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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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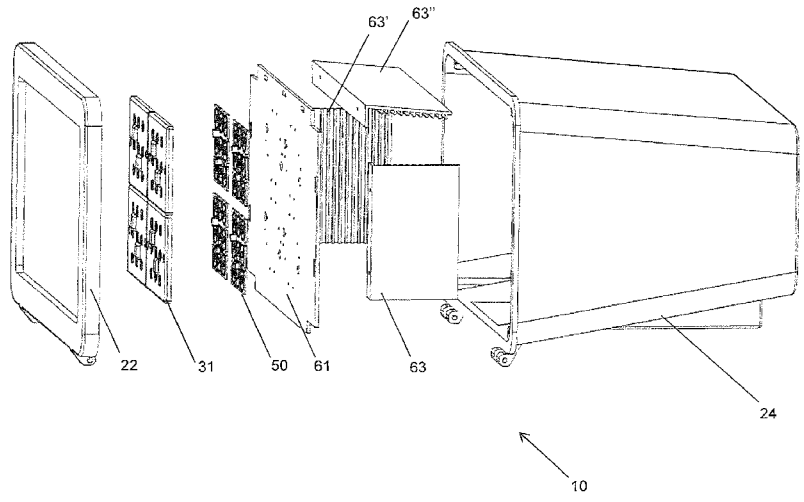
(54) Title: LED LUMINAIRE

Figure 1



(57) Abstract: An LED luminaire has a luminaire housing, an LED light module, and an LED driver. The LED light module comprises at least one LED array, a first thermal interface, and at least two second thermal interfaces. The first thermal interface is removably attached to the second thermal interfaces. The first and second thermal interfaces have sufficient surface area so as to maintain the ambient temperature within the luminaire housing at a level below which LED longevity significantly degrades.

LED LUMINAIRE

BACKGROUND OF THE INVENTION

[0001] This application is directed to a solid-state luminaire comprising an LED luminaire that features optimal heat dissipation through an improved thermal management system.

[0002] Due to the increasingly widespread quest for energy savings, light emitting diodes (LEDs) have become more and more popular in the lighting industry. LEDs are so popular because of their small size, fast on-time and quick on-off cycling, resistance to vibration damage, and high efficiency. LEDs present challenges for luminaire manufacturers, however, with respect to heat and glare.

[0003] In contrast to most other currently available light sources, LEDs radiate very little heat in the form of infrared radiation. Waste energy is dispersed as heat through the base of the LED. Typically, LED luminaires incorporate a plurality of LEDs and the heat given off can be substantial. Over-driving an LED in high ambient temperatures may result in overheating the LED array, eventually leading to device failure. Adequate heat dissipation is desirable to maintain the long life of which LEDs are capable.

[0004] For the most part, LED luminaires deal with the heat dissipation issue in one of two ways. Some luminaires incorporate air vents and complex heat sinks, sometimes involving fins on the exterior of the housing where they are visible to the consumer and aesthetically unappealing, and often requiring complicated internal housing to allow for weatherproofing. Moreover, in many cases, because the number and size of LEDs affects heat dissipation requirements, the configuration and dimensions of the finned housing vary according to the number and size of the LEDs, which increases stocking requirements, makes it more difficult to substitute fixtures if lighting needs change, and increases architectural planning considerations. Those issues create a deterrent for businesses seeking to transition from existing non-LED luminaires to the greater efficiencies provided by LEDs.

[0005] Other luminaires simply do not provide adequate thermal management. If such fixtures are used for long periods of time, heat becomes a problem resulting in a likely shortening of the LED lifetimes and potential serious color shift of the devices.

[0006] PCT Application US 2012/028527 describes an improved LED luminaire that addresses the heat dissipation issue by incorporating stacked thermal interfaces which allow a dual path for quick heat dissipation. While this device addresses the issues described above, there remains an opportunity for improving the access to internal components.

SUMMARY OF THE INVENTION

[0007] An LED luminaire in accordance with a preferred embodiment of the subject invention comprises a luminaire housing, an LED light module, an LED driver, a diffuser, and reflectors. The LED light module comprises at least one LED array, a first thermal interface structure, and at least two second thermal interface structures. The first thermal interface is of sufficient size so that at least two of its outside edges contact or nearly contact at least two of the interior sides of the housing when the first interface is removably attached to the second thermal interfaces. The first and second thermal interfaces together have sufficient surface area so as to maintain the ambient temperature within the luminaire housing at a level below which LED longevity significantly degrades. This may be accomplished through the incorporation of a plurality of fins on the sides of the thermal interfaces open to the interior of the housing. These thermal interfaces, particularly when used in conjunction with a heat-conductive housing, allow for optimal thermal management by utilizing a dual path to quickly remove the heat from inside the luminaire into the surrounding air external to the luminaire. This configuration of components further allows for easy access to the internal components of the luminaire for maintenance and replacement of the components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 depicts a disassembled, exploded view of one luminaire embodiment.

[0009] Figure 2 depicts a disassembled, exploded view of a second luminaire embodiment.

[0010] Figure 3 depicts a disassembled, exploded view of a third luminaire embodiment.

[0011] Figures 4A and 4B provide a cutaway and a detail, cutaway view of the embodiment shown in Figure 3.

[0012] Figure 5 depicts an exploded, cutaway view of an embodiment of an LED module and housing.

DETAILED DESCRIPTION OF THE DRAWINGS

[0013] Figure 1 depicts an LED luminaire 10 in accordance with one embodiment of the inventive thermal management system. Figure 2-4B depict additional embodiments of the inventive thermal management system. The exploded cutaway view shown in Figure 5 is a schematic representative of an exemplary embodiment of the inventive system.

[0014] As depicted in Figures 1-4, the LED luminaires 10 of the depicted embodiments comprise variations on traditional units, unmodified on the exterior but internally modified to provide a highly conductive thermal path to minimize LED junction temperatures. Of course, the inventive system is not limited to conventional housings, but it was felt that utilizing such illustrations demonstrates the manner in which substantial improvements can be made without affecting the exterior look to which architects and other users have become accustomed. The inventive thermal management design results in minimal temperature rise at the location of the one or more LEDs 70, thereby insuring higher lumen maintenance and more stable correlated color temperature over the life of the product. Using a traditionally shaped and sized housing 24 offers end users the ability to enjoy the energy savings of LED technology without having to modify existing surroundings to accommodate new housing designs.

[0015] The luminaire housing 24 may be a wet location enclosure for protection of electrical

components and connections. In the depicted embodiments, the housing 24 is removably attached to a front face frame 22. It is preferred that the housing 24 and front face frame 22 be of die cast aluminum, but the housing 24 and/or the front face frame 22 could be manufactured from other materials or in other ways. Aluminum is the presently preferred material because it works well for the die casting process, and it also is lower in cost than other conventionally available alternatives, which include zinc, magnesium, and copper. Aluminum is further preferred over zinc and magnesium due to its high thermal conductivity, an important aspect to assist in heat dissipation. Copper would be desirable as well, but the cost, and weight may make it less desirable than aluminum.

[0016] The housing 24 may be used as the primary means for mounting the luminaire 10 to the desired location, as is shown in the embodiment depicted in Figure 1, or the housing may further comprise other components for mounting, such as is shown in the embodiments depicted in Figures 2 and 3. The front face frame 22 and housing 24 enclose an LED driver 54 as well as the LED module 100 (see Figure 5) as shown, for example, in Figures 4A and 4B, which illustrate how these elements may be located for each of the described embodiments, although other suitable positioning could be selected by those skilled in the art. The frame 22 may further act as a heat transfer mechanism to the exterior environment and provides a suitable mounting angle for the LED module 100.

[0017] As already noted above, the LED module 100 is mounted to the housing 24. The LED module 100 in the depicted embodiment comprises of three main parts (schematically shown in Figure 5) - one or more LED arrays 50, one or more first thermal interface structures 61, and at least two second thermal interface structures 63, 63', 63". The LED arrays 50 are printed circuit boards 52 containing one or more LEDs 70. Any shape or number of LEDs 70 may be used on the LED arrays 50, subject to size and number constraints imposed by fixture and circuit board dimensions and power limitations imposed by the selected LED driver 54. Further, the circuit board 52 could use multi-chip LEDs 70, use single or multi-array configurations, or contain secondary optics placed in conjunction with the LEDs 70 to modify the resulting light distribution.

[0018] As shown more specifically in Figure 5, the inventive thermal management system allows for optimum heat dissipation through a multi-layer heat sink. An LED array 50 is comprised of an LED 70 and printed circuit board 52. When activated, the LED 70 generates heat at its base. The heat of the LED 70 first passes through the board 52. To allow for the most efficient heat dissipation, the board 52 may have a metal core, such as aluminum or copper.

[0019] The heat from the LED array 50 continues to dissipate, passing through a first thermal interface 61 attached to the underside of the circuit board 52. This first interface 61 is at least as large as the LED array 50 and preferably is of sufficient size so that at least two of its outside edges contact or nearly contact at least two of the interior sides of the housing 24 when the first interface 61 is attached to the housing 24. The first interface 61 in the embodiments depicted in Figures 1-4B is of a size such that each of its outside edges contact or nearly contact each of the interior sides of the housing 24. In embodiments in which the first thermal interface 61 abuts the interior sides of the housing 24, a thermally conductive gap filler may be interposed between the first thermal interface 61 and the housing 24 at the overlapping area between the two.

[0020] Optionally, points of contact between the LED array 50 and the first interface 61 may be attached through the use of a thermally conductive gap filler between the two. Appropriate materials for the gap filler include ultra-soft acrylic elastomer, thermal grease, thermal tape, thermal adhesive, or some other material suitable to create a thermal path for heat dissipation. The main requirement is to use materials that are more heat-conductive than air.

[0021] The first thermal interface 61 is attached along at least two edges to at least two second thermal interfaces 63, 63', 63" as shown in the embodiments depicted in Figures 1-4B. A thermally conductive gap filler may be interposed between the first thermal interface 61 and the second thermal interfaces 63, 63', 63" at the overlapping area 26 between the two as shown in Figure 4B. The second thermal interfaces 63, 63', 63" provide two paths for heat dissipation. In the embodiments shown, the second thermal interface 63 is attached to the interior sides of the housing 24. This second interface 63 provides a direct path for heat dissipation from the first thermal interface 61 to the housing 24, which then dissipates the heat to the ambient air. In addition, a second path is provided from the first thermal interface 61 to the second interface 63

that provides a broad surface to dissipate heat to the air enclosed by the housing 24. This air, in turn, conducts the heat to the housing 24 via natural convection from whence it is conducted to the air external to the housing 24. Due to the effectiveness of this dual path for heat dissipation, there is no need for vents, exterior fins, or complex weatherproofing.

[0022] Using the first and second thermal interfaces 61, 63, 63', 63" for mounting the LED array 50 provides an easily modified mounting solution that is an improvement over attaching the LED array 50 directly to the housing 24. If the LED array 50 were mounted directly to the housing 24, any change in the size or type of arrays 50 would potentially mean modifying the housing 24 and, thus, the die cast molding. Changing hole sizes or positions in the first and second thermal interfaces 61, 63, 63', 63" is much easier and can be accomplished in less time and at lower cost.

[0023] As described herein, the second interfaces 63, 63', 63" comprise plates that are flat on at least the side pressed to the housing 24. These second interfaces 63, 63', 63" may be attached to the sides of the housing 24 such as with attachment material such as ultra-soft acrylic elastomer, thermal grease, thermal tape, thermal adhesive, or some other material suitable to create a thermal path for heat dissipation. The first interface 61 is removably attached to the second interfaces 63, 63', 63" using fasteners such as screws. This configuration provides for much easier manufacturing assembly method. For example, if during product burn-in, which occurs after assembly, a driver 54 should be found to be defective, this configuration of the luminaire 10 allows a repair person access to the driver 54 for replacement without the difficulty of prying a heat sink from a housing and then, after repair, having to use a hydraulic press to push the heat sink back into the housing. A second advantage of this improved configuration is the ability of the customer to repair the fixture in the field. Should a driver 54 fail in the field, with the inventive luminaire 10 design, the customer need not return the luminaire 10 to the manufacturer for repair but instead may simply unscrew the first thermal interface 61, repair or replace the driver 54, and then reattach the first thermal interface 61. This requires no special tools or machines and can even be done while leaving the luminaire 10 attached, for example, to a building or pole.

[0024] The first and second thermal interfaces 61, 63, 63', 63" may be made of aluminum. Other suitable materials, such as copper or other materials more heat-conductive than the ambient air, may be used in the alternative. Greater heat conductivity will improve performance.

[0025] Additionally, the first and/or second thermal interfaces 61, 63, 63', 63" may comprise fins extending into the open space within the housing 24. The incorporation of fins provides additional surface area to increase the effectiveness of heat dissipation. A certain amount of surface area on a heat sink is required in order to dissipate a certain amount of heat. It is well known to persons skilled in the art that the efficacy of heat sinks can be improved by increasing their surface area.

[0026] The foregoing details are exemplary only. Other modifications that might be contemplated by those of skill in the art are within the scope of this invention, and are not limited by the examples illustrated herein.

CLAIMS

What is claimed is:

1. An LED (light emitting diode) luminaire having a dual means for heat dissipation, comprising:
    a. a luminaire housing,
    b. an LED driver, and
    c. an LED light module, said LED light module comprising:
        i. at least one LED array,
        ii. a first thermal interface structure, and
        iii. at least two second thermal interface structures, said LED array being attached to the first thermal interface structure, at least a portion of said first thermal interface structure being attached to the luminaire housing and to the at least two second thermal interface structures, at least a portion of each second thermal interface structures being attached to the luminaire housing and to the first thermal interface.

2. The LED luminaire of claim 1 wherein the attachment of the at least a portion of said first thermal interface structure to the luminaire housing and to each of the at least two second thermal interface structures is a removable attachment.

3. The LED luminaire of claim 1 further comprising thermally conductive material interposed between the LED array and the first thermal interface structure.

4. The LED luminaire of claim 1 further comprising thermally conductive material interposed between the first thermal interface structure and the luminaire housing.

5. The LED luminaire of claim 1 further comprising thermally conductive material interposed between the first thermal interface structure and the second thermal interface structures at a point of attachment.

6. The LED luminaire of claim 1 further comprising thermally conductive material interposed between at least one of the second thermal interface structures and the luminaire housing at a point of attachment.

7. The LED luminaire of claim 1 in which the first thermal interface structure is composed primarily of material selected from the group consisting of copper or aluminum.

8. The LED luminaire of claim 1 in which the at least two second thermal interface structures are composed primarily of material selected from the group consisting of copper or aluminum.

9. The LED luminaire of claim 1 in which the first thermal interface structure further comprises a plurality of fins.

10. The LED luminaire of claim 1 in which at least one of the second thermal interface structures further comprises a plurality of fins.

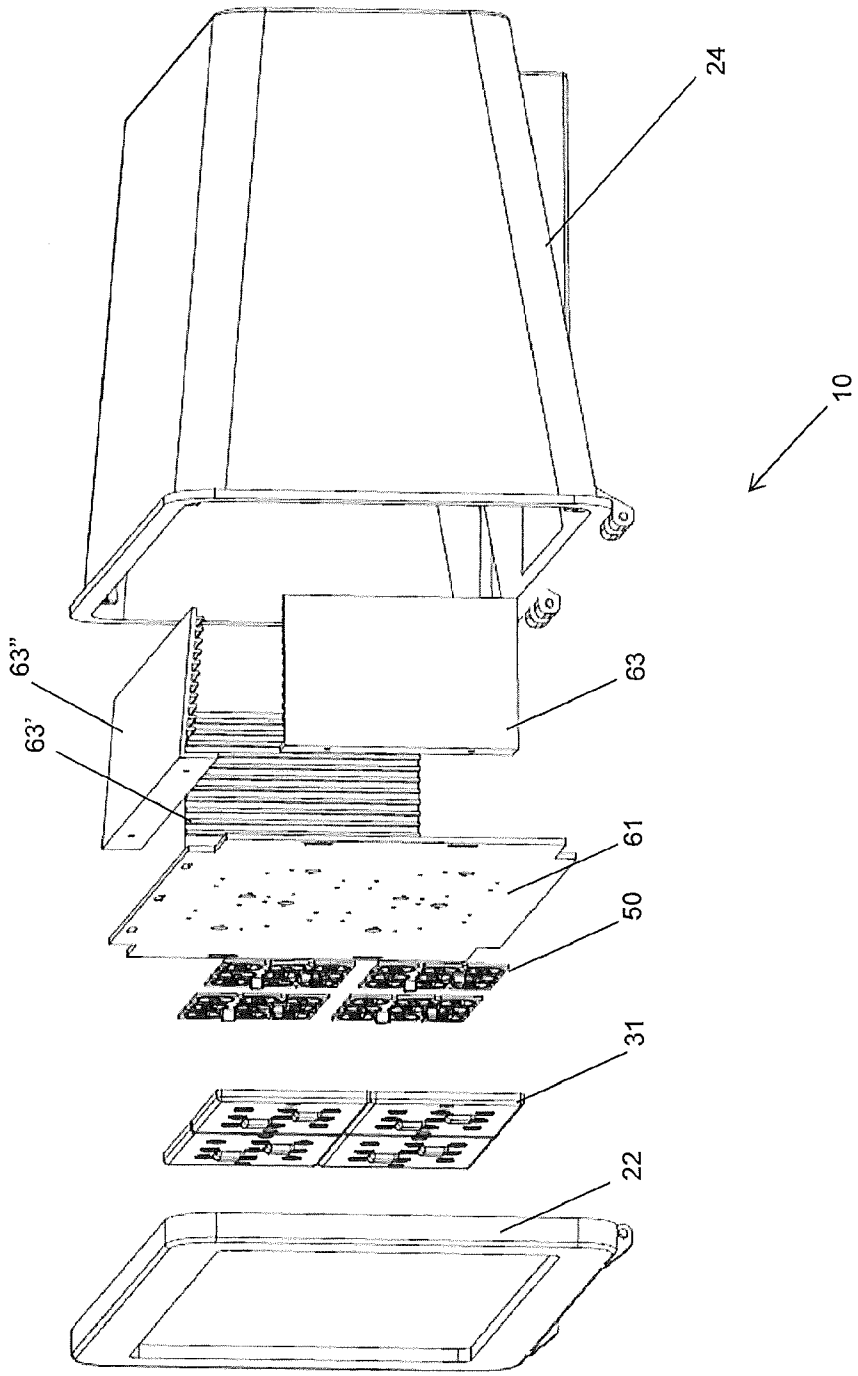


Figure 1

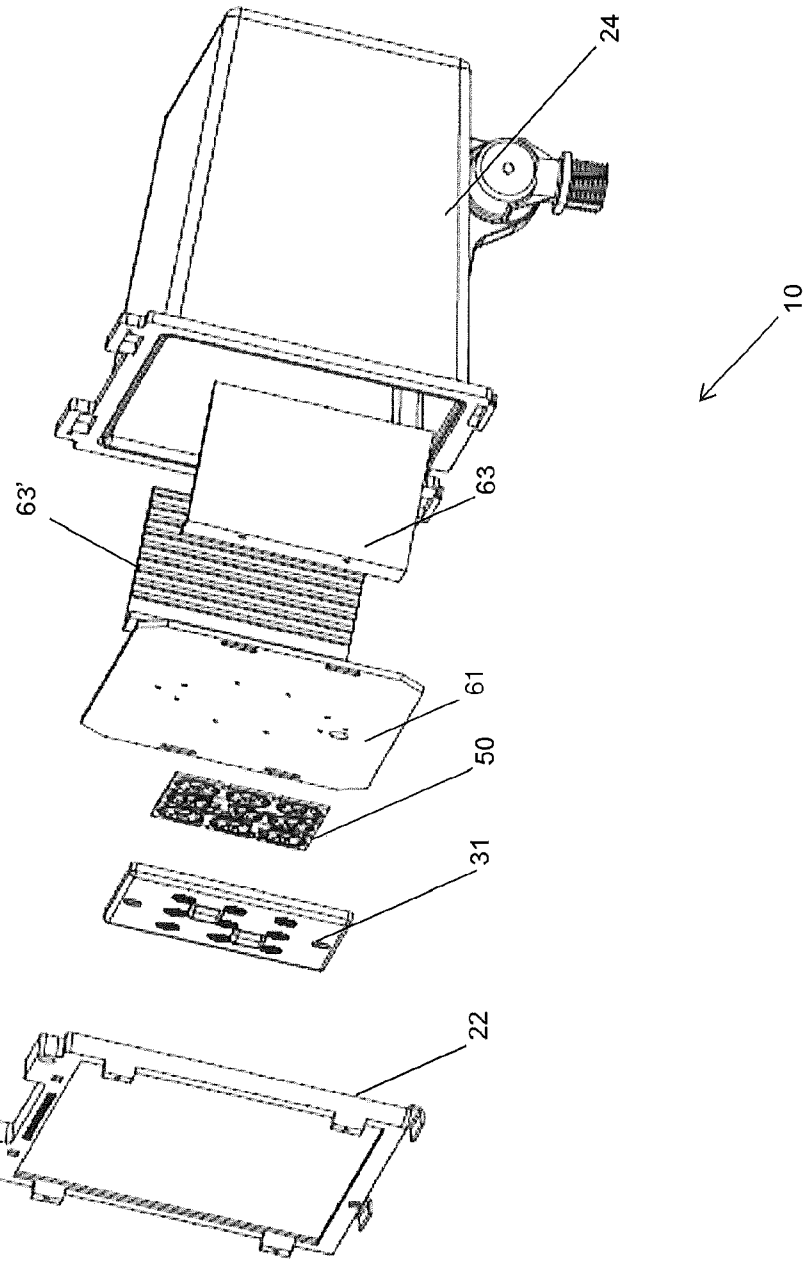


Figure 2

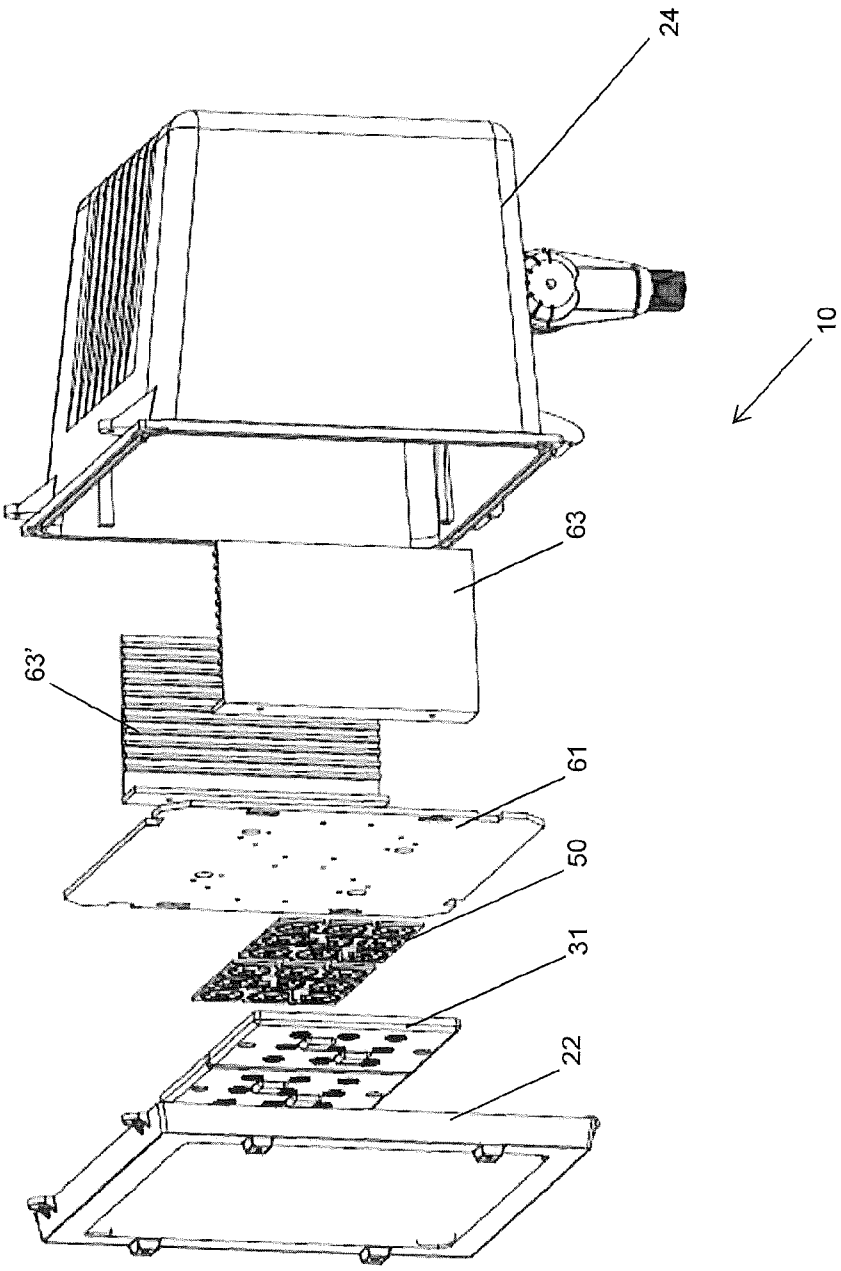


Figure 3

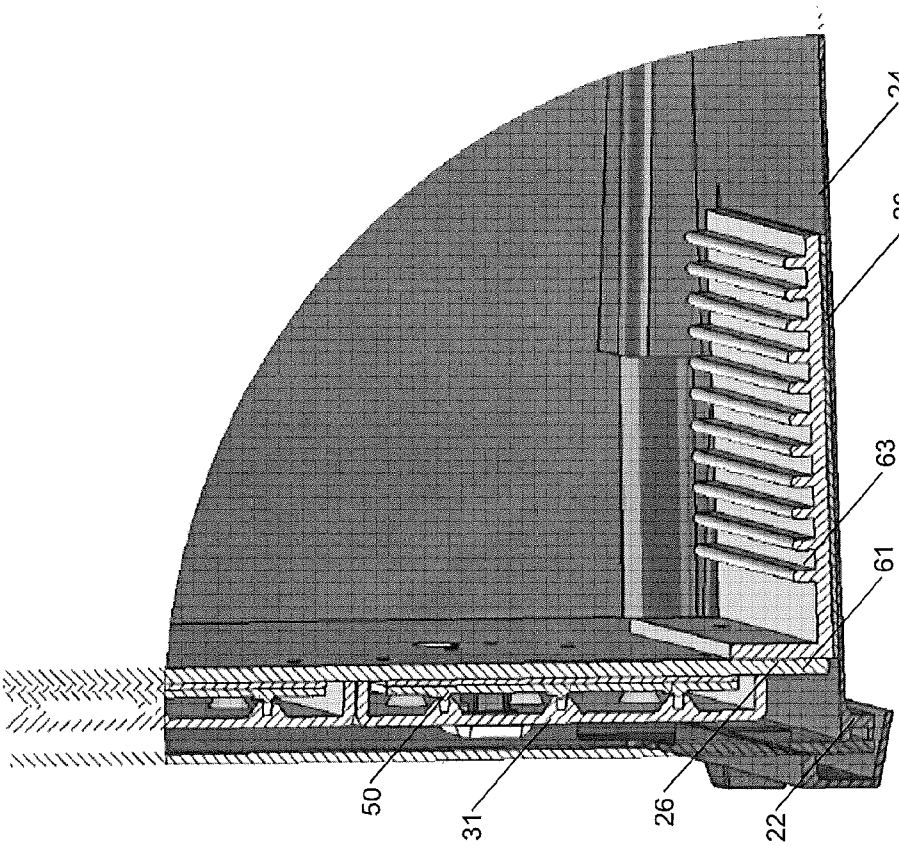


Figure 4B

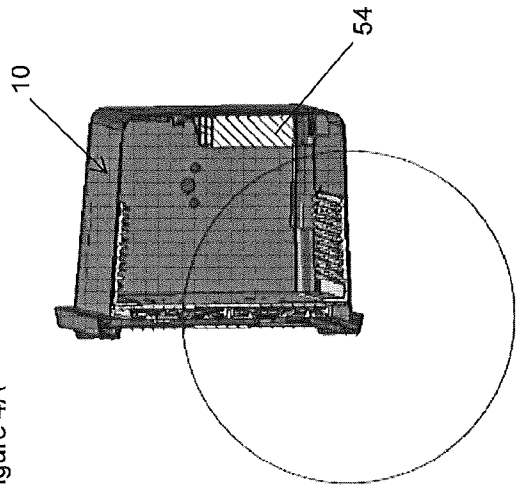


Figure 4A

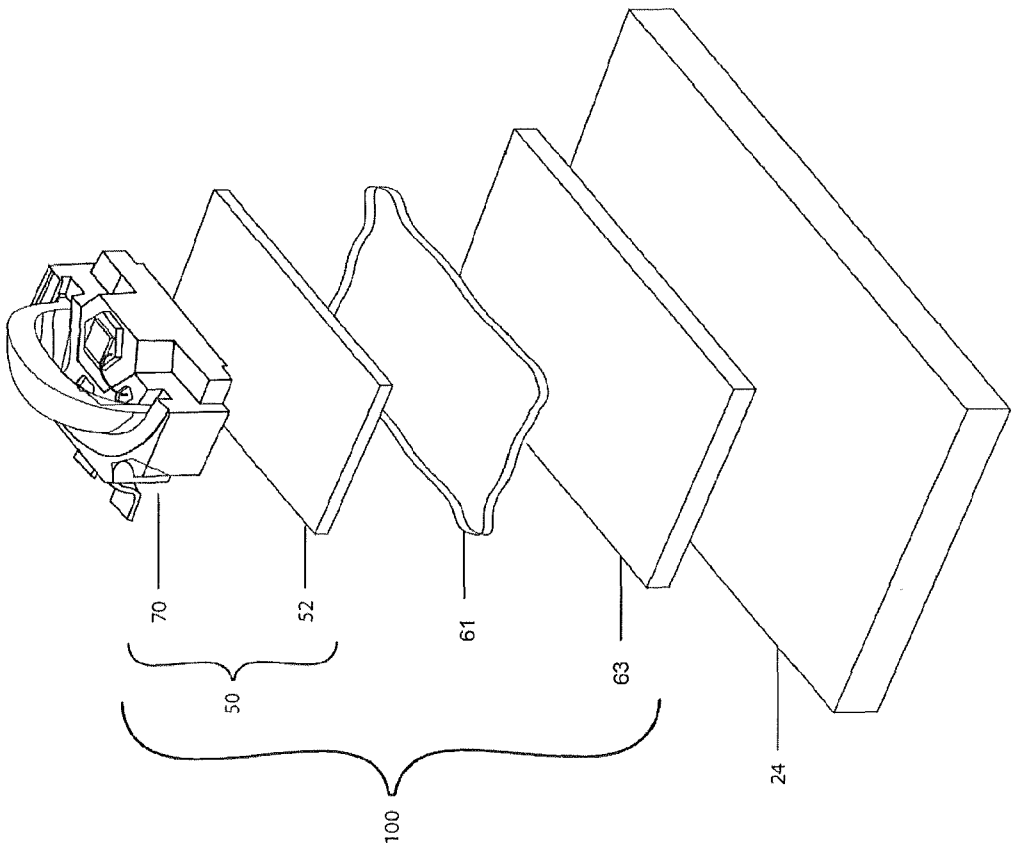


Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/012485

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H01J 1/02 (2014.01)
USPC - 313/46
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H01J 1/02, H01J 7/24, H01J 61/52, H01J 1/58, F21V 1/00, F21V 11/00 (2014.01)
USPC - 313/46, 11; 362/235, 237, 240, 294

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - F21V 29/004, H05K 7/20963, F21S 4/003, F21W 2121/00 (2014.02)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Orbit, Google Patents, Google Scholar, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US 2010/0314985 A1 (PREMYSLER) 16 December 2010 (16.12.2010) entire document.	1-3, 7-10 ---------- 4-6
Y	US 2011/0286219 A1 (GUERCIO et al.) 24 November 2011 (24.11.2011) entire document.	4-6
A	US 2010/0149809 A1 (RUUD et al.) 17 June 2010 (17.06.2010) entire document.	1-10
A	US 2012/0236602 A1 (FLAHERTY et al.) 20 September 2012 (20.09.2012) entire document.	1-10
A	US 2012/0262917 A1 (COURCELLE) 18 October 2012 (18.10.2012) entire document.	1-10
A	US 2010/0124058 A1 (MILLER) 20 May 2010 (20.05.2010) entire document.	1-10

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* Special categories of cited documents:
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 April 2014	14 MAY 2014

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774