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(54) **LIGHTING APPARATUS**

(57) A lighting apparatus includes a base (220), a light-emitting module (240) fixed on the base, a shell (260) connected to the base to form a hollow space with a first volume, and an inert liquid (280) confined within

the shell and the base and having a second volume. The first and second volumes are increased or decreased at a similar tendency or volume change rate in response to a temperature difference.

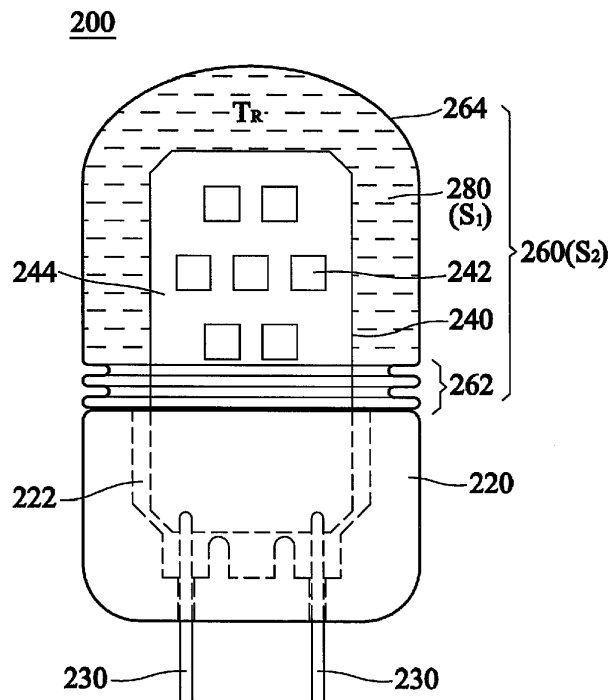


FIG. 2A

Description**TECHNICAL FIELD**

[0001] The present disclosure relates to a lighting apparatus and in particular to a lighting apparatus with a shell including a flexible portion able to release the thermal stress.

DESCRIPTION OF THE RELATED ART

[0002] Light-emitting diodes (LEDs) are energy efficient, durable, and compact, and have faster response time and longer life span compared with incandescent light bulbs or fluorescent tubes. Therefore, LEDs are widely used in household appliances. As shown in FIGS. 1A and 1B, a lighting apparatus 100 includes a base 120, a light-emitting module 140 fixed on the base 120, a shell 160 covering the light-emitting module 140 and connected to the base 120, and a liquid 180 filled in a space between the shell 160 and base 120. In general, the liquid 180 increases in volume from lower temperature to higher temperature, and decreases in volume from higher temperature to lower temperature. Larger volume also causes higher pressure inside the shell 160 and base 120, and vice versa. The repeatedly changing in pressure usually weakens the structure or joint of the shell 160 and the base 120. After many hours operation, some cracks may generate in the lighting apparatus 100, and consequently, the liquid 180 leaks out from those cracks so as inducing one or more voids 182 inside the shell 160.

SUMMARY OF THE DISCLOSURE

[0003] A lighting apparatus includes a base, a light-emitting module fixed on the base, a shell connected to the base to form a first hollow space with a first volume between the shell and base, and an inert liquid filled in the first hollow space and having a second volume. The first and second volumes are increased or decreased at a similar tendency in response to a temperature variation.

[0004] The following description illustrates embodiments and together with drawings to provide a further understanding of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005]

FIGS. 1A and 1B show a conventional lighting apparatus.

FIG. 2A illustrates a lighting apparatus in accordance with an embodiment of the present disclosure.

FIGS. 2B~2C illustrate status change of the shell of the lighting apparatus from lower to higher operating temperature.

FIG. 3A illustrates a lighting apparatus in accordance with another embodiment of the present disclosure.

FIGS. 3B~3C illustrate status change of the shell of the lighting apparatus from lower to higher operating temperature.

FIG. 4A illustrates a lighting apparatus in accordance with another embodiment of the present disclosure.

FIGS. 4B illustrates an appearance of the shell of the lighting apparatus at higher operating temperature.

FIG. 5A illustrates a lighting apparatus in accordance with another embodiment of the present disclosure.

FIG. 5B illustrates an appearance of the shell of the lighting apparatus at higher operating temperature.

FIG. 6 illustrates a lighting apparatus in accordance with another embodiment of the present disclosure.

FIGS. 7A~7E illustrate steps of making a lighting apparatus in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0006] The drawings illustrate the embodiments of the disclosure and, together with the description, serve to illustrate the principles of the application. The same name or the same reference number given or appeared in different paragraphs or figures along the specification should have the same or equivalent meanings while it is once defined anywhere of the disclosure. The thickness or the shape of an element in the specification can be expanded or narrowed.

[0007] As used herein, the term "inert liquid" refers to a substance not reacting with an electrical component immersed within it and kept in liquid state (from an initial state of solid or liquid) at almost operating temperatures of the electrical component. For example, the operating temperature of the electrical component, such as a lighting apparatus, is ranged from 25°C to 100°C. The inert liquid is kept in liquid state even the operating temperature higher than 35°C. The inert liquid retained in liquid state can draw much more heat out from the lighting apparatus through convective heat transfer.

[0008] FIG. 2A shows a drawing of a lighting apparatus 200 in accordance with an embodiment of the present disclosure. Referring to FIG. 2A, the lighting apparatus 200 includes a base 220, a light-emitting module 240 having a plurality of light-emitting elements 242 and partially arranged in or integrated with the base 220, a shell 260 covering the light-emitting module 240 and connected to the base 220, and an inert liquid 280 filled into a chamber (hollow space) defined by the base 220 and the

shell 260 to submerge the light-emitting module 240. Furthermore, the chamber has a first space (volume) S1, and the inert liquid 280 occupies a second space (volume) S2. The first and second spaces (volumes) are increased or decreased at a similar tendency or volume rate in response to a temperature variation.

[0009] The base 220 can support the light-emitting module 240 and physically connect to the shell 260. The light-emitting module 240 and the inert liquid 280 are arranged within an inner hollow space cooperatively defined by the base 220 and the shell 260. The base 220 and the shell 260 can be physically connected to each other by mechanical means and/or chemical means. The mechanical means includes but limited to splice joint, ultra-sonic joint, or thermal joint. The chemical means includes but limited to adhesive. In one embodiment, the light-emitting module 240 has a lower portion accommodated by a cavity 222 of the base 220, and an upper portion surrounded by the shell 260. The upper portion and lower portion can be partially overlapped with each other if the base 220 and the shell 260 are assembled together by splice joint.

[0010] In one embodiment, the lighting apparatus 200 includes a pair of electrical connectors 230. Each electrical connector 230 has one end not covered by the base 220 and adapted to external connection, and another end covered by the base 220 and/or shell 260 and electrically connected to the light-emitting module 240. The lighting apparatus 200 can be plugged into a socket (not shown) and electrically powered through the electrical connectors 230. The electrical connector 230 can be a metallic wire or plate with an adequate rigidity for plug and pull.

[0011] The light-emitting module 240 can emit a visible or invisible light. In one embodiment, the visible light is a red, orange, yellow, green, blue, or white light. The invisible light is a UV (including UVA, UVB, or UVC), or infra-red radiation. The light-emitting module 240 includes a plurality of light-emitting elements 242, and a submount or carrier 244 on which the light-emitting elements 242 are mounted. In one embodiment, the light-emitting elements 242 are arranged on the submount 244 in an array or non-array type configuration. The array type configuration is a M*N matrix, wherein M and N are any integer not less than 1, each cell of the matrix can stand for or be placed a single light-emitting element or multiple light-emitting elements. The non-array type configuration includes but not limited to circle, oval, octangle, hexagon, rectangle, triangle, saw-tooth, U-shape, V-shape, W-shape, S-shape, random arrangement. The light-emitting element 242 can include a growth substrate, an n-type semiconductor layer, an active layer, a p-type semiconductor layer, a p-type electrode, and an n-type electrode (not shown). The p-type electrode is electrically connected to the p-type semiconductor layer. The n-type electrode is electrically connected to the n-type semiconductor layer. In further embodiment, one of the light-emitting elements 242 includes a plurality of light-emitting structures disposed on a single growth sub-

strate (common substrate). A single light-emitting structure can have the aforementioned layer(s) and/or electrode(s). The light-emitting structures can be electrically connected to each other in parallel, in series, or a combination thereof. The submount 244 can include a transparent, translucent and/or light reflective material. Moreover, the submount 244 includes at least one metal layer (not shown) to electrically connect the light-emitting elements 242 with each other, and/or the light-emitting elements 242 with the electrical connectors 230. In one embodiment, the metal layer is a circuit and made of conductive material, such as Cu, Au A1 or a combination thereof.

[0012] The shell 260 can form an upper portion of the first space S1 to accommodate the light-emitting module 240 and be physically connected to the base 220 to confine the inert liquid 280 in a sealed structure, close space, or a chamber defined by the base 220 and the shell 260. Moreover, the shell 260 is transparent or translucent to light emitted from the light-emitting module 240. The light from the light-emitting module 240 can pass through, mix within, and/or scatter by the shell 260. In one embodiment, the shell 260 has a transmittance ((%T) greater than 40%, such as 50%, 60%, 70%, 80% 90%, or 99%, in the wavelength of 400nm~700nm.

[0013] The shell 260 has one or more flexible portions which can expand and recover to change the volume of shell 260. The volume herein can be directed to a total space defined by the outmost surface or the innermost surface of the shell 260. In one embodiment, the shell 260 includes a flexible portion 262 and a main portion 264. The flexible portion 262 is closer to the base 220 than the main portion 264. The flexible portion 262 can significantly or apparently increase or decrease its dimension, such as length, width, perimeter, upon receiving a force, in comparison with the main portion 264. For example, the flexible portion 262 has a spring-like structure which can be compressed or stretched to change the first space (volume) S1. In one embodiment, the flexible portion 262 and the main portion 264 both are made of elastic material(s), however the main portion 264 is less stretchable or compressible than the flexible portion 262. In other embodiment, the flexible portion 262 is made of an elastic material(s), but the main portion 264 is made of rigid or less elastic material(s). Accordingly, the main portion 264 can retain its volume or shape even the flexible portion 262 changes its volume or shape. The elastic material herein can be defined as a material having an elongation rate ranging from 3% to 20%. The elastic material can be chosen from silicone resin or rubber. The rigid or less elastic material can be chosen from glass or plastic. The plastic is such as PMMA or PC.

[0014] The inert liquid 280 is filled into the hollow space between the base 220 and the shell 260 and occupies the second space (volume) S2. The inert liquid 280 is a medium transparent or translucent to the light emitted from the light-emitting module 240. In other words, the light from the light-emitting module 240 can pass through,

be mixed within, and/or be scattered by the inert liquid 280. In one embodiment, the inert liquid 280 has a transmittance (%T) greater than 40%, such as 50%, 60%, 70%, 80% 90%, or 99%, in the wavelength of 400nm~700nm. The inert liquid 280 can have different transmittances at different temperatures, especially when the inert liquid 280 has a phase change during the operating temperature. For example, when the operating temperature changes from 25°C to 40°C, the inert liquid 280, such as paraffin wax, can have a phase change from solid to liquid, and the transmittances of solid and liquid are usually different. In one embodiment, the transmittance of paraffin wax becomes greater from solid to liquid in the wavelength of 400~700nm. Moreover, the operating temperature can be measured from a predetermined position, such a point at the outer surface of the shell 260, a point in the solid part of the shell, a point within the inert liquid 280, a point on the light-emitting module, and/or a point on the light-emitting unit. The operating temperature can be also an average value of several temperatures taken on different positions of the lighting apparatus 200. For example, the temperatures are measured on 3, 5, or 10 positions between the light-emitting module 240 and the shell 260.

[0015] The inert liquid 280 can also provide a path of heat dissipation from the light-emitting module 240 to the shell 260. In one embodiment, the inert liquid 280 can be chosen from a material having a high thermal conductivity and/or a low viscosity. In one embodiment, the thermal conductivity of the inert liquid 280 is not less than 0.1 W/m-K. The inert liquid 280 is such as silicone oil, mineral oil, engine oil, glycerol, synthetic hydro carbon (SHC), synthetic ester oil, paraffin wax, and per-fluoro alkylether (PFAE).

[0016] FIGS. 2B and 2C show the expanding and shrinking status of shell 260. When emitting light, the light-emitting module 240 also generates heat which can elevate the temperature of the inert liquid 280. The volume of inert liquid 280 expands when temperature increases, while shrinks when temperature decreases. As shown in FIGS. 2B and 2C, the flexible portion 262 is constructed in a fold structure which can be stretched to increase its length/size or compressed to decrease its length/size. When the flexible portion 262 is stretched, the fold structure becomes longer and smooth-ened/flatted, or has looser wrinkled. When the flexible portion 262 being compressed, the fold structure becomes shorter and has denser wrinkles.

[0017] In one embodiment, the inert liquid 280 contains a silicone oil. The silicone oil has 10% volume expansion rate when the operating temperature T rises from 25°C to 100°C. In response the volume change of the inert liquid 280, the flexible portion 262a can be stretched or pushed by the pressure of the inert liquid 280 to meet the volume expansion of the inert liquid 280. In one embodiment, the flexible portion 262a expands in a direction away from the base 220. When the operating temperature T decreases, the inert liquid 280 has a volume shrinkage. In

one embodiment, the first space (volume) S1 and second space (volume) S2 have more than 5% of volume change rate if the operating temperature increases from 25°C to 100°C. The expansion and shrinkage of the shell 260 can release the stress due to the thermal expansion or contraction of the inert liquid 280. Therefore, the inert liquid 280 can be safely confined within the lighting apparatus 200 to avoid leakage. Moreover, shell shrinkage can eliminate air bulb(s) generated inside the inert liquid 280 when the operating temperature decreases.

[0018] FIG. 3A shows a lighting apparatus 300 in accordance with another embodiment of the present disclosure. The lighting apparatus 300 includes a base 320, a light-emitting module 340 having a plurality of light-emitting elements 342 and arranged on the base 320, a shell 360 covering the light-emitting module 340 and connected to the base 320, an inert liquid 380 filled into a hollow space defined the base and the shell 360 to submerge the light-emitting module 340, and a pair of electrical connectors 330 electrically connected to the light-emitting module 340. The base 320 and the shell 360 are sealed together to prevent the inert liquid 380 from leaking out the lighting apparatus 300. In one embodiment, the light-emitting module 340 includes a plurality of light-emitting elements 342, and a submount or carrier 344 on which the light-emitting elements 342 are mounted. As shown in FIG. 3A, the shell 360 has a flexible portion 362 substantially integrated with its total outer surface. The flexible portion 362 has protrusions and recessions interposed with each other around the outer surface. The protrusion can be formed in a shape of hemisphere, cylinder, prism, frustum, plate, or a combination thereof.

[0019] Referring to FIG. 3B, in one embodiment, the light-emitting elements 342 can be mounted on the two sides of a submount 344. One group of the light-emitting elements 342 can be deposited on right hand side of the submount 344 and other group of the light-emitting elements 342 can be deposited on left hand side of the submount 344.

[0020] FIGS. 3B and 3C show the recovering and expanding status of the shell 360, respectively. In one embodiment, FIG. 3B shows the shape of the shell 360 at a lower operating or room temperature T_R , for example, 25°C. FIG. 3C shows the shape of the shell 360 at a higher operating temperature T_H , for example, 100°C. However, T_R and T_H are not limited herein, they could be any reasonable temperatures which can cause a substantial change of the shell 360. When $T = T_R$ or cooling from a higher temperature to T_R , the volume of the inert liquid 380 becomes smaller so that the flexible portion 362a can be retained in its shape or shrunk to meet the decrease of the volume of the inert liquid 380. When the lighting apparatus 300 stays at a lower temperature, the protrusion of the shell 360 has a smaller size. When the lighting apparatus 300 stays at a higher temperature, the protrusion of the shell 360 becomes bigger till reaching its maximum size, for example, the protrusion is flatten, and the shell 360 becomes an object with a smoother

contour, as shown in FIG. 3C.

[0021] FIG. 4A shows a lighting apparatus 400 in accordance with another embodiment of the present disclosure. The lighting apparatus 400 includes a base 420, a light-emitting module (not shown) arranged on the base 420, a shell 460 covering the light-emitting module and connected to the base 420, an inert liquid 480 filled into an inner space defined by the base 420 and the shell 460 to submerge the light-emitting module, and a pair of electrical connectors 430 electrically connected to the light-emitting module. The shell 460 includes a plurality of concave portions distributed on an outer surface of the shell 460. In one embodiment, the concave portions are arranged uniformly on the outer surface. FIGS. 4A and 4B show the recovering and expanding status of the shell 460, respectively. FIG. 4A shows the shape of the shell 460 at a lower operating or room temperature T_R , FIG. 4B shows the shape of the shell 460 at a higher operating temperature T_H . However, T_R and T_H are not limited herein, they could be any reasonable temperatures which can cause a substantial change of the shell 460. When $T = T_R$ or cooling from a higher temperature to T_R , the volume of the inert liquid 480 becomes smaller so that the flexible portion 462a can be retained its shape or shrunk to meet the decrease of the volume of the inert liquid 480. When the lighting apparatus 400 stays at a lower temperature, the plurality of concave portions of the shell 460 make the shell 460 have a smaller size. When the lighting apparatus 400 stays at a higher temperature, the shell 460 becomes bigger till reaching its maximum size, for example, the concave portions are flatten, and the shell 460 becomes an object with a smoother contour, as shown in FIG. 4B.

[0022] FIG. 5A shows a lighting apparatus 500 in accordance with another embodiment of the present disclosure. The lighting apparatus 500 includes a base 520, a light-emitting module (not shown) arranged on the base 520, a shell 560 covering the light-emitting module and connected to the base 520, an inert liquid 580 filled into an inner space defined by the base 520 and the shell 560 to submerge the light-emitting module, and a pair of electrical connectors 530 electrically connected to the light-emitting module. In one embodiment, the shell 560 includes a plurality of grooves 562a and a plurality of 564a strips being parallel to each other and distributed on an outer surface of the shell 560. The grooves 562a and the strips 564a can extend from a bottom of shell 560 to a top of the shell 560. Moreover, the grooves 562a and the strips 564a can both include flexible portions, or only the grooves 562a have a flexible portion. FIGS. 5A and 5B show the recovering and expanding status of the shell 560, respectively. FIG. 5A shows the shape of the shell 560 at a lower operating or room temperature T_R . FIG. 5B shows the shape of the shell 560 at a higher operating temperature T_H . However, T_R and T_H are not limited herein, they could be any reasonable temperatures which can cause a substantial change of the shell 560. When $T = T_R$ or cooling from a higher temperature to T_R , the volume

of the inert liquid 580 becomes smaller so that the flexible portion 562a and/or 564a can be retained in its shape or shrunk to meet the decrease of the volume of the inert liquid 580. When the lighting apparatus 500 stays at a lower temperature, the plurality of grooves of the shell 560 have deeper trenches, the shell has a smaller size/volume. When the lighting apparatus 500 stays at a higher temperature, the shell 560 becomes bigger till reaching its maximum size, for example, the grooves become shallower, and the shell 560 becomes an object with a smoother contour, as shown in FIG. 5B.

[0023] FIG. 6 shows a lighting apparatus 600 in accordance with another embodiment of the present disclosure. The lighting apparatus 600 includes a base 620, a light-emitting module 640, a shell 660 with a flexible portion 662, an inert liquid 680, and a pair of electrical connectors 630 electrically connected to the light-emitting module 640. The shell 660 is arranged to cover the light-emitting module 640 and tightly connect to the base 620. The inert liquid 680 is filled into the hollow space defined by the base 620 and the shell 660 to submerge the light-emitting module 640. The light-emitting module 640 includes a plurality of light-emitting filaments 640a, 640b and 640c arranged on the base 620. In one embodiment, each of the light-emitting filaments 640a, 640b and 640c includes a plurality of light-emitting elements 642 disposed on a submount 644 in a linear arrangement. The amount of the light-emitting filaments 640a, 640b and 640c are not limited to the number shown in the drawing, and can be added or deleted according to a requirement or design input. In other embodiment, the lighting apparatus 600 includes one or more light-emitting filaments. Each light-emitting filament can have an outer structure made of resin (such as silicone or epoxy), and/or phosphor. The outer structure can be formed on a carrier on which a plurality of light-emitting units is arranged. The carrier is a transparent sheet made of transparent or translucent material(s), such as glass, sapphire, zinc oxide. In further embodiment, the outer structure is transparent tube covering the light-emitting units and material(s) filled with the transparent tube.

[0024] FIGS. 7A~7E are drawings of making a lighting apparatus in accordance with one embodiment of the present disclosure. Referring to FIG. 7A, a light-emitting module 740 is disposed on a base 720. Two or more electrical connectors 730 are electrically and/or physically connected to the light-emitting module 740. Each electrical connector 730 has one end connected to the light-emitting module 740, and the other end passing through a bottom surface 724 of the base 720 and adapted to external connection, such as a socket (not shown). The base 720 includes a cavity 722 to receive a portion of the light-emitting module 740 and a plurality of through hole 726, 728. The through hole 728 can be passed through by the electrical connector 730. The through hole 726 can be used to inject and/or discharge air and/or material filled into the lighting apparatus.

[0025] Referring to FIG. 7B, a shell 760 includes a flex-

ible portion 762 which can be stretched or compressed upon receiving external force. The shell 760 is connected to the base 720 and covers the light-emitting module 740. The shell 760 and the base 720 can be physically connected to each other by mechanical means and/or chemical means. The mechanical means includes but limited to splice joint, ultra-sonic joint, or thermal joint. The chemical means includes but limited to adhesive. Referring to FIGS. 7C and 7D, an inert liquid 780 is filled into a hollow space formed between the base 720 and shell 760 through one or more holes 726. If there are two holes 726, the inert liquid 726 can be filled into one through hole 726 and outflows through the other one. Referring to FIG. 7E, after filling the inert liquid 780, the through holes 726 can be sealed to prevent the leakage of the inert liquid. The sealing material can be a resin, such as silicone or epoxy.

[0026] The aforesaid embodiment can be also applied to U-shaped lamp, spiral lamp, Edison bulb, candle lamp, and any lighting fixtures suitable for use of the lighting apparatus described in the aforementioned embodiments (for example, troffer).

[0027] It will be apparent to those having ordinary skill in the art that various modifications and variations can be made to the devices in accordance with the present disclosure without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the present disclosure covers modifications and variations of this disclosure provided they fall within the scope of the following claims and their equivalents.

Claims

1. A lighting apparatus comprising:
 - a base;
 - a light-emitting module fixed on the base;
 - a shell connected to the base to form a hollow space with a first volume therebetween, and;
 - an inert liquid filled into the hollow space and having a second volume, wherein the first and second volumes are substantially the same at an initial state, and are increased or decreased at a similar rate in response to a temperature change.
2. The lighting apparatus according to claim 1, wherein the shell comprises a flexible portion.
3. The lighting apparatus according to claim 2, wherein the flexible portion comprises a spring-like structure.
4. The lighting apparatus according to claim 2, wherein the shell further comprises a main portion farther away the base than the flexible portion.
5. The lighting apparatus according to claim 2, wherein

the flexible portion comprises an elastic material.

6. The lighting apparatus according to claim 2, wherein the flexible portion is capable of being stretched or compressed in response to a volume change of the inert liquid.
7. The lighting apparatus according to claim 1, wherein a thermal conductivity of the inert liquid is not less than 0.1 W/m-K.
8. The lighting apparatus according to claim 1, wherein the first volume has a volume change rate of more than 5% between 25°C and 100°C.
9. The lighting apparatus according to claim 1, wherein the second volume has a volume change rate of more than 5% between 25°C and 100°C.
10. The lighting apparatus according to claim 1, wherein the shell has an outer surface substantially integrated with a flexible portion on its total area.
11. The lighting apparatus according to claim 1, wherein the light-emitting module comprises a plurality of light-emitting elements arranged in an array type configuration.
12. The lighting apparatus according to claim 1, wherein the light-emitting module comprises a plurality of light-emitting elements arranged in a non-array type configuration.

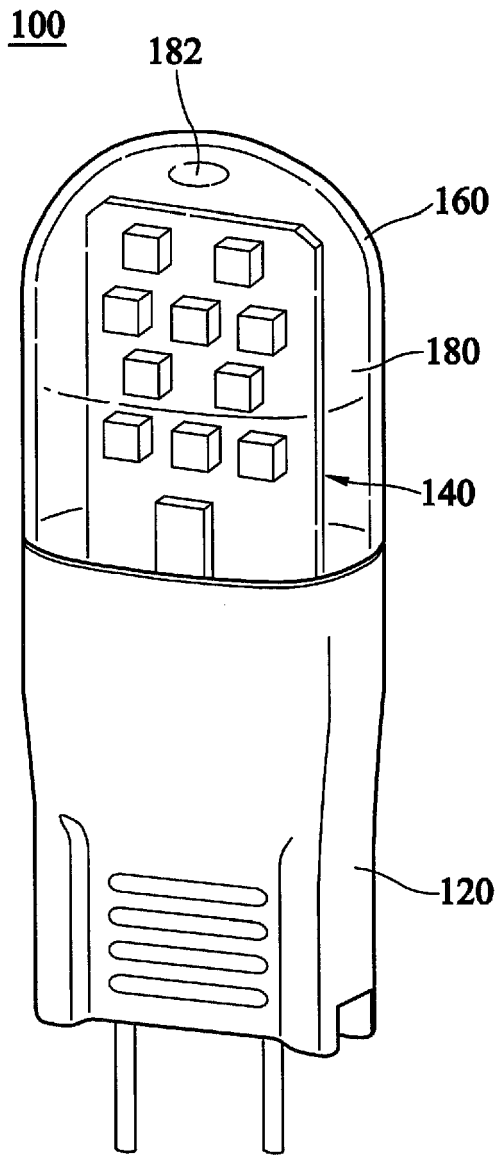


FIG.1A

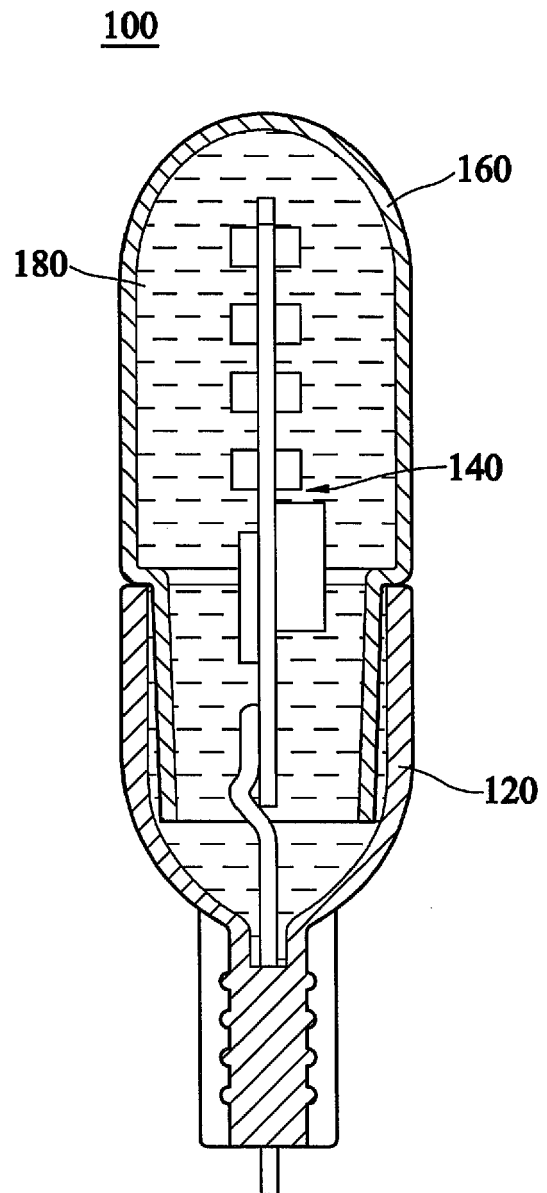


FIG.1B

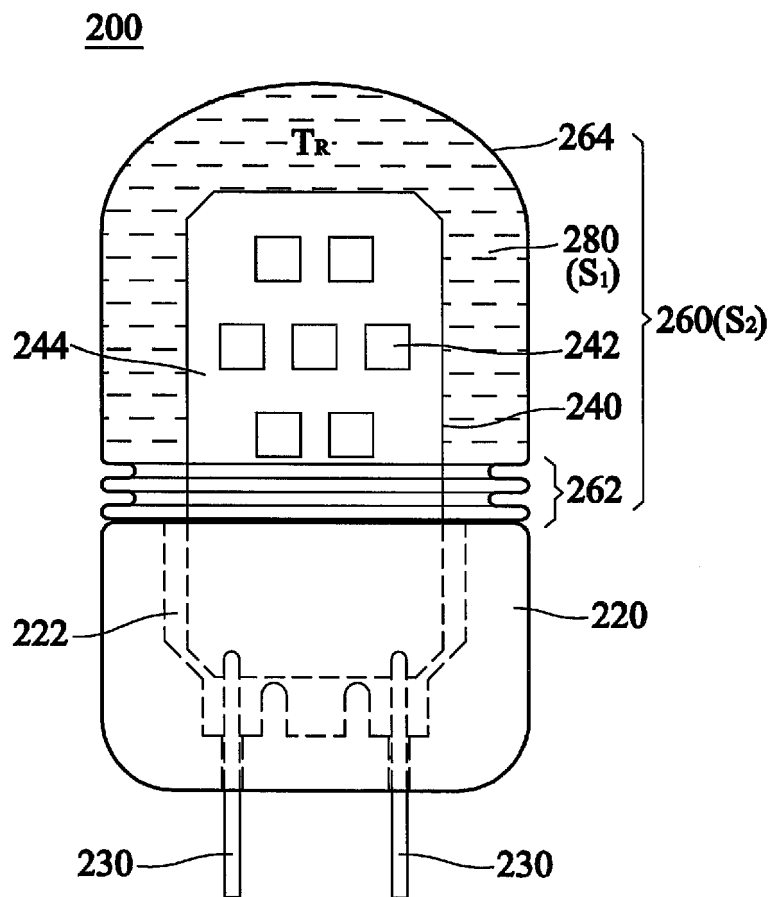


FIG.2A

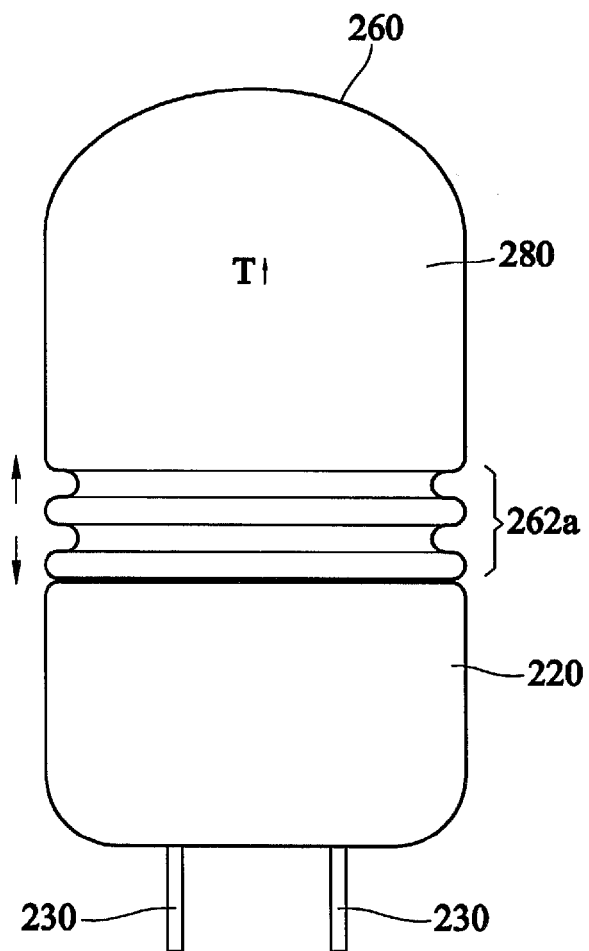


FIG. 2B

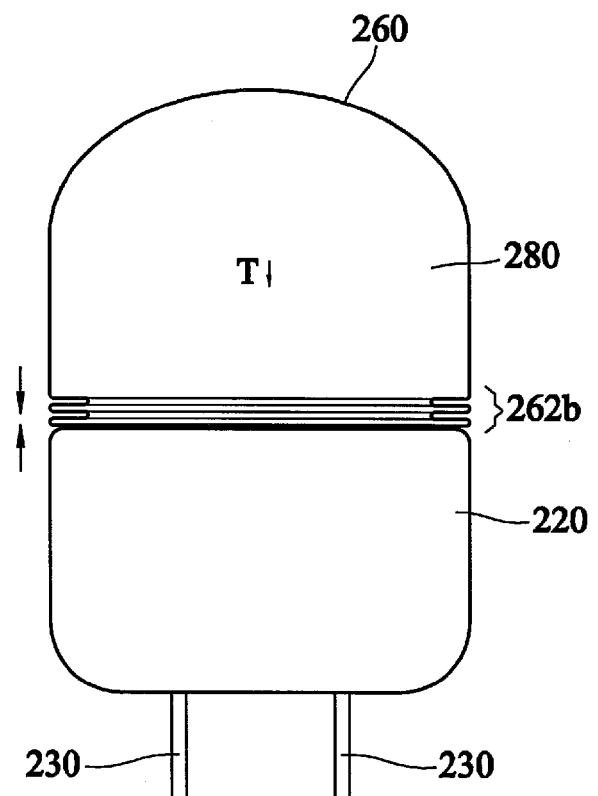


FIG. 2C

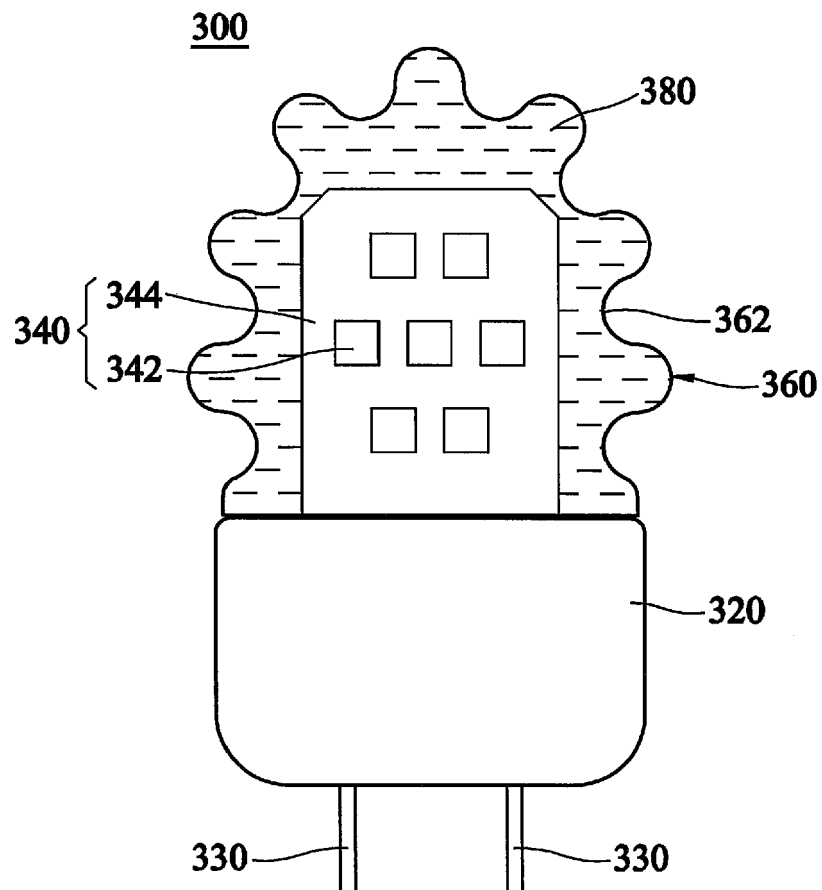


FIG.3A

300

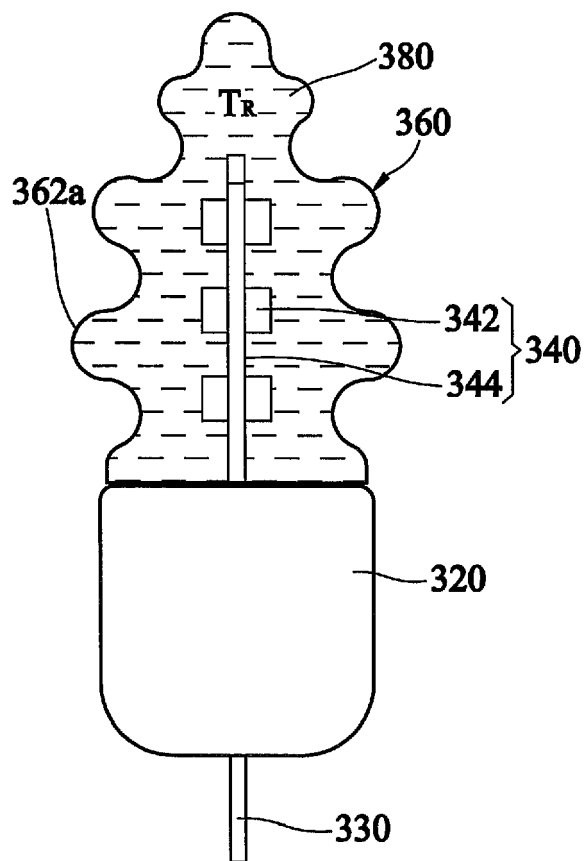


FIG. 3B

300

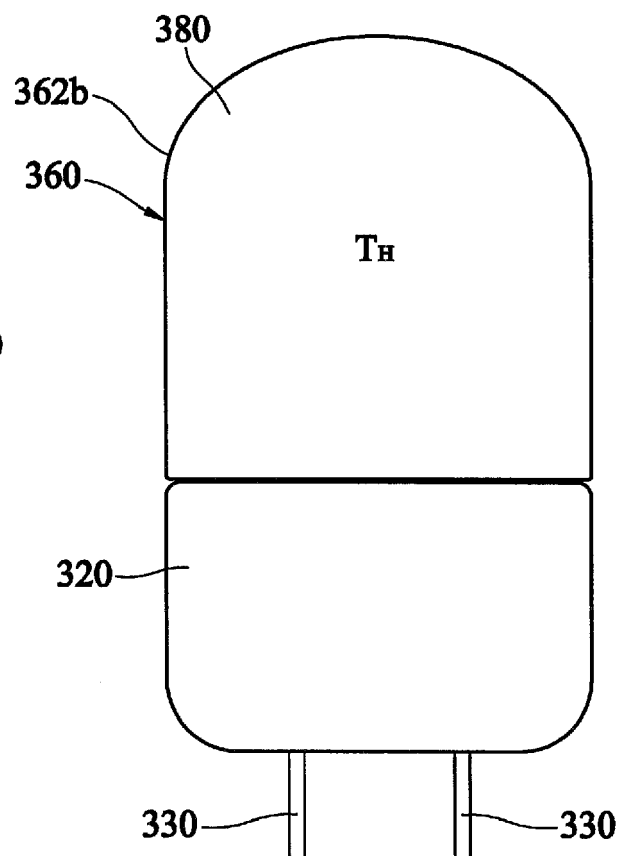


FIG. 3C

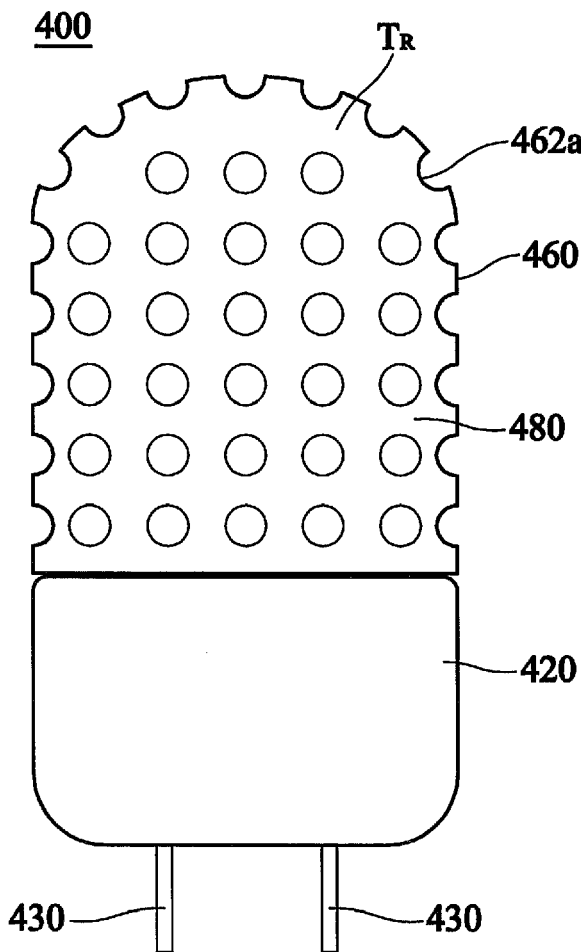


FIG. 4A

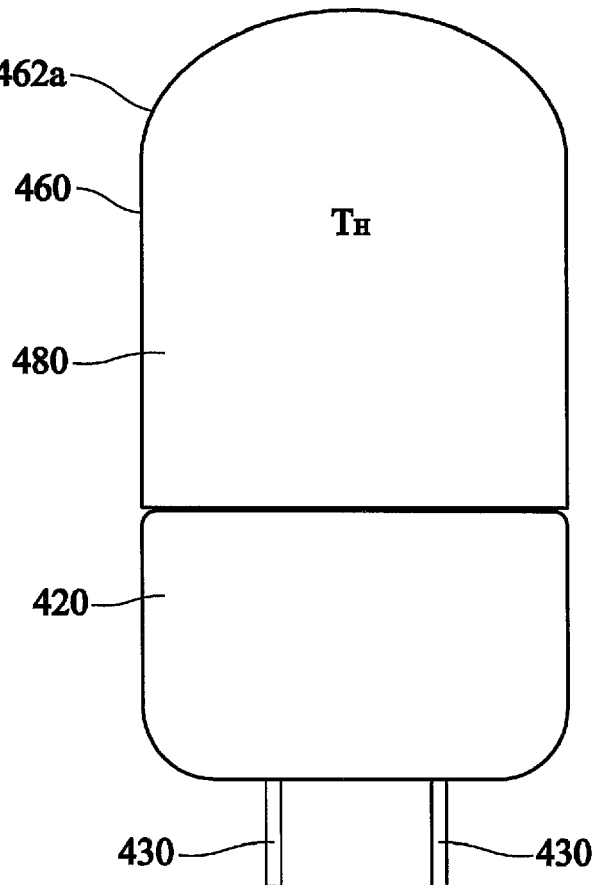


FIG. 4B

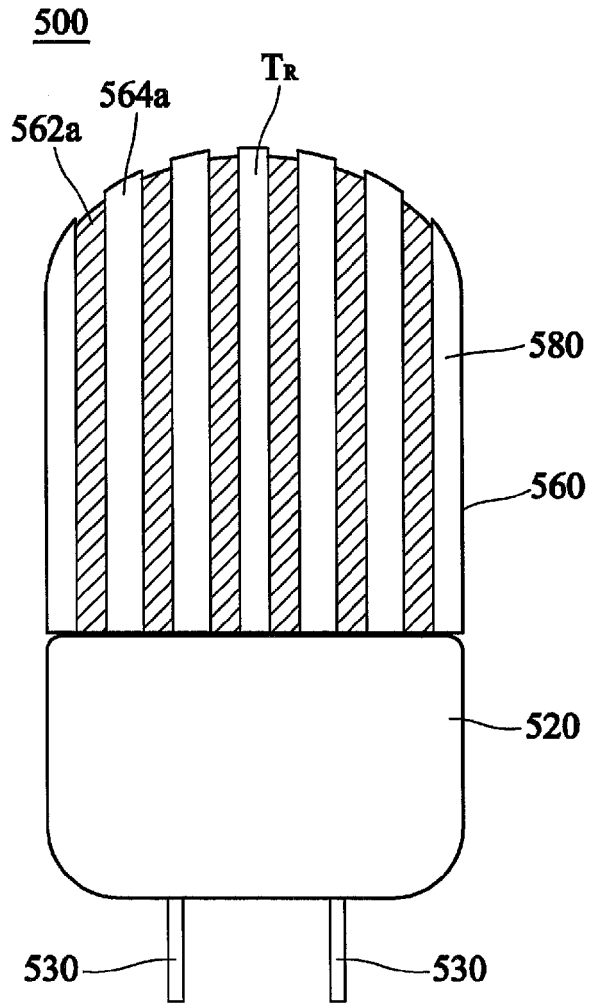


FIG. 5A

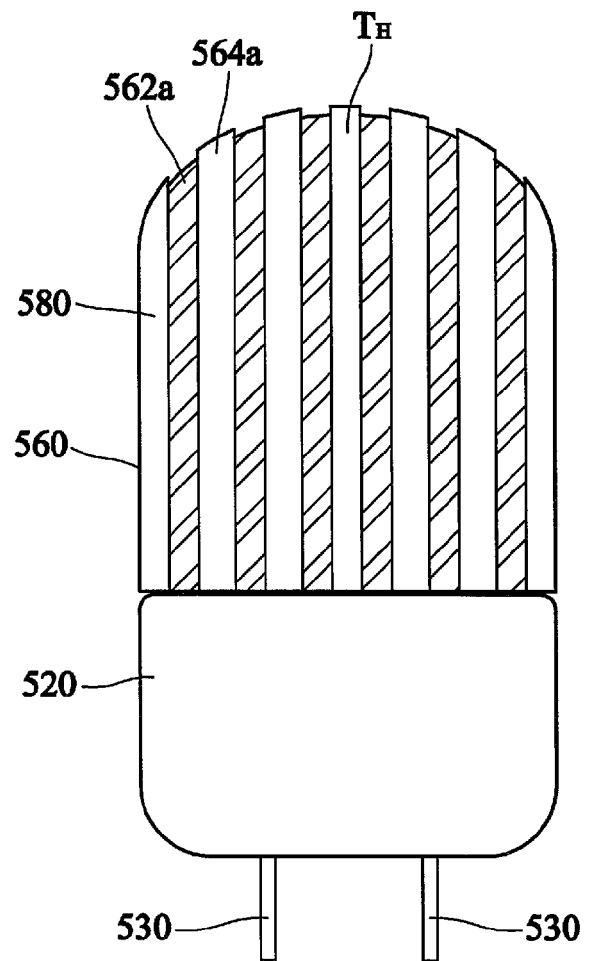


FIG. 5B

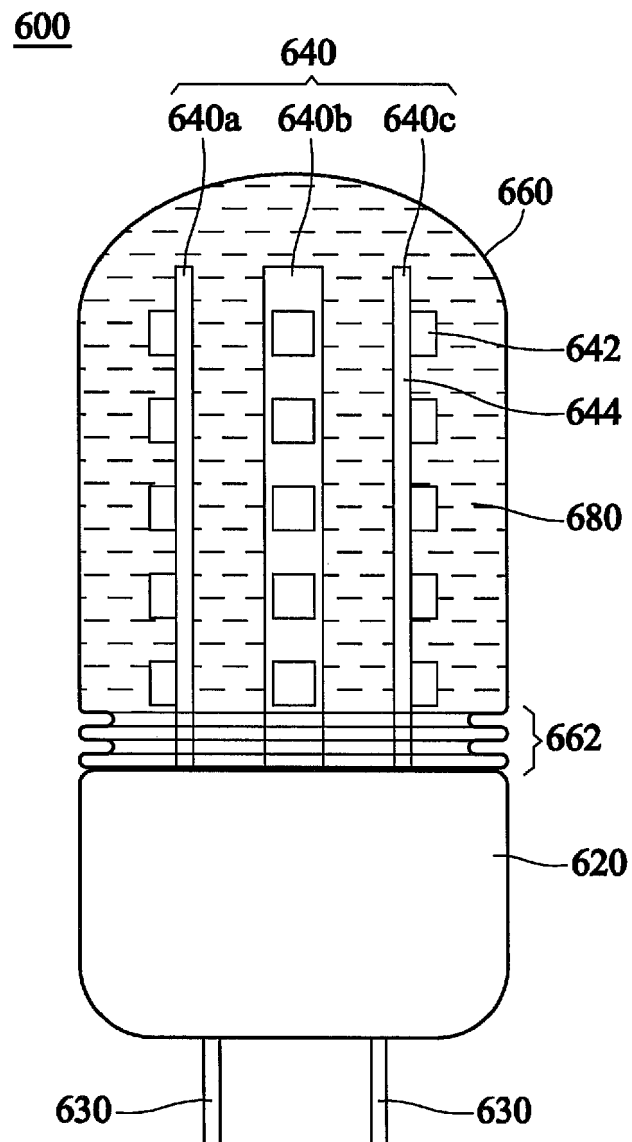


FIG.6

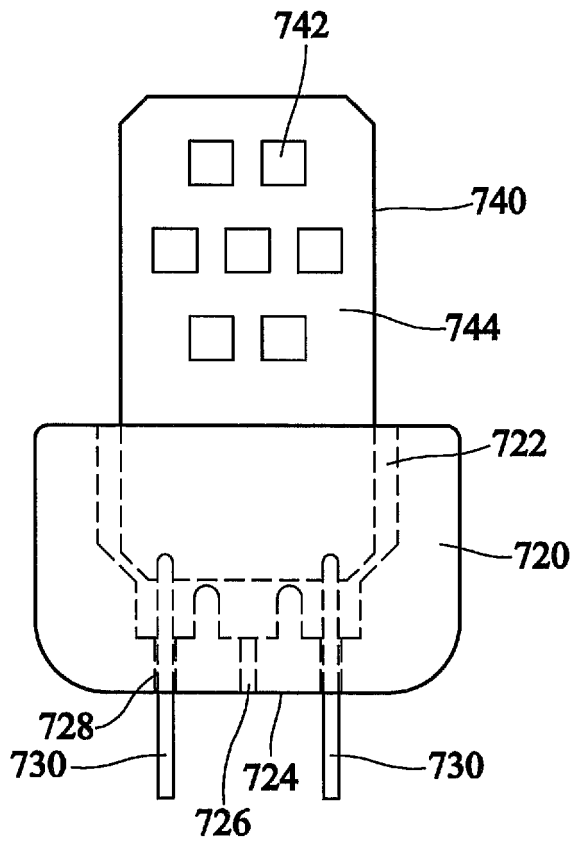


FIG. 7A

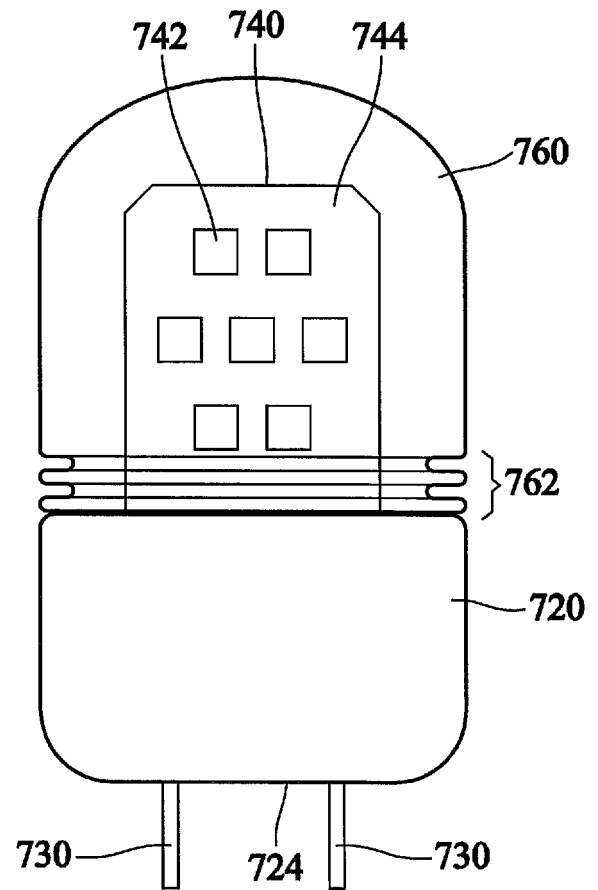


FIG. 7B

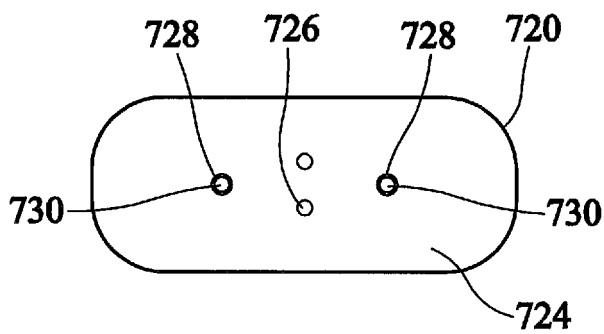


FIG. 7C

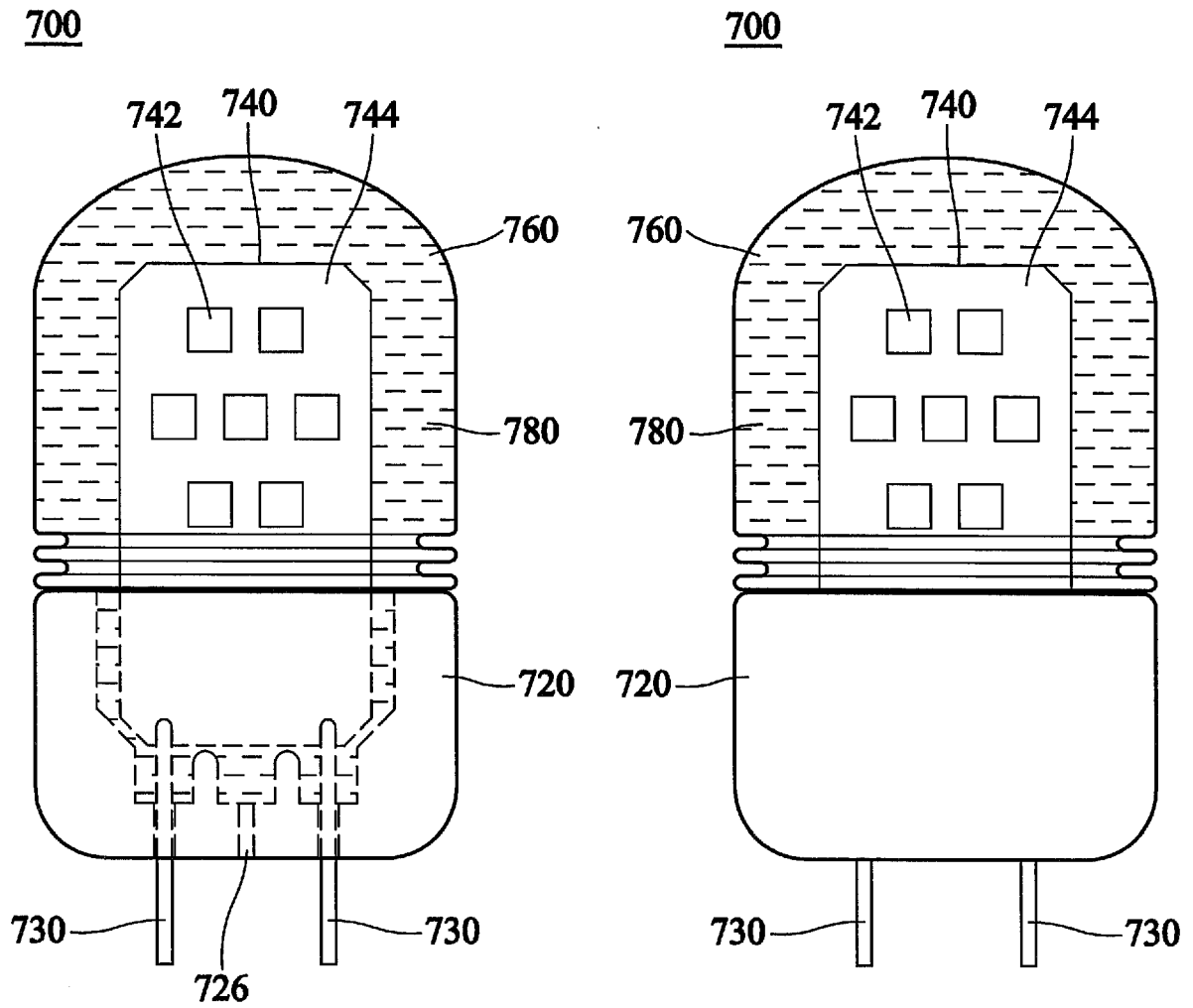


FIG. 7D

FIG. 7E



EUROPEAN SEARCH REPORT

Application Number
EP 15 19 9597

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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	US 2015/028370 A1 (YONG LIG YI [MY] ET AL) 29 January 2015 (2015-01-29) * figures 1, 4A-5 * * paragraph [0021] - paragraph [0026] * * paragraph [0042] - paragraph [0051] *	1-12	INV. F21K99/00 F21V3/02 F21V3/04 F21V29/56
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