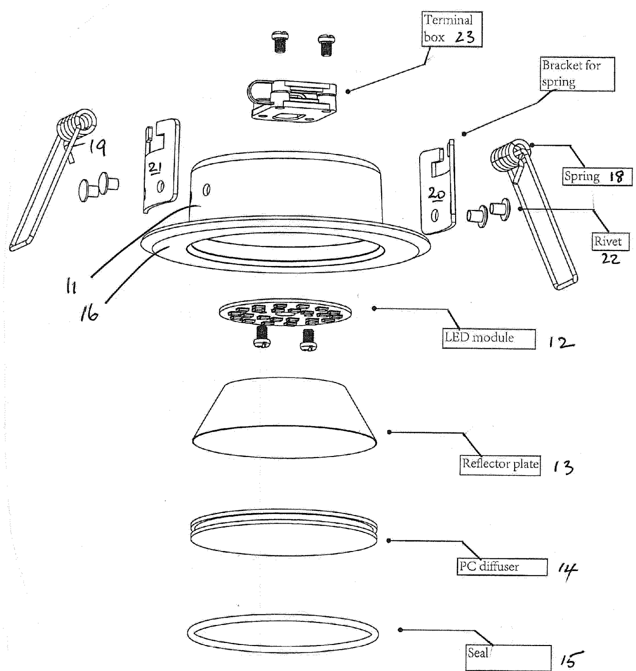

FIG 1

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Description

Field of the Invention

[0001] The present invention relates to downlight luminaires. It is particularly applicable, but in no way limited, to fire rated downlight luminaires.

Background to the Invention

[0002] It is well known in the lighting industry that it is most important to prevent overheating of LED solid state lighting elements. Much of the electricity used by an LED becomes heat rather than light and if this heat is not removed effectively both the life expectancy and the light efficiency of the LED unit will be much reduced. Thus efficient thermal management of high powered LED's is considered a crucial area of research and development and all such LED downlights on the market today, especially fire rated downlights where the LED solid state lighting element is contained in a fire rated housing, incorporate a separate heat sink of some sort.

[0003] A number of methods have been used to remove heat from LED solid state lighting units such as passive and active heat sinks, heat pipes and vapour chambers. Passive heat sinks have proved to be both cost-effective and efficient in this application, particularly in downlight designs and it is the perceived wisdom that a finned heat sink is an essential requirement in any LED downlight. Of the common metals, aluminium is most often used as heat sink material because it is relatively inexpensive, can be extruded or cast, and has quite a high thermal conductivity constant k of about 200 W/(m.k) (Watts per metre Kelvin), depending on the purity of the aluminium. Copper (k value 400) and silver (k value 429) are both better conductors of heat than aluminium but are more expensive and are not commonly used in heat sinks in fire rated downlights. In contrast, mild steel which is the material generally used to construct the fire rated housing or can of a downlight is a relatively poor conductor of heat, having a k value in the order of 43 to 53 depending on the percentage of carbon in the steel. Because of this low k value, heat sinks for use in downlight luminaires are never made from mild steel.

[0004] In summary, as a result of the above observations, it is currently the perceived wisdom in the lighting industry that, in order to have a good working life, a high powered LED solid state lighting element must be in positioned in good thermal contact with a heat sink made from a material with good thermal conductivity that is to say with a thermal conductivity constant k of above about 100 W/(m.k), and preferably a finned aluminium heat sink. Such heat sinks are referred to in this context as conventional heat sinks. This has an impact on the cost of a downlight because a separate heat sink must be provided, which costs money, uses up valuable natural resources, and adds to the cost of and time taken for assembly in the manufacturing process. It also has an impact on the total depth of the downlight, because the heat sink is inevitably located on the rear end face or wall of the downlight can. This is an important factor when there is limited space in the ceiling above the downlight or behind the panel in which the downlight is fitted.

[0005] It is an object of the present invention to overcome or mitigate some or all of the problems outlined above.

Summary of the Invention

[0006] According to a first aspect of the present invention there is provided a downlight assembly according to Claim 1. For example,

(i) a fire rated housing made from material with a melting point in excess of 900° C, said housing comprising a substantially tubular body having a front side and a rear side and at least one side wall and a rear end wall closing the rear of the housing;
(ii) a solid state lighting element mounted in thermal contact with the rear end wall of the housing;

characterised in that the downlight assembly is devoid of a separate conventional heat sink and does not rely on intumescent material to achieve the desired fire rating. Contrary to the general belief and thinking in the lighting industry, a separate conventional heat sink located inside or outside the housing is not required and a fire rated housing, made for example out of mild steel, is capable of dissipating the heat generated by the solid state lighting element by conduction, convection and radiation. This results in a considerable saving in both material and manufacturing costs.

[0007] Preferably the housing is made from a material having a melting point in excess of 1000° C.

[0008] Preferably the fire rated housing further comprises an outwardly extending flange at or towards the front side of the downlight housing. This flange enables the downlight to be fixed in a partition surface, such as in a ceiling.

[0009] In a particularly preferred embodiment the solid state lighting element comprises a plurality of LEDs. By using a number of small LEDs rather than one large LED light engine the heat generated is spread over a much larger surface area of the rear wall of the housing, improving the life expectancy and the light efficiency of the LED unit.

[0010] Preferably the plurality of LEDs are mounted on a printed circuit board (PCB), which is preferably a metal printed circuit board (MPCB) and more preferably the metal PCB includes aluminium. Aluminium PCBs, or PCBs made from other metals with a high heat transfer coefficient, transfer heat away from the LED and into the housing most efficiently.

[0011] Preferably the printed circuit board is attached directly to the inside face of the rear end wall of the housing.

[0012] Preferably a thermally conductive interface is provided between the PCB and the rear end wall of the housing. Suitable thermally conductive interfaces are, by way of example, thermally conductive grease, thermally conducting pads, graphite foil, or thermally conductive acrylic film.

[0013] Preferably the control circuitry and components required to power and control the solid state lighting element comprise one or more components selected from the group of components comprising power supply components, dimmer control components, control IC components, and other electronic components.

[0014] Preferably the downlight assembly further comprises a reflector adapted to direct light from the solid state lighting element out of the front of the housing. The assembly may also include a lens adapted to focus the light emitted by the solid state lighting element.

[0015] Preferably the control circuitry and components required to power and control the solid state lighting element are accommodated in an annular space provided around the lens or reflector.

[0016] Preferably the control circuitry and components required to power and control the solid state lighting element are thermally isolated as well as electrically isolated from the housing, and are preferably substantially located in a bottom cover and preferably the additional electronic components are substantially covered by a top cover.

[0017] Preferably the housing comprises steel, more preferably mild steel and the housing can advantageously be pressed out of a sheet of mild steel, to keep manufacturing costs down, and preferably the housing comprises a substantially tubular body having a front side and a rear side and at least one side wall. The housing can thus be formed as a pressing, for example from sheet material. The only aperture required in the rear wall of the pressing is to allow cable entry to the solid state lighting element and any associated control gear. However, it will be understood that other ventilation apertures may be provided in the rear end wall or side wall(s) of the housing to assist in heat dissipation. If these apertures are small they do not impair the fire rating of the assembly in fire tests.

[0018] Also described is a downlight assembly comprising:-

(i) a housing made from material with a melting point in excess of 900° C, said housing having at least one side wall and a rear end wall closing the rear of the housing;

(ii) a solid state lighting element mounted in thermal contact with the rear end wall of the housing such that heat generated by the solid state lighting element is transferred to the housing:

characterised in that the downlight assembly is devoid of a separate conventional heat sink.

[0019] Also described is a downlight assembly comprising:-

(a) a housing;

(b) a solid state lighting element;

(c) a lens or reflector adapted to focus or direct light emitted from the solid state lighting element;

(d) a substantially annular space around the lens or reflector;

characterised in that one or more additional electronic components are accommodated in the substantially annular space.

Brief description of the drawings

[0020] The invention will now be described, by way of example only, in relation to the accompanying figures wherein:

Figure 1 illustrates an exploded view of a downlight assembly;

Figures 2A to 2F illustrate various views of an assembled downlight;

Figures 3 to 7 illustrate various views, including sectional views, of an embodiment of the present invention in which the control circuitry and components required to power and control the LEDs are included within the housing, in this embodiment in an annular space around the lens;

Figure 8 illustrates an exploded view of the components of a further embodiment in which the control circuitry and components required to power and control the LEDs are included within the housing;

Figures 9 & 10 show cross-sectional views of housings including a solid state lighting element that require a remote driver (not shown), installed in a ceiling;

Figures 11 & 12 illustrate cross-sectional views of housings that include a built in driver, including a solid state lighting element, installed in a ceiling;

Figure 13 illustrates diagrammatically how heat from the LEDs is transferred first to the PCB and then to the housing and thus into the air and environment surrounding the rear of the housing.

Description of the Preferred Embodiments

[0021] In the context of the present invention the term 'LED lighting module' refers to a functioning LED light engine and its associated control circuitry, such as a power supply, dimmer, and/or control IC or electronics. The term 'LED module' refers to one or more LED light engines mounted on a suitable PCB, with or without any associated control circuitry.

[0022] Referring to Figure 1, this shows an exploded view of the components for a fire rated downlight assembly 10 which has no external or separate conventional heat sink other than a metal housing and which does not rely on intumescent material to achieve the desired fire rating. The assembly comprises a fire rated housing 11, an LED module 12, a reflector 13, a diffuser 14 and a seal 15 to retain the diffuser in place. The housing is in effect a closed shallow can with an outwardly extending flange 16 around the front face of the can. The rear of the can is closed off by a rear wall 17, as shown in Figure 2B. The assembly includes spring loaded arms 18, 19 supported by brackets 20, 21 which are attached to the can by rivets 22. These spring loaded arms press against the concealed side of the surface in which the downlight is fitted and hold the flange 16 firmly against the visible side of that surface. A cord grip 23 is attached to the outside of the rear wall of the housing, with a small aperture (not shown) in the rear wall of the can to allow cable entry to the LED module and any associated control gear. This one small cable entry aperture does not affect the fire rating of the can.

[0023] The LED module is attached directly to the inside face of the rear end wall of the can, such that light from the LED's is directed out of the front open face of the can or housing.

[0024] Where the housing is fire resistant, the housing is preferably made from metal with a melting point in excess of 900° C, and more preferably in excess of 1000° C. Steel is a suitable material and mild steel is particularly suitable as its melting point is over 1400° C and it can be readily and cheaply pressed into the desired shape.

[0025] Fire resistance standards for fire rated ceilings for the United Kingdom are set out in BS EN 1365-2:2014. This requires that a fire resistant member must be able to withstand a specified temperature for a specified period of time. The specified temperature is around 1000°C so any metal that can withstand temperatures of that order could be used in the manufacture of a fire rated housing. It will be appreciated that other countries may specify different temperatures in their fire resistance standards. Importantly, although the present example shows a housing pressed out of one piece of metal, the housing can be formed from two, or more components welded or otherwise firmly fixed together.

[0026] Use of mild steel in construction of the housing works well even if the downlight assembly does not need to be fire rated. However, if the downlight assembly does not need to be fire rated then it will be understood that a wide variety of other materials could be used to manufacture the housing, providing they have a relatively high thermal conductivity constant, or ventilation holes are provided in the housing. For example, a variety of plastics material, such as polyamides could be used for this purpose, or lower melting point metals such as aluminium.

[0027] The LED module 12 comprises a plurality of individual LED chips mounted on an aluminium PCB. The exact number of LED chips is not critical to the invention and will be determined by the relevant expert depending on the power rating and the lumen output required. The arrangement of multiple LED chips is preferred over a single large LED chip because the heat generated is spread over a significantly larger surface area of the PCB, and thus into a larger area of the housing. In the example shown in Figure 1 there are approximately 24 individual LED chips spread across substantially the whole area of the PCB. A reflector plate 13, in the form of a polished frustoconical reflector, serves to direct light from the LEDs out of the front of the housing. The LEDs are protected by a diffuser 14, and the downlight assembly is held in a surface such as a ceiling by flange 16 and spring loaded arms 18, 19 acting against the concealed surface of ceiling in a conventional manner.

[0028] The LED PCB and thus the LED module 12 must be in good thermal contact with the inside of the rear end wall 17 of the housing 11. This good thermal contact may be enhanced by means of thermally conductive interface materials such as thermally conductive grease, a thermally conducting pad or pads, graphite foil, thermally conductive acrylic film, or thermally conductive nano composites or polymers. It will be understood that any suitable thermally conductive material can be used for this purpose. The inside face of the rear end wall 17 of the housing 11 is substantially planar to facilitate heat transfer over the whole surface area of the back of the LED PCB.

[0029] In the example described above the necessary power supply, dimmer and control IC are located in a remote driver unit (not shown). Embodiments are shown in Figures 3 to 8 inclusive in which the power supply, dimmer and/or control IC or electronics are located within the housing. In the example shown in Figures 3 to 7 a 3 x 3 array of 9 LEDs are located on a PCB situated on the rear wall 37 of a housing 31 and may be in good thermal contact with the rear wall 37 if desired. Alternatively these components may be thermally insulated from the housing if required. Power supply, dimmer and other control IC and other electronic components are located in a separate annular space around the LED PCB and around the outside of the lens 33. These other components are in one embodiment preferably mounted on one or more PCBs separate from and spaced away from the LED PCB. In this case a solid substantially frustoconical lens 33 of conventional format directs light from the LEDs out of the front of the housing by total internal reflection. This arrangement creates an annular cavity 44 in which these additional components can be accommodated. A similar annular cavity is formed when a reflector plate 13 is used as shown in Figure 1.

[0030] In order not to add directly to the heat load that has to be dissipated by the housing, these additional components can be thermally isolated, as well as electrically isolated, from the housing, either by using a thermal insulating material or by an air gap, or both.

[0031] Figure 8 shows the components in exploded diagram format that comprise the type of downlight assembly shown in Figures 3 to 7. A housing pressed from steel includes a front flange 46. An LED module 42 on a PCB is fixed to the inside of the rear wall of housing 41 with a thermally conducting paste between the two surfaces.

Set around the LED PCB is a bottom cover 54 for the power, control and driver components, which can be seen on their own PCB as 55 in Figure 8. A top cover 56 is fitted over the driver components and optionally a lens, not shown, occupies the space within the top cover. The assembly is completed by a diffuser 44 and a seal 45. A sectional view of a downlight assembly of this type installed in a ceiling is shown in Figure 11, and the housing and LED module alone are shown in Figure 12. Corresponding views of a downlight assembly with a remote driver (not shown) are shown in Figures 9 and 10.

[0032] It will be appreciated that this arrangement described above by which control components are located in a substantially annular space around or behind a lens or a reflector, or both, is applicable to other downlight assemblies, not just those described above and in the foregoing examples. That is to say, most lenses and reflectors are substantially frustoconical in shape and this tends to leave a substantially annular space around the base of the lens or reflector. This space can be advantageously used to accommodate a wide range of electrical and electronic components.

[0033] It will also be appreciated from the foregoing description that the downlight assembly according to the present invention is devoid of any outer housing and there is no outer housing around or associated with the housing described. The housing described is therefore located in free airspace when properly installed behind some partition surface, such as a ceiling.

[0034] The method by which heat from the LED module is dissipated from the housing is shown in Figure 13. From the description above it will be appreciated that heat produced by the LED module in use is transferred from the aluminium PCB into the housing 11, 31, 41, 61 and then dissipated by convection and radiation into the surrounding air space and environment around the outside of the housing. Uniquely this is achieved without the need for a separate conventional finned heat sink attached to or associated with the housing. Since some of the heat generated by the LED module is dissipated from the housing by radiation, it is advantageous that the outer surface of the housing is finished in a dark colour, preferably black and more preferably matt black. A black finish on a steel housing is very easy and inexpensive to achieve using a paint or black oxide. However it is expected that the majority of the heat lost from the housing will be lost by convection rather than radiation.

Claims

1. A downlight assembly comprising:-

   (i) a fire rated housing made from material with a melting point in excess of 900° C, said housing comprising a substantially tubular body having a front side and a rear side and at least one side wall and a rear end wall closing the rear of the housing;

   (ii) a solid state lighting element mounted in thermal contact with the rear end wall of the housing;

   characterised in that the downlight assembly is devoid of a separate conventional heat sink.

2. A downlight assembly according to Claim 1 wherein the fire rated housing further comprises an outwardly extending flange at or towards the front side of the tubular body.

3. A downlight assembly according to Claim 1 or Claim 2 wherein the solid state lighting element comprises a plurality of LEDs.

4. A downlight assembly according to Claim 3 wherein the plurality of LEDs are mounted on a printed circuit board (PCB).

5. A downlight assembly according to Claim 4 wherein the printed circuit board is a metal printed circuit board (MPCB).

6. A downlight assembly according to claim 4 or claim 5 wherein the printed circuit board is attached directly to the inside face of the rear end wall of the housing.

7. A downlight assembly according to Claim 4 or Claim 5 wherein a thermally conductive interface is provided between the PCB and the rear end wall of the housing.

8. A downlight assembly according to any preceding claim further comprising a reflector adapted to direct light from the solid state lighting element out of the front of the housing.

9. A downlight assembly according to any preceding claim wherein the assembly further comprises a lens adapted to focus the light emitted by the solid state lighting element.

10. A downlight assembly according to Claim 8 or Claim 9 wherein additional electronic component(s) are accommodated in an annular space provided around a lens or reflector.

11. A downlight assembly according to Claim 10 wherein the additional electronic components comprise one or more components selected from the group comprising power supply components, dimmer control components, control IC components, and other electronic components.

12. A downlight assembly according to Claim 10 or Claim 11 wherein the additional electronic components are substantially located in a bottom cover.

13. A downlight assembly according to Claim 10, Claim 11 or Claim 12 wherein the additional electronic components are substantially covered by a top cover.

14. A downlight assembly according to any preceding claim wherein the housing comprises steel.

15. A downlight assembly according to claim 14 wherein the housing comprises mild steel.

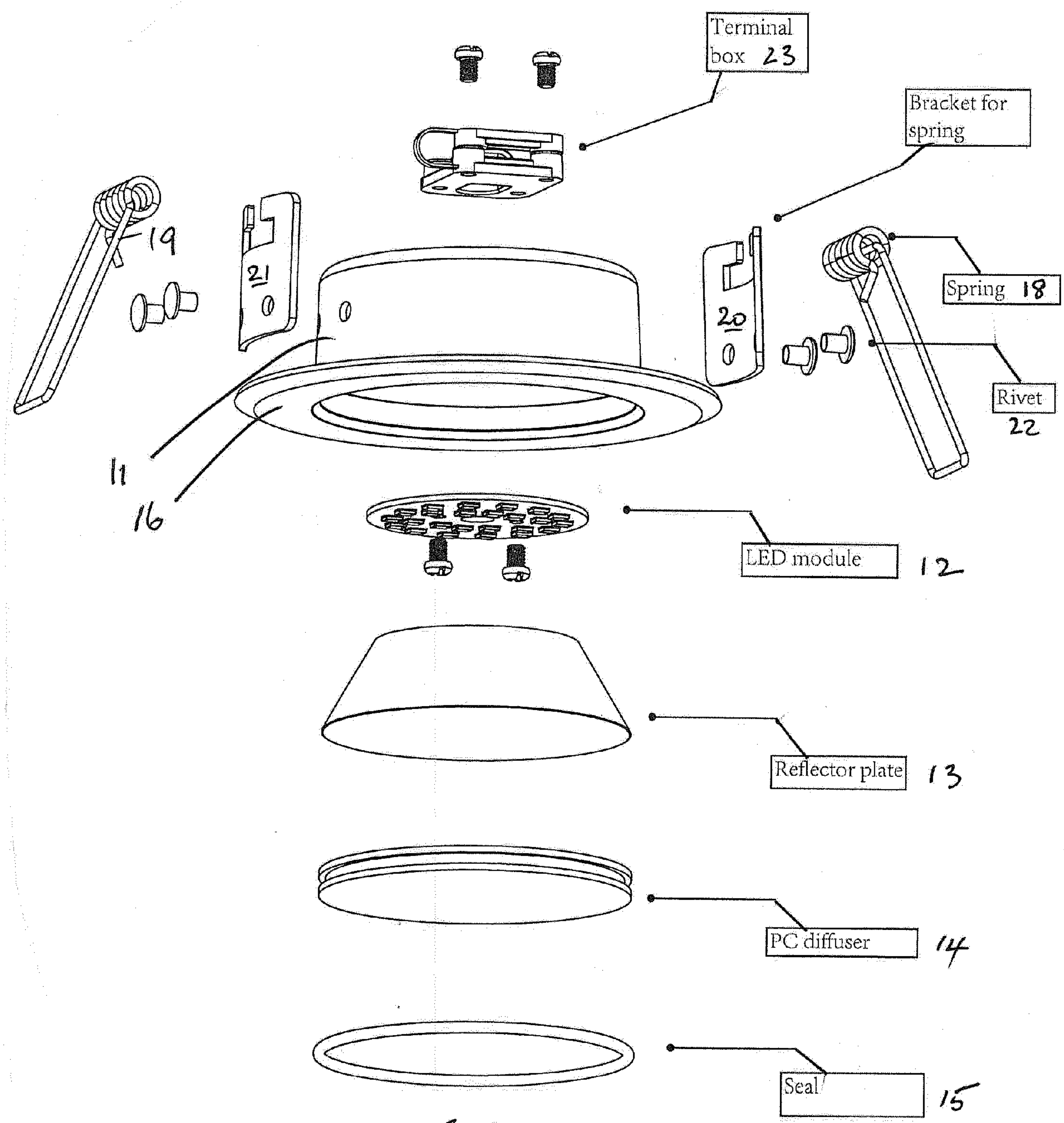
Terminal box 23
Bracket for spring
Spring 18
Rivet 22
19
21
20
11
16
LED module 12
Reflector plate 13
PC diffuser 14
Seal 15

FIG 1

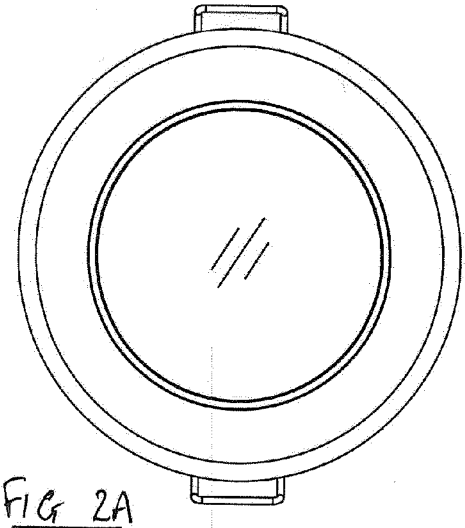

FIG 2A

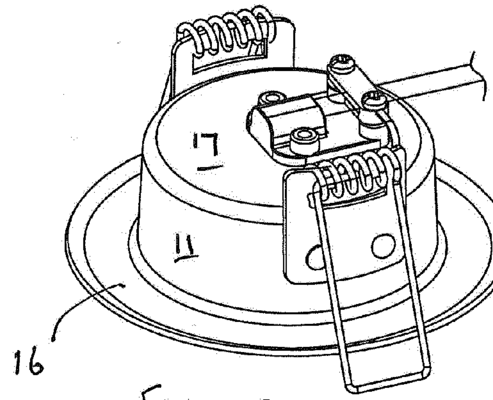

FIG 2B

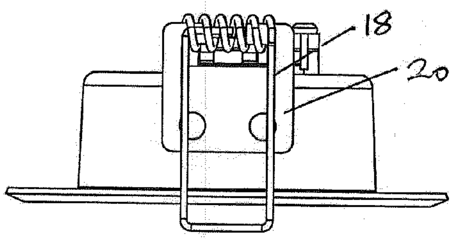

FIG 2C

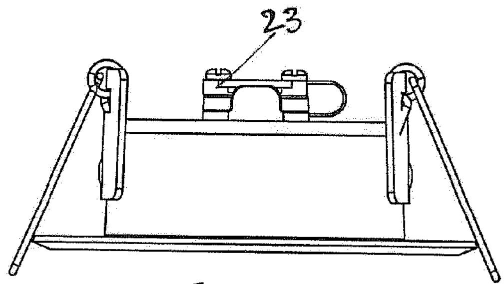

FIG 2D

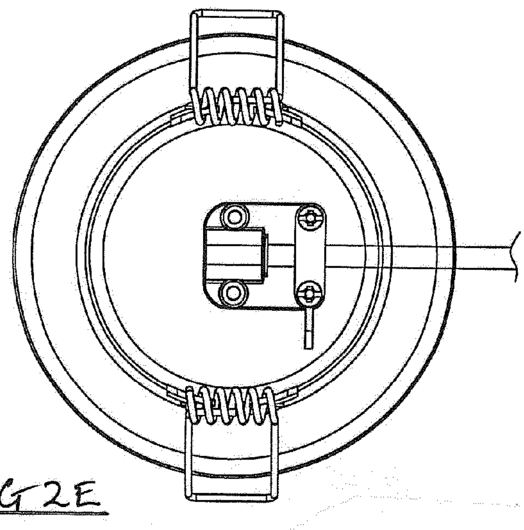

FIG 2E

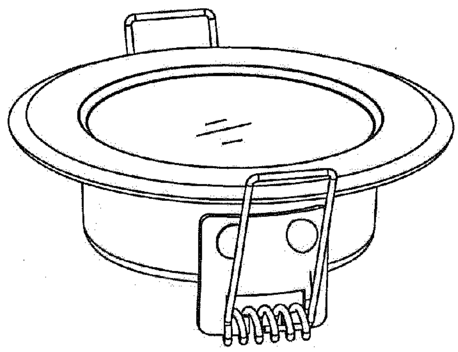

FIG 2F

FIG 2

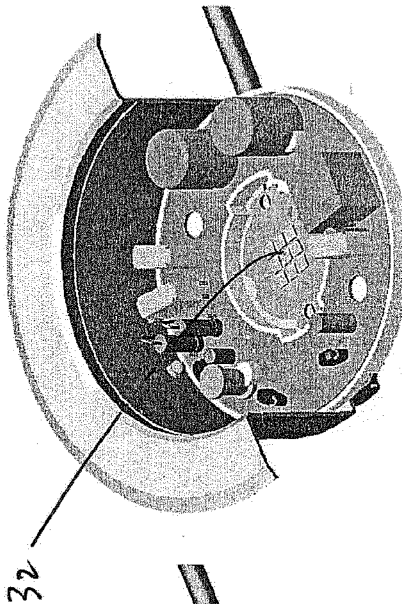

FIG 6

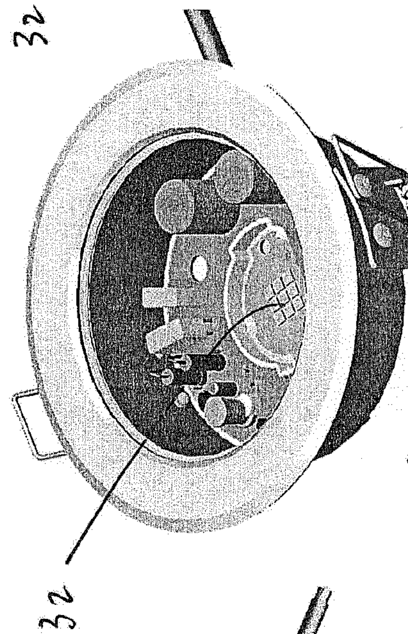

FIG 5

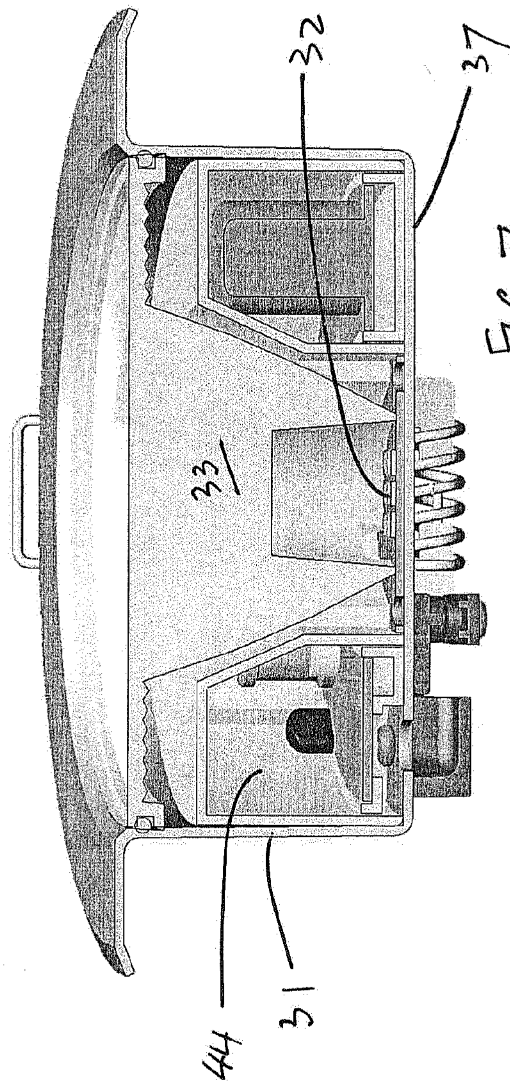

FIG 7

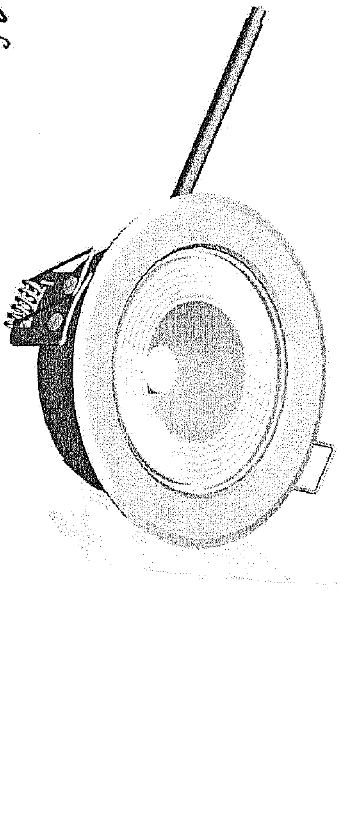

FIG 3

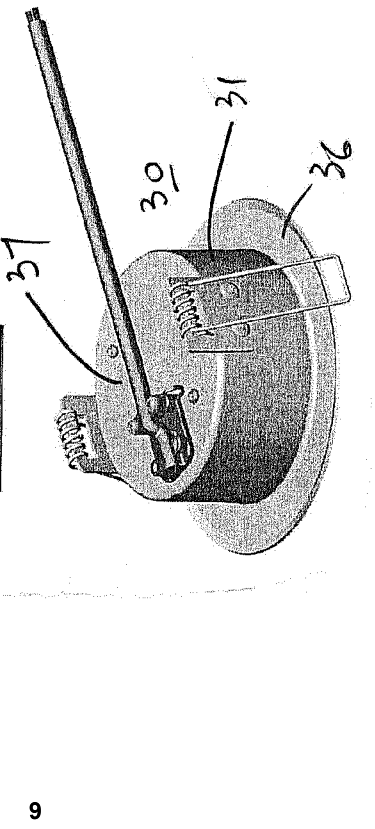

FIG 4

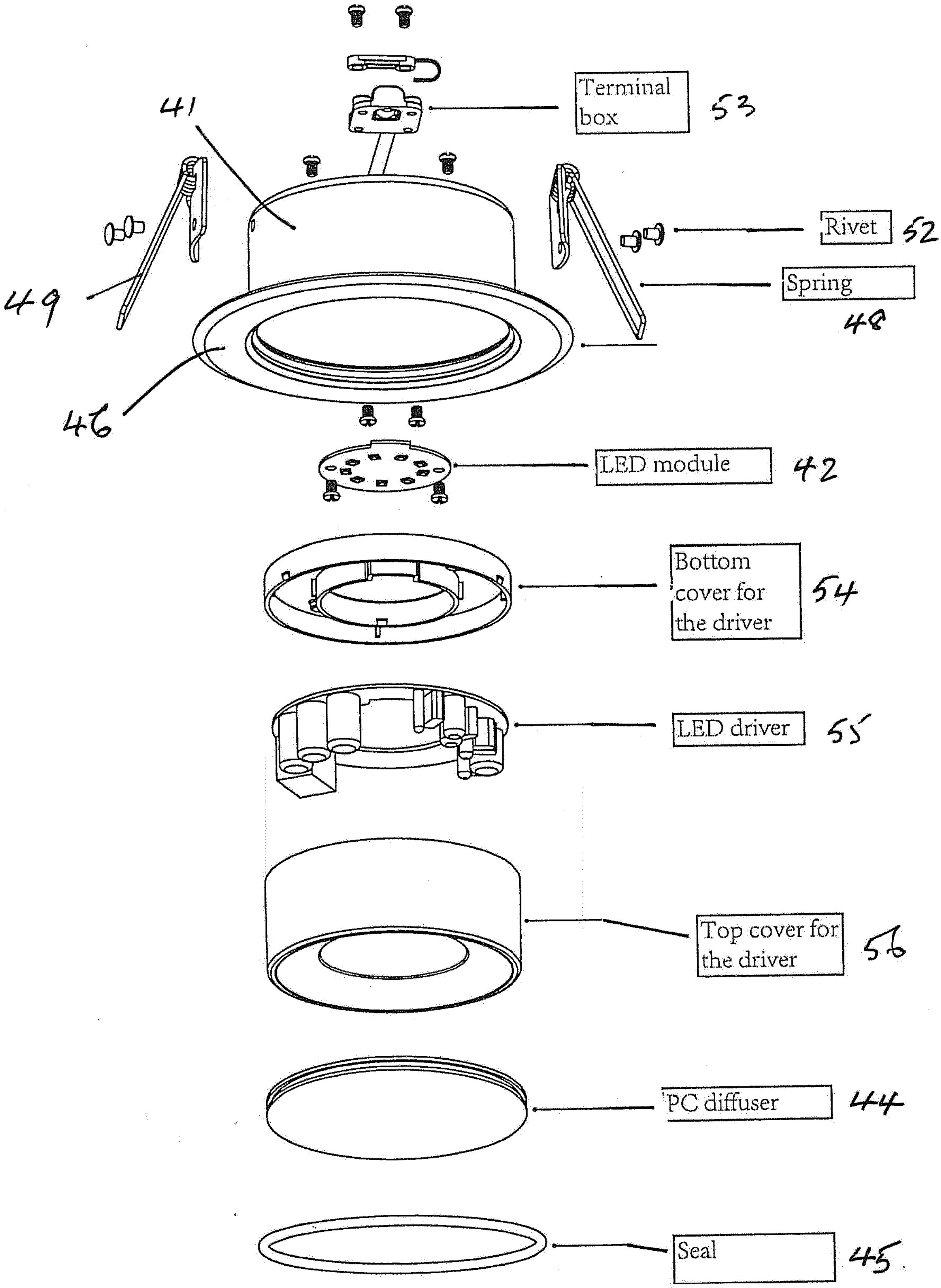
Terminal box
53
41
Rivet
52
Spring
48
49
46
LED module
42
Bottom cover for the driver
54
LED driver
55
Top cover for the driver
56
PC diffuser
44
Seal
45

FIG 8

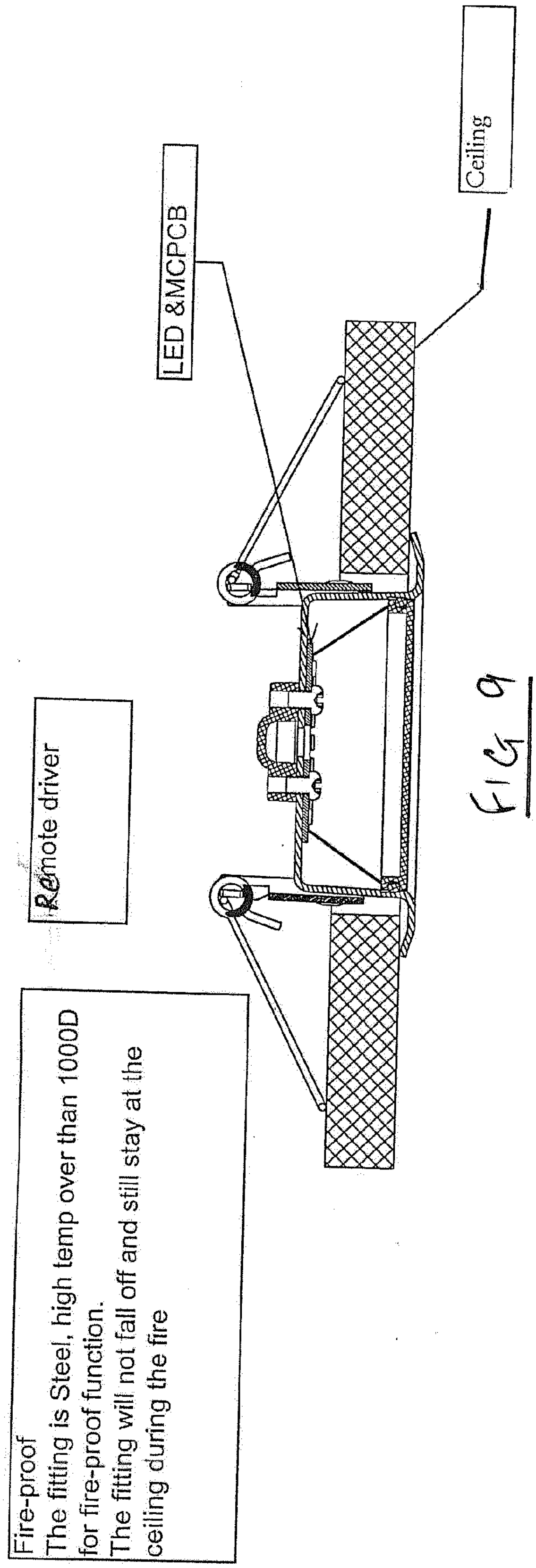
LED &MCPCB
Ceiling
Remote driver
Fire-proof
The fitting is Steel, high temp over than 1000D for fire-proof function.
The fitting will not fall off and still stay at the ceiling during the fire

FIG 9

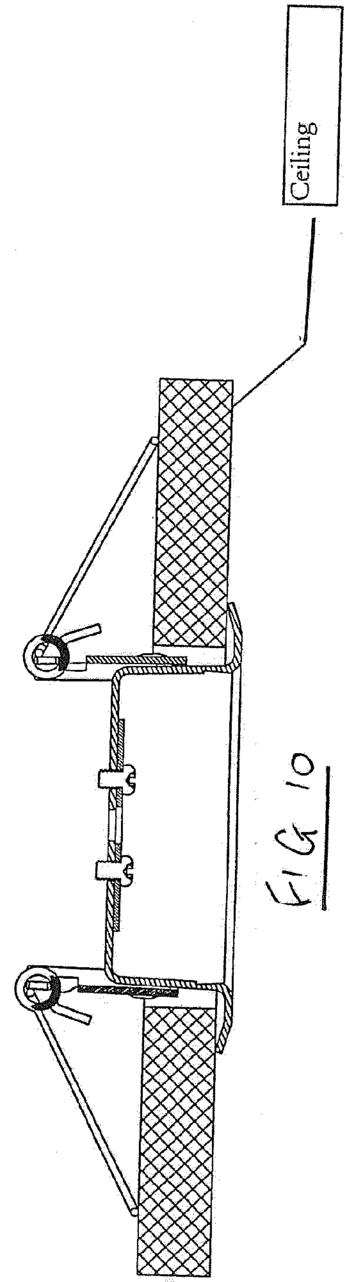
Ceiling

FIG 10

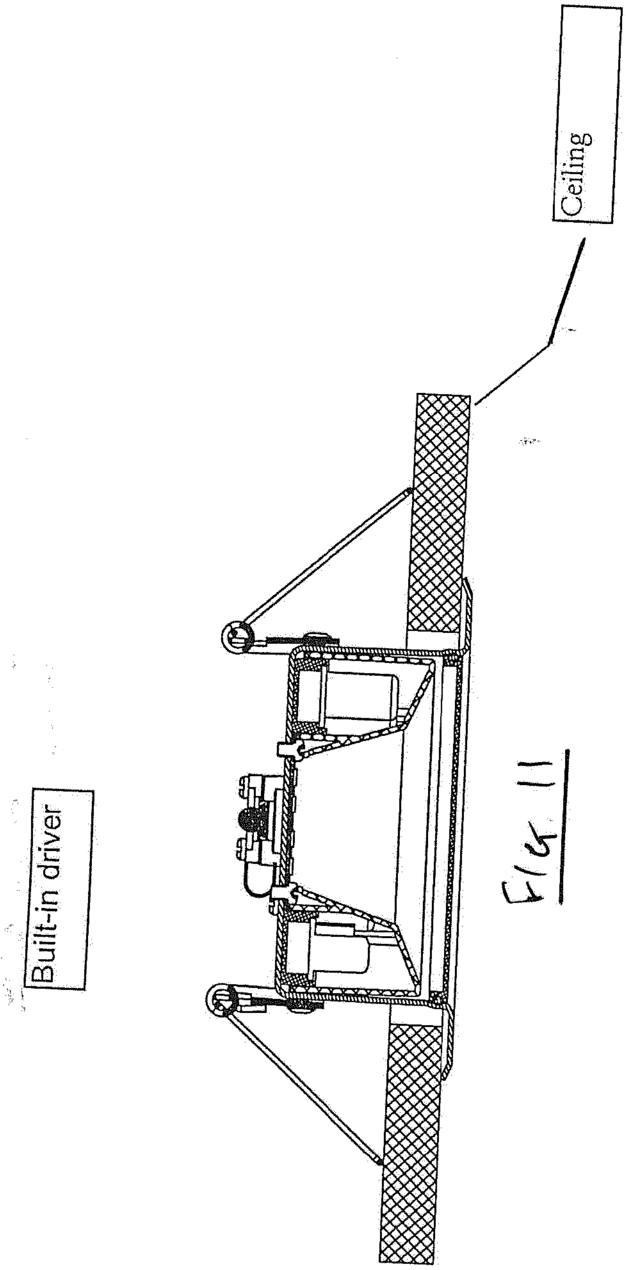

FIG 11

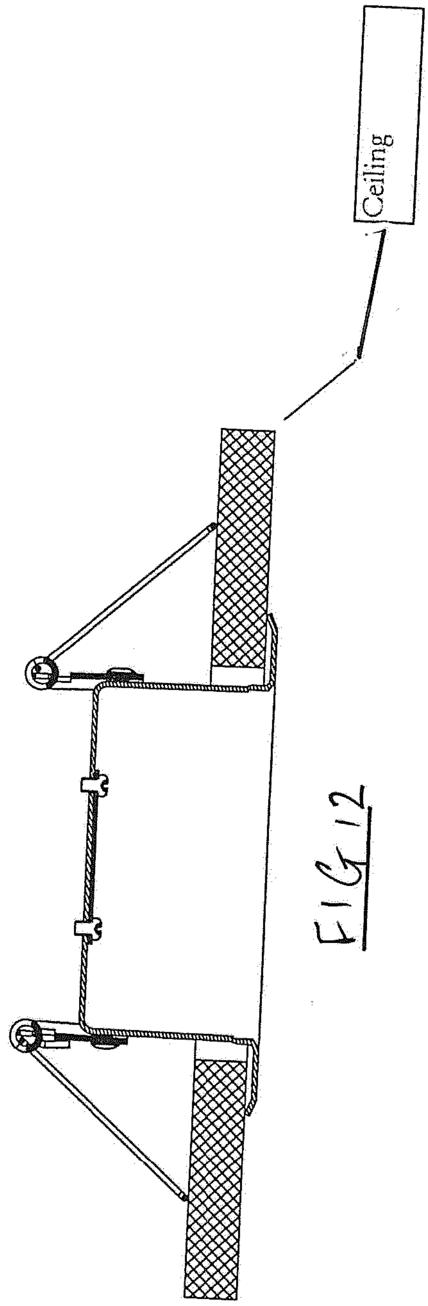

FIG 12

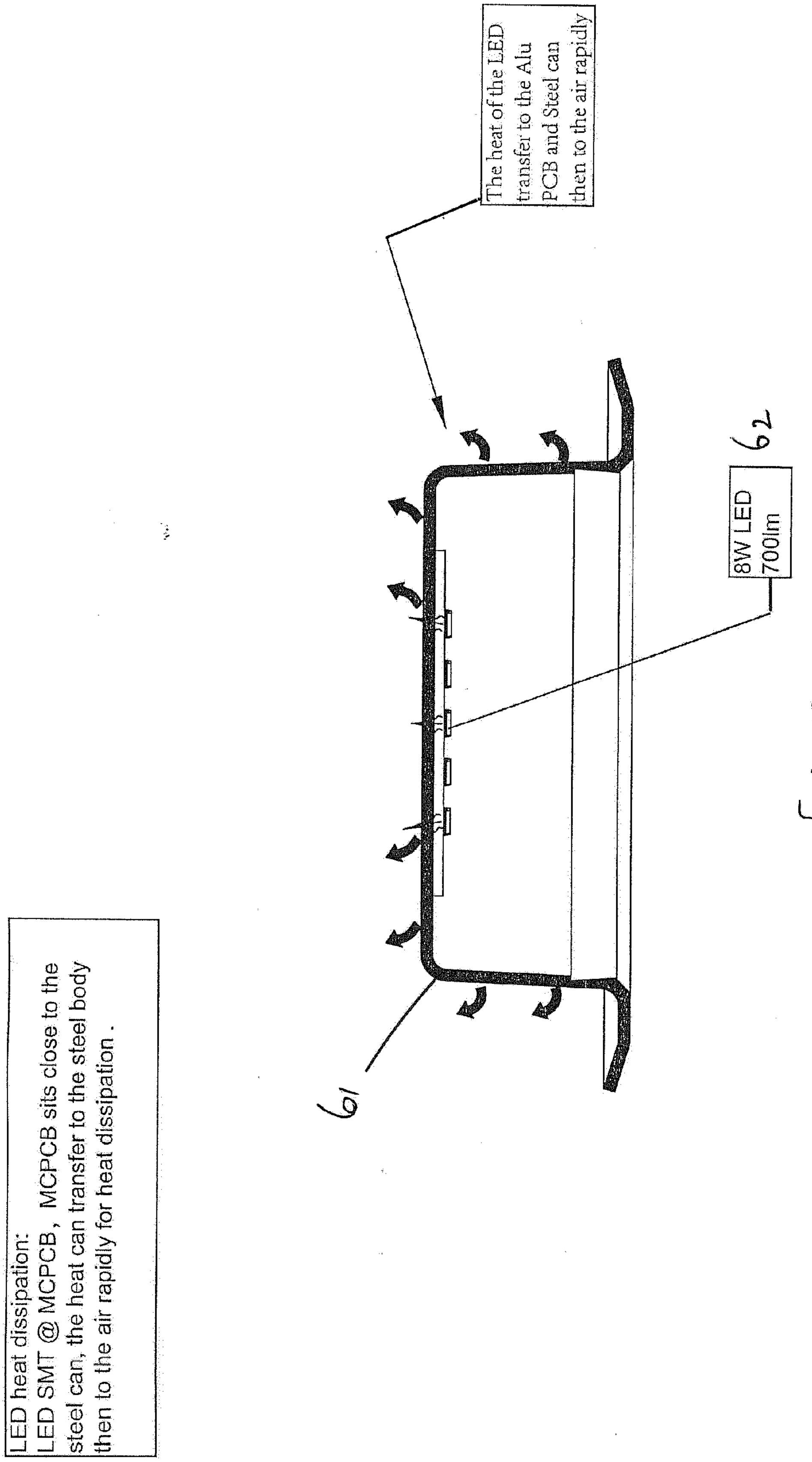
The heat of the LED transfer to the Alu PCB and Steel can then to the air rapidly
8W LED 700lm
62
61
LED heat dissipation:
LED SMT @ MCPCB, MCPCB sits close to the steel can, the heat can transfer to the steel body then to the air rapidly for heat dissipation .

FIG 13

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 16 7447

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	CA 2 879 629 A1 (DANESH MICHAEL D [US]) 19 August 2015 (2015-08-19) * figures 1-3 * * paragraph [0009] - paragraph [0032] *	1-4,6, 8-12,14 5,7,13, 15	INV. F21S8/02 F21V5/04 F21V7/04 F21V21/04 F21V23/00 F21V29/502
Y	GB 2 504 133 A (AURORA LTD [GB]) 22 January 2014 (2014-01-22) * the whole document *	5,15	
Y	EP 2 674 671 A1 (PANASONIC CORP [JP]) 18 December 2013 (2013-12-18) * the whole document *	13	
Y	US 2010/259919 A1 (KHAZI MOHAMED ASLAM [US] ET AL) 14 October 2010 (2010-10-14) * figure 5 * * paragraph [0032] *	7	
A	CN 104 565 930 A (DONGGUAN GAOYI ELECTRONIC TECHNOLOGIC CO LTD) 29 April 2015 (2015-04-29) * figures 1-3 * & GB 2 533 864 A (WEN-HSIN CHAO [TW]) 6 July 2016 (2016-07-06)	1-4,8,9, 14	TECHNICAL FIELDS SEARCHED (IPC) F21S F21V F21Y
A	GB 2 509 772 A (KOSNIC UK LTD [GB]) 16 July 2014 (2014-07-16) * the whole document *	1	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	13 May 2022	Van Overbeeke, Sim

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 16 7447

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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