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(71) Applicant: **GE LIGHTING SOLUTIONS, LLC** [US/US]; 1975 Noble Road, Bldg. 338, Nela Park, East Cleveland, OH 44112 (US).

(72) Inventors: **RAMAIAH, Raghu**; GE Lighting, 1975 Noble Road, Nela Park, East Cleveland, OH 44112-6300 (US). **KNAPP, Thomas Alexander**; 1975 Noble Rd, Bulding 335C, East Cleveland, OH 44112-6300 (US). **YODER, Benjamin Lee**; 1975 Noble Road, East Cleveland, OH 44112 (US). **FIRIS, James William**; 1975 Noble Road, East Cleveland, OH 44112-6300 (US).

(74) Agents: **DIMAURO, Peter T.** et al.; General Electric Company, Global Patent Operation, 901 Main Avenue, 3rd floor, Norwalk, CT 06851 (US).

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(54) Title: SOLID STATE LAMP FOR RETROFIT

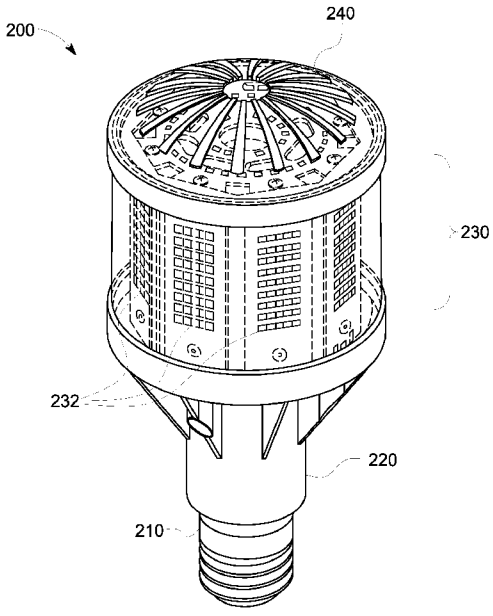

FIG. 2

(57) Abstract: A solid state lamp for retrofit of an HID includes a circumferential array of solid state light sources mounted on circuit boards, a heat sink located in the lamp's interior volume, and a fan positioned in the interior volume to force airflow across the heat sink. A capper assembly includes at least one aperture to vent the interior volume, and an intermediate circuit board within the capper assembly. The intermediate circuit board distributes electrical power to the circuit boards by tabs and contacts extending from the boards that are mechanically bonded together. An optical transmissive shield is positioned exterior to the circumferential array, and can include prismatic structures to direct light emitted from the LED sources in an off axis direction.

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SOLID STATE LAMP FOR RETROFIT

CLAIM OF PRIORITY

[0001] This patent application claims the benefit of priority, under 35 U.S.C. § 119, of U.S. Provisional Patent Application Serial No. 62/221,400, filed September 21, 2015, titled "LED Lamp Design for HID Retrofit" the entire disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] The light distribution of a light emitting diode (LED) lamp can be sometimes closely linked to the heat sink design. Design choices of a retrofit LED lamp can require compromising its light distribution to simplify the heat sink design, or the heat sink design can be overdesigned to compensate for an inferior LED driver electronics design.

[0003] Many conventional high-intensity discharge (HID) LED retrofit lamps do not have a light distribution similar to a conventional HID lamp. This is sometimes due to the LEDs of these conventional retrofit lamps being distributed in a plane, resulting in an optical distribution that is not capable of providing the omnidirectional lighting of the HID lamp. LED lamp thermal properties are important to the lamp's design. These thermal properties can be primarily a function of the heat sink design, and how heat is extracted from the LEDs and transferred to the ambient environment. Proper thermal design benefits the photometric properties of a LED retrofit lamp.

[0004] A LED retrofit lamp for existing HID installations should mimic as closely as possible the optical light distribution of the existing HID lamp it is replacing. What is needed in the art is a retrofit HID LED lamp that balances a suitable optic performance with an acceptable, efficient heat sink design.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1A depicts an optical distribution for a conventional HID lamp;

[0006] FIG. 1B depicts a coordinate system for the optical distribution depicted in FIG. 1A;

[0007] FIG. 2 depicts a perspective view of a retrofit lamp in accordance with embodiments;

[0008] FIG. 3A depicts a perspective view of an optical transmissive shield for the retrofit lamp of FIG. 2 in accordance with embodiments;

[0009] FIG. 3B depicts a cross-sectional view of the optical transmissive shield of FIG. 3A along line 3B-3B in accordance with embodiments;

[0010] FIG. 4 depicts a perspective view of a retrofit lamp in accordance with embodiments;

[0011] FIG. 5 depicts an exploded view of a retrofit lamp in accordance with embodiments;

[0012] FIG. 6A depicts an embodying retrofit lamp superimposed on a ANSI ED28 form profile; and

[0013] FIG. 6B depicts another embodying retrofit lamp superimposed on the ANSI ED28 profile.

DESCRIPTION

[0014] While the aspects of the disclosed embodiments are generally described herein with respect to an LED light source, the aspects of the disclosed embodiments apply to any suitable solid-state light source. As used herein, the term "solid-state light source" (or SSL source) includes, but is not limited to, light-emitting diodes (LEDs), organic light-emitting diode (OLEDs), polymer light-emitting diodes (PLEDs), laser diodes, or lasers. In some implementations, the LEDs can be sealed from ambient air to prevent LED sulfuration. In addition, although the figures depict LED light sources, it should be understood that other types of SSL sources could be utilized in some embodiments in accordance with the novel implementations described herein.

[0015] In accordance with embodiments, a retrofit lamp (hereinafter "retrofit lamp") has an optical distribution truer to a conventional HID lamp than current LED lamps. Embodying retrofit lamps include SSL sources arranged in a circumferential array around the body of the retrofit lamp, with the heat sink located interior to the circumferential array of SSL sources. This arrangement of light sources provides an embodying retrofit lamp with a light distribution that is omnidirectional to closely mimic the light distribution of the conventional HID lamp it is replacing.

[0016] Figure 1A depicts light distribution 100 for a conventional HID lamp. Each point of light distribution 100 can be described as located within spherical coordinate system

110 (FIG. 1B) by a point (r, θ, ϕ). Conventional LED HID retrofit lamps do not have a light distribution similar to HID light distribution 100. The conventional LED HID retrofit lamps have the LED light sources distributed in a plane, where the mounting surface for the LED light sources eliminate light distribution behind the mounting surface.

[0017] Figure 2 depicts a perspective view of retrofit lamp 200 in accordance with embodiments. An embodying retrofit lamp includes lamp base 210 that completes an electrical connection between the retrofit lamp and a power source when the lamp is connected to a socket of a lighting fixture, and capper assembly 220 located adjacent to the base. Within capper assembly 220 can be located the driver electronics supply. At the distal end of the capper assembly is located circumferential array 230 composed of SSL sources. The SSL sources can be mounted on one or more circuit boards 232 positioned around the circumferential array. In some implementations the circuit boards can be formed from one flexible circuit board conformed to a cylindrical shape. The circumferential array can be covered by an optical transmissive shield (e.g., a polycarbonate shroud, glass, etc.). At the distal end of retrofit lamp 200 is located dome 240.

[0018] The overall form fit of the retrofit lamp conforms with standards promulgated by the American National Standards Institute (ANSI), so that the lamp can be installed in existing fixtures, both open and enclosed, for conventional HID lamps. Figure 6A depicts retrofit lamp 200 conforming within ANSI ED28 form profile 600. In some implementations, the retrofit lamp may meet the maximum allowable diameter and length of the ANSI profile, but might exceed the limits of the profile in the corners. Figure 6B depicts embodying retrofit lamp 620 exceeding ANSI ED28 form profile 600 at its corners. Alternative embodiments of the retrofit lamp can be scaled to fit the form function of ANSI BT/ED17, BT/ED23.5, BT/ED28, BT/ED37, BT56, etc.

[0019] In some implementations, a series of SSL sources can be placed on the dome end (distal to the lamp base), to increase the light distribution in the θ plane. The presence of an additional light source(s) on the top of the lamp eliminates a dark spot in the light distribution created when the primary SSL source circuit boards are around the exterior faces of the heat sink. The secondary SSL source board can include at least one aperture (e.g., a hole and/or slot) to allow air to pass through into the interior volume of the LED HID retrofit lamp.

[0020] Figure 3 depicts a perspective view of optical transmissive shield 300 for LED HID retrofit lamp 200 in accordance with embodiments. The optical transmissive shield can

be a clear, or translucent, tube placed to surround circumferential array 230. On the surface of this tube is arranged a series of prismatic structures 305 (shown in cross-section along line 3B-3B in FIG. 3B)

[0021] The prism structures direct some of the light in the θ direction. In particular, the transmissive shield depicted in FIG. 3A can increase downlight distribution (i.e., when the lamp is oriented vertical, and base-up (VBU)). By inverting the structure by 180 degrees, the uplight distribution can be increased. In some implementations to produce a more uniform illumination over a broad angular region, half the structure can have alternating groups of prisms facing downward and upward around the circumference of the prism. Additional implementations can include varying the prism extension length (FIG. 3B, length A).

[0022] Figure 4 depicts a perspective view of LED HID retrofit lamp 400 in accordance with embodiments. LED HID retrofit lamp 400 includes reflector 410 located about between capper 220 and circumferential array 230. In some implementations reflector 410 can be a conical or parabolic structure, coated on the inside surface with a reflective film; in other implementations reflector 410 can be a diffuse structure. In either implementation, reflector 410 can divert a portion of the LED generated light in the r-ϕ direction and direct it into the θ direction. Varying the angle of the sloped section can increase or decrease the amount of down-light and its angular distribution. In an alternative embodiment, reflector 410 may be translucent, such that a portion of light is transmitted through the reflector 410. Permitting some light to pass through the reflector 410 allows the surrounding fixture to be illuminated.

[0023] Figure 5 depicts an exploded view of LED HID retrofit lamp 500 in accordance with embodiments. LED HID retrofit lamp 500 includes lamp base 510, and capper assembly 520 located adjacent to the base. Within capper assembly 520 can be located LED driver electronics 524. The LED driver electronics condition the input electrical power to meet the requirements of the LED light sources. At the distal end of the capper assembly is located circumferential array 530 composed of LED light sources. The LED light sources can be mounted on circuit boards 532 positioned around the circumferential array. In some implementations, the circuit boards can be metal-clad printed circuit boards (MCPCB) to provide thermal conductivity away from the LED light engines mounted on the circuit boards.

[0024] Electrical power from the LED driver electronics can be distributed to the circuit boards 532 by intermediate printed circuit board (PCB) 526. The power distribution network of the intermediate PCB can be electrically connected to the output of LED driver electronics

524 by wire jumper(s). Each board 532 can be electrically connected to the intermediate PCB by tab(s) 528 located on the intermediate PCB at positions corresponding to electrical input contacts 534 on each of circuit boards 532. These protruding tabs can be mechanically bonded (e.g., soldered, welded, conductively glued, etc.) to the corresponding contacts on respective circuit boards 532 to reduce assembly time and costs, while improving the reliability of the electrical contact between intermediate PCB 526 and circuit boards 532.

[0025] Within the interior volume of the SSL retrofit lamp can be located heat sink 560. The heat sink is positioned interior to the circumferential array of SSL sources. The heat sink can include flat external faces and internal fins. The external flat faces are in thermal contact with circuit boards 532. For example, in one embodiment heat sink 560 can have the same amount of external faces as there are SSL circuit boards.

[0026] The internal fins increase the heat sink surface area, thereby increasing heat transfer by forced convection from fan 555 positioned within the interior volume to force airflow in a fluidic manner across heat sink 560. The heat sink can be manufactured by an extrusion process, but could also be manufactured — including die-casting, roll forming, and sheet metal bending.

[0027] Circumferential array 530 can be covered by optical transmissive shield 550. At the distal end of retrofit lamp 500 can be located top cap 542 and fan guard 545. In some embodiments, the top cap and fan guard can be integrated into a single part. The top cap and fan guard can be in the shape of dome 240 (FIG. 2). In some embodiments, the dome can be flat on top and have a series of vents which are radial spokes or alternatively a square grid or other geometry to have air flow into the lamp's interior volume. The dome can be made from a polycarbonate or other material of sufficient transparency and resistance to heat. In some implementations, the dome can diffuse the light to reduce glare when the lamp is oriented VBU.

[0028] The top cap can include a vented region having aperture(s) to supply air flow into the fan. The vent aperture(s) may be circular, square, rectangular, trapezoidal, or other shape which allows air to flow through the lamp efficiently. In order to minimize air flow impedance, it is desirable for the vent aperture(s) to maximize the open area while still preventing external objects from penetrating the lamp. A fine mesh sheet can replace or be added to the vented region to further prevent foreign objects from entering the lamp. Vent aperture(s) in the capper assembly can provide outlets for the forced air. In some implementations the direction of air flow can be reversed.

[0029] Other features of the top cap include a plurality of tabs and/or bosses that position the components in place. One set can position the top cap on the heat sink. Another set can position the optical shield around the heat sink. Another set can position the corners of the fan to center it on the heat sink. Some implementations can have four sets of tabs, but as few as two sets of tabs could be used to position all of the components.

[0030] In accordance with embodiments, the retrofit lamp can be a direct screw-in replacement for the conventional HID lamp (i.e., the SSL sources operate off the conventional HID ballast). In some implementations, the retrofit lamp can operate off an input line voltage, after the conventional HID ballast is removed prior to installing the retrofit lamp. Accordingly, driver electronics 524 can condition one or both of the line voltage input or the conventional HID ballast output. the LED lamp runs off the HID ballast).

[0031] Although specific hardware and methods have been described herein, note that any number of other configurations may be provided in accordance with embodiments of the invention. Thus, while there have been shown, described, and pointed out fundamental novel features of the invention, it will be understood that various omissions, substitutions, and changes in the form and details of the illustrated embodiments, and in their operation, may be made by those skilled in the art without departing from the spirit and scope of the invention. Substitutions of elements from one embodiment to another are also fully intended and contemplated. The invention is defined solely with regard to the claims appended hereto, and equivalents of the recitations therein.

CLAIMS:

1. A solid state lamp comprising:

one or more circuit boards configured as a circumferential array defining an interior volume of the lamp, each circuit board having an interior surface, an exterior surface, a first edge, and a second edge;

solid-state light sources mounted on the exterior surface of the one or more circuit boards;

a heat sink located in the interior volume, the heat sink in thermal communication with the interior surface of the one or more circuit boards;

an active cooling device positioned proximal to the interior volume configured to force airflow across the heat sink;

a capper assembly located proximal to the first edge of the one or more circuit boards, the capper assembly including at least one aperture configured to vent the interior volume; and

a top cap located proximal to the second edge of the one or more circuit boards, the top cap including at least one aperture configured to vent the interior volume.

2. The lamp of claim 1, the heat sink including internal fins extending into the interior volume.

3. The lamp of claim 1, including a dome assembly located distal from the second edge, the dome assembly including a secondary circuit board having solid-state light sources.

4. The lamp of claim 1, including an optical transmissive shield positioned proximal to the exterior surfaces of the one or more circuit boards.

5. The lamp of claim 4, the optical transmissive shield including prismatic structures extending laterally from the optical transmissive shield, the prismatic structures configured to direct light emitted from the solid state light sources in an off axis direction.

6. The lamp of claim 1, including a lamp base at an end of the capper assembly opposite the first edge.

7. The lamp of claim 1, including an intermediate circuit board and a light source driver electronics supply within the capper assembly.

8. The lamp of claim 7, the intermediate circuit board in electrical communication with the driver electronics supply, the intermediate circuit board configured to distribute electrical power to the one or more circuit boards.

9. The lamp of claim 8, the intermediate circuit board including:

protruding tabs extending inwards from the intermediate circuit board; and

electrical contacts extending from the first edge of the one or more circuit boards.

9. The lamp of claim 9, the protruding tabs and the electrical contacts mechanically bonded to form an electrical connection.

10. The lamp of claim 1, including a reflector between the circumferential array and the capper assembly.

11. The lamp of claim 10, the reflector having a reflective film coated on a first surface of the reflector.

12. The lamp of claim 10, the reflector formed from a diffuse material.

13. The lamp of claim 1, the one or more circuit boards being metal-clad printed circuit boards.

14. The lamp of claim 1, the one or more circuit boards being a flexible circuit board conformed to an external profile of the heat sink.

15. The lamp of claim 1, the SSL source being one of a light emitting diode, an organic light-emitting diode, polymer light-emitting diodes, a laser diode, and a laser.

16. The lamp of claim 1, the active cooling device being a fan.

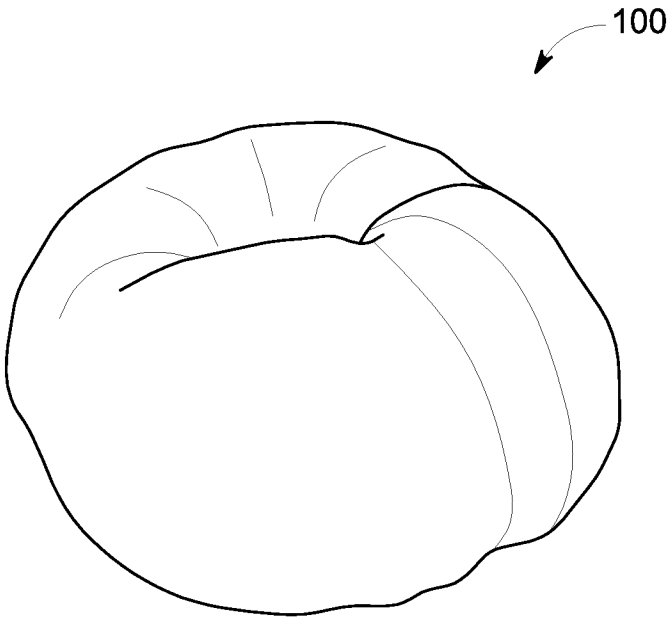

FIG. 1A
PRIOR ART

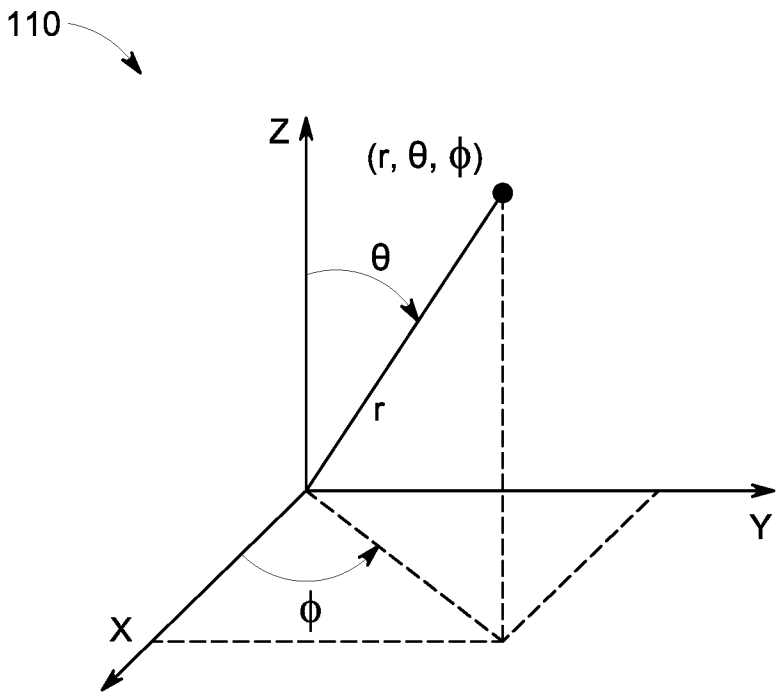

FIG. 1B

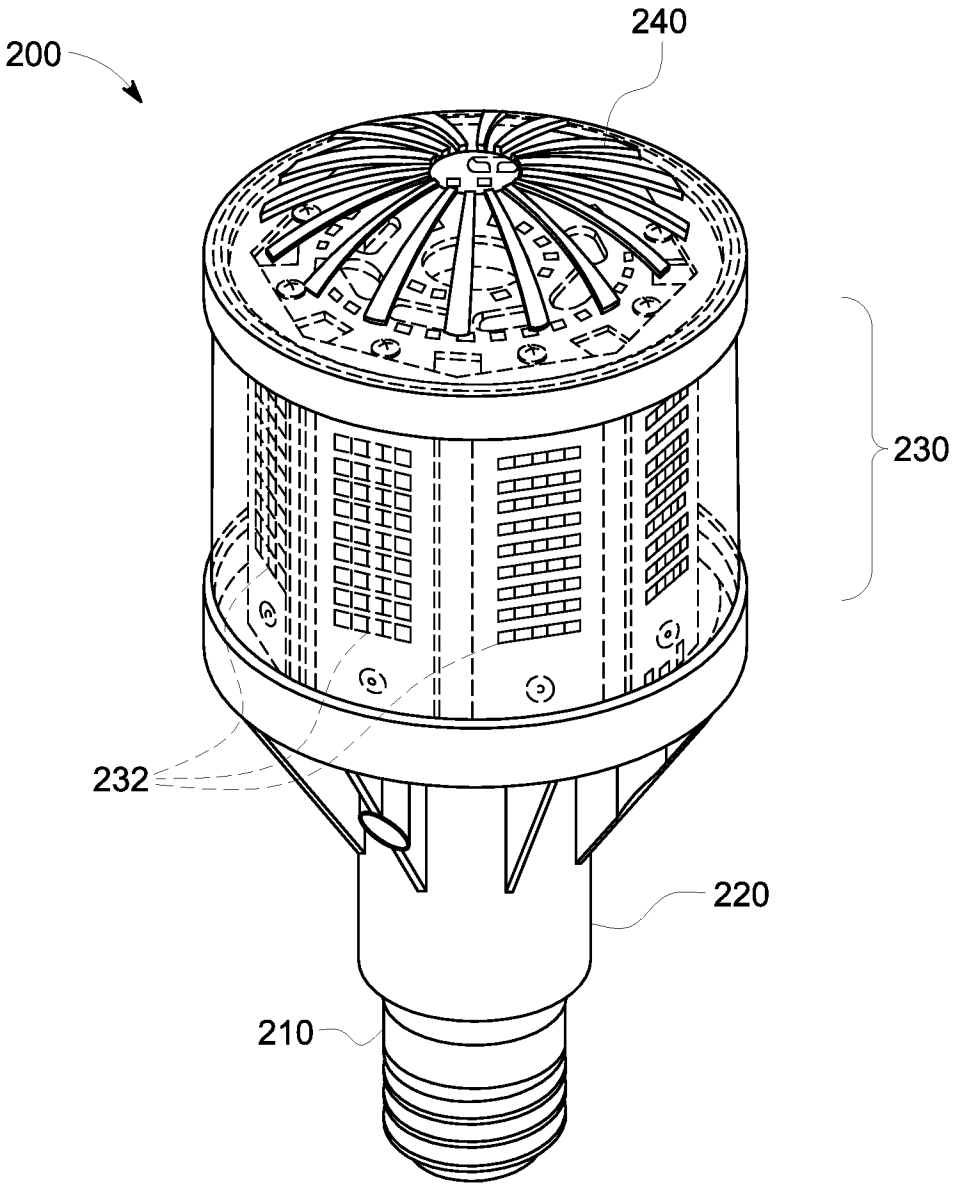

FIG. 2

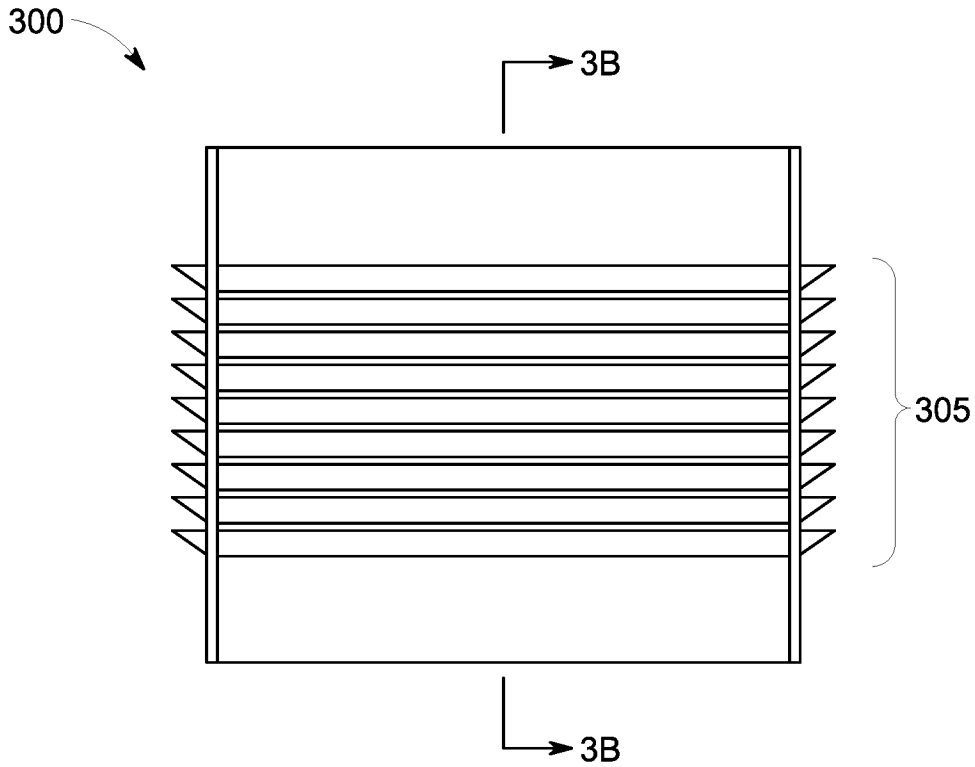

FIG. 3A

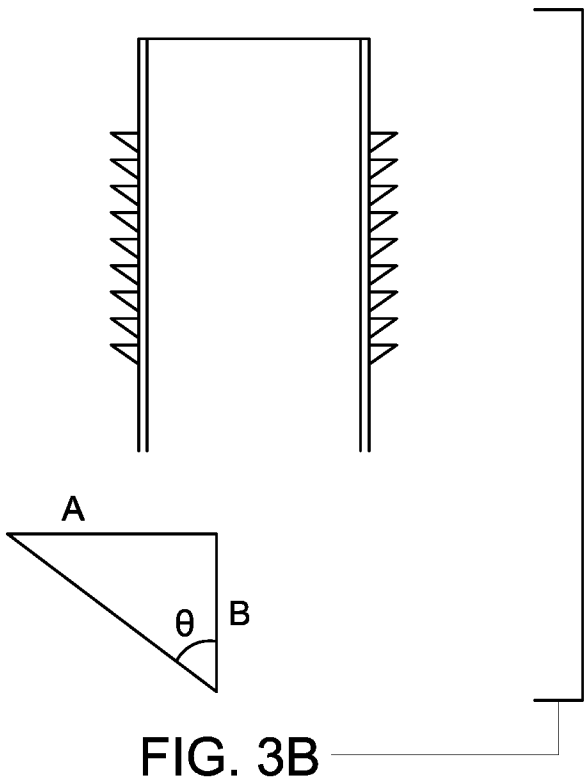

FIG. 3B

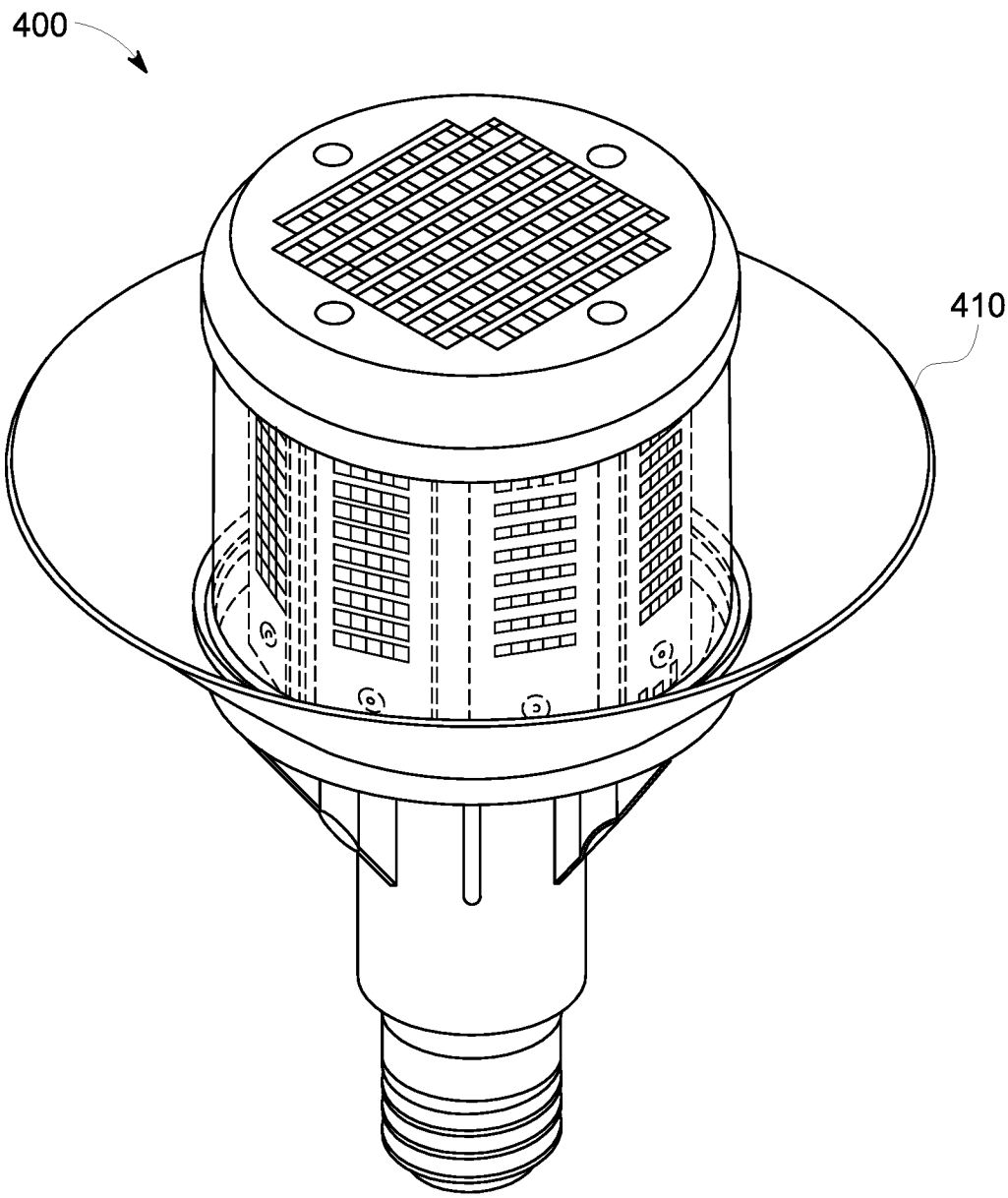

FIG. 4

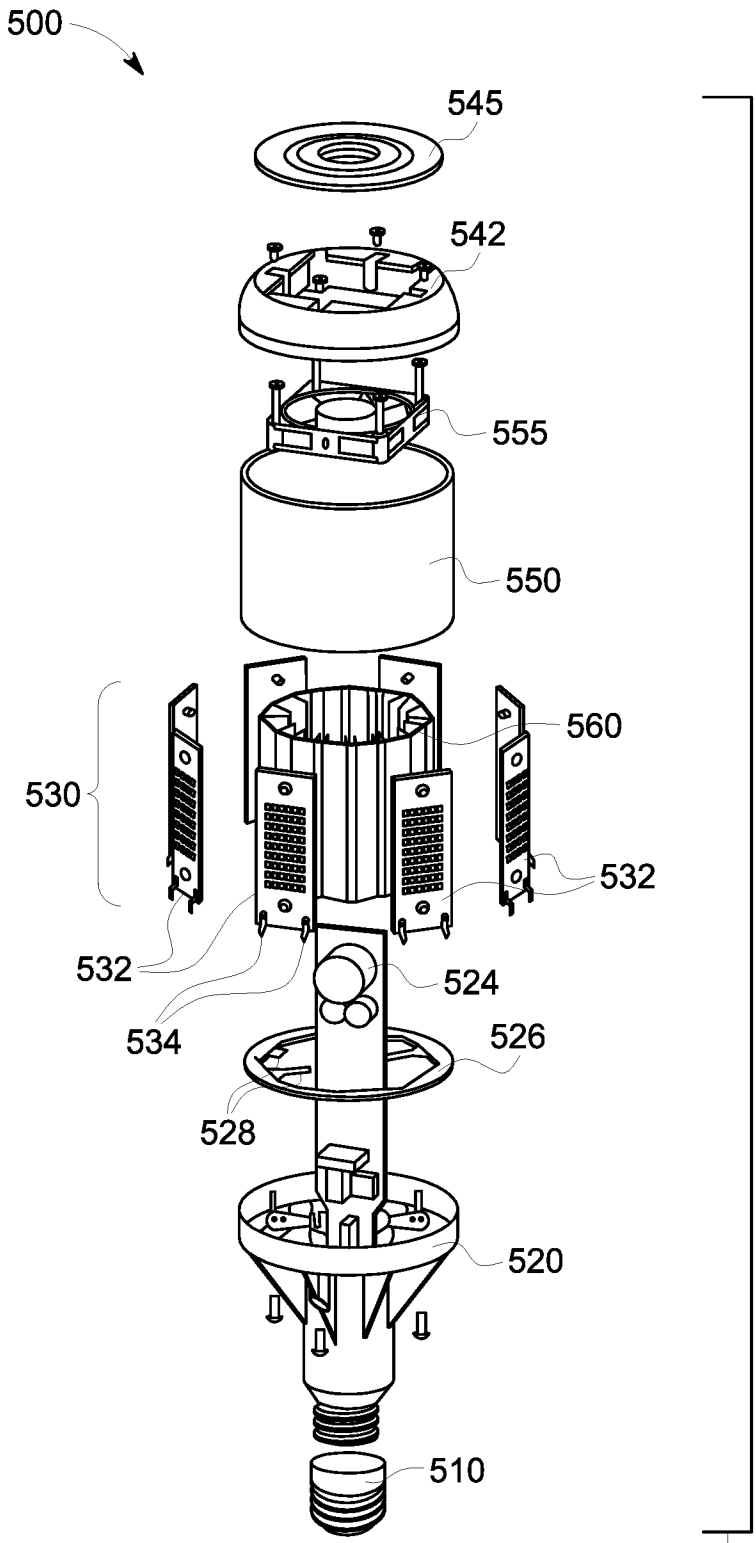

FIG. 5

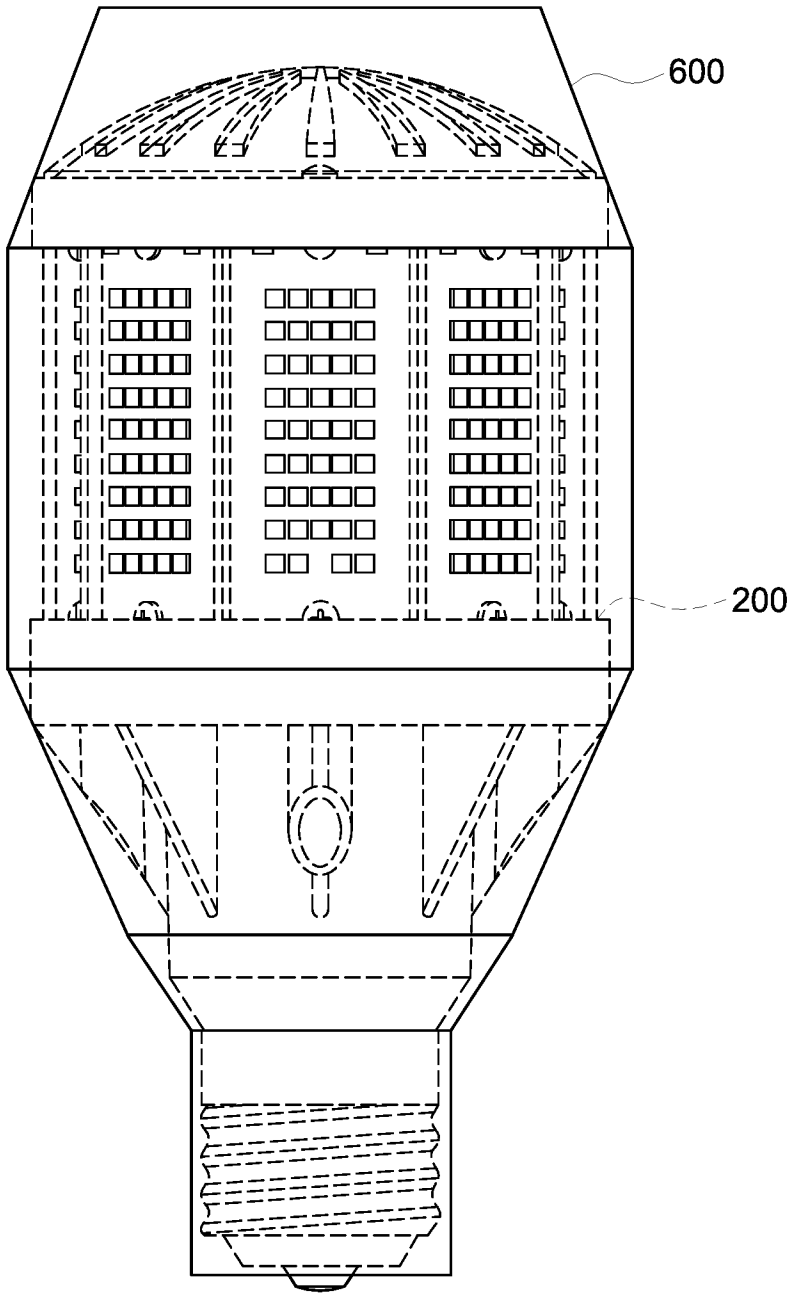

FIG. 6A

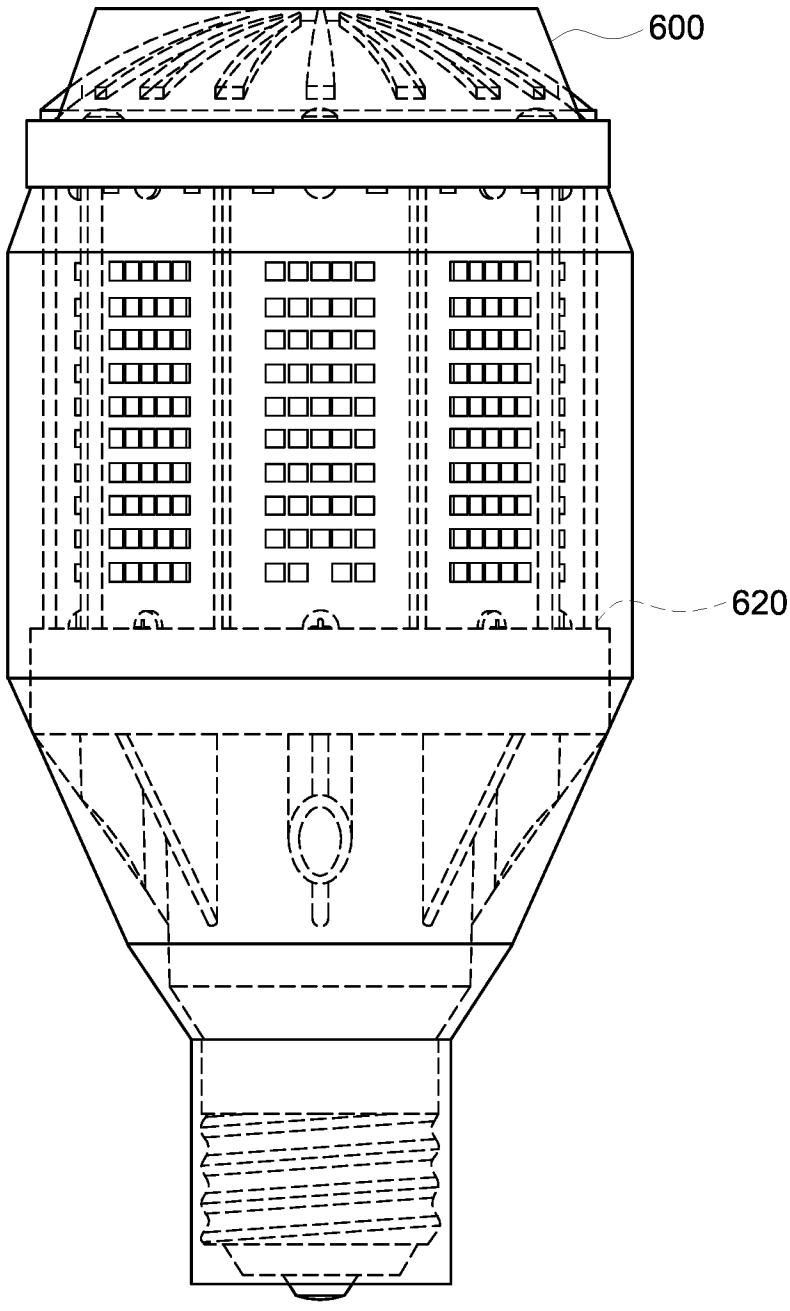

FIG. 6B

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. F21K9/232 F21K9/238 F21V29/67 F21V29/83
ADD. F21Y107/30 F21Y115/10

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)
F21K F21V F21Y

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2009/052175 A1 (XU FANG-WEI [CN] ET AL) 26 February 2009 (2009-02-26) paragraph [0015] - paragraph [0021] figures 1-4	1,2,4-6, 14-17
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X	US 2014/340870 A1 (PREMYSLER PHILIP [US]) 20 November 2014 (2014-11-20) paragraph [0034] - paragraph [0065] figures 1-15	1,2,4-8, 14-17

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 2016	24/11/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Demirel, Mehmet

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/307443 A1 (CLIFFORD SCOTT [US] ET AL) 16 October 2014 (2014-10-16) figure 6	1-17
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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