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(54) LED lighting device for street light

(57) In one embodiment, an LED lighting device for street light includes a metal substrate (1); a circuit board (2) mounted on the substrate (1); a plurality of integral reflection members (5) arranged in rows mounted on the circuit board (2); a plurality of lamp units (3) mounted on the circuit board (2); a heat conduction plate (4) mounted under the substrate (1); and a transparent globe (6) having a substantially corrugated inner surface. The lamp unit (3) includes a cup (31), a reflection layer (35) coated on a bottom of the cup (31), and an LED chip (32) mounted on the bottom of the cup (31). The reflection member (5) is of cup-shaped and includes a bottom hole (523) for mounting the lamp unit (3) thereat. A peak (522) is formed at a joining point of four adjacent reflection members (5).

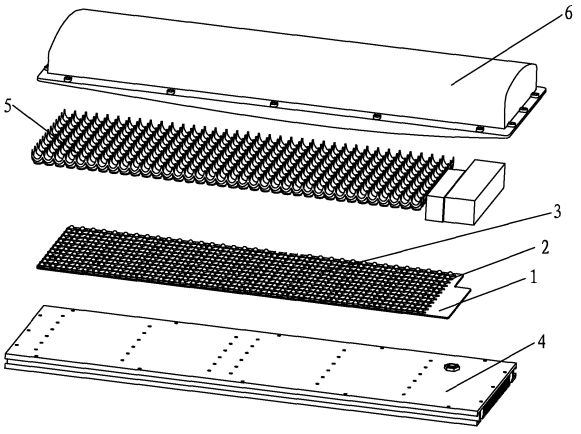

Fig. 1

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Description

1. Field of Invention

[0001] The invention relates to LED (light-emitting diode) lighting devices and more particularly to a small power LED lighting device having a high luminance so as to be ideal for street light applications.

2. Description of Related Art

[0002] Illumination in streets has typically been provided exclusively by incandescent lamps, mercury lamps, and fluorescent lamps. Typically, such street lights have a power in the range of 250W and 400W in order to illuminate an enlarged range in the street. However, their power consumption is great and this is not acceptable in view of energy saving.

[0003] The utilization of LEDs, which consume much less electric power, has been studied as a means of saving energy. It is typical of arranging tens or even hundreds of LED elements in row(s) as a light source for street light. This is because LEDs have strong directivity (i.e., being a point light source) and the glaring quality of their light.

[0004] Conventional LEDs are low power LEDs. The trend is to develop high power LEDs. However, temperature may rise significantly within the lamp body of the street light if high power LEDs are used as light source. And in turn, high temperature can reduce illumination and shorten a useful life of LEDs.

[0005] A high power and high luminance LED lighting device is disclosed in Chinese Utility Model Patent No. CN1807971A in which a cooling fan and a bowl-shaped structure for reflection on LED units are described.

[0006] However, the patent suffered from several disadvantages. For example, the provision of fan can increase the manufacturing cost greatly. This is not desired in the competitive market of the industry. Further, high power LEDs mean high power consumption. This contradicts the trend of energy saving. Furthermore, an illuminance distribution is not uniform due to poor arrangement of LED arrays. Thus, a need for improvement exists.

SUMMARY OF THE INTENTION

[0007] It is therefore one object of the invention to provide an LED lighting device for street light, the LED lighting device consuming a small power, being capable of illuminating an enlarged range, and having a uniform illuminance distribution so as to be ideal for street light applications.

[0008] The above and other objects, features and advantages of the invention will become apparent from the following detailed description taken with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is an exploded view of an LED lighting device according to the invention;

[0010] FIG. 2 is a top plan view of FIG. 1;

[0011] FIG. 3 is a sectional view taken along line C-C of FIG. 2;

[0012] FIG. 4 is a sectional view taken along line B-B of FIG. 2;

[0013] FIG. 5 is a sectional view of the cup of the lamp unit;

[0014] FIG. 6 is a sectional view of the lamp unit according to a first preferred embodiment of the invention;

[0015] FIG. 7 is a sectional view of the lamp units and the reflection members for showing light direction when the LED lighting device is turned on;

[0016] FIG. 8 is a perspective view of a portion of the reflection members;

[0017] FIG. 9 is a perspective view of the globe viewed from inside;

[0018] FIG. 10 is a sectional view of the globe;

[0019] FIG. 11 is a detailed view of the area in a closed loop in FIG. 10;

[0020] FIG. 12 is a sectional view of the lamp unit according to a second preferred embodiment of the invention;

[0021] FIG. 13 is an enlarged view of the projection of FIG. 12;

[0022] FIG. 14 is a sectional view of the lamp unit according to a third preferred embodiment of the invention;

[0023] FIG. 15 is a detailed view of the area in closed loop D in FIG. 14;

[0024] FIG. 16 is a top plan view of FIG. 14;

[0025] FIG. 17 is a view similar to FIG. 14 where an LED chip is formed in the cup;

[0026] FIG. 18 is a detailed view of the area in closed loop F in FIG. 17;

[0027] FIG. 19 is a perspective view of two LED lighting devices, brackets, and a support arm which is fixedly secured to the pole of a street light; and

[0028] FIG. 20 is a side elevation of the street light incorporating the LED lighting devices of the invention as a light source.

[0029] FIG. 21 is a sectional view taken along line C-C of FIG.4

[0030] FIG. 22 is a sectional view of the heat pipe of the heat conduction plate of the invention.

[0031] FIG. 23 is another sectional view of the heat pipe of the heat conduction plate of the invention.

DETAILED DESCRIPTION OF THE INTENTION

[0032] Referring to FIGS. 1 to 8, an LED lighting device for street light in accordance with a preferred embodiment of the invention is shown. The LED lighting device comprises a rectangular metal plate 1, a circuit board 2 formed on the plate 1, a plurality of reflection members 5 arranged in connected rows and columns mounted above the circuit board 2, a plurality of lamp units 3 securely provided on the circuit board 2 and under holes 523 of the reflection members 5, a heat conduction plate 4 provided under the plate 1, and a colorless, transparent globe 6 threadedly secured to the heat conduction plate 4 for housing the components 1, 2, 3, and 5. Each component is discussed in detail below.

[0033] The lamp units 3 are electrically connected to the circuit board 2. An insulation member (not shown) is provided between the plate 1 and the circuit board 2. The plate 1 and the heat conduction plate 4 are threadedly secured together. The lamp unit 3 comprises a metal cup (e.g., formed of copper) 39 formed on the plate 1. Heat generated by the lamp units 3 are conducted through the cups 39, the plate 1, and the heat conduction plate 4 prior to exiting to the air for removal.

[0034] The lamp units 3 are arranged in a plurality of rows and columns. A distance between any two adjacent lamp units 3 is equal to that between any two adjacent reflection units 51 of the reflection members 5. The number of the lamp units 3 is equal to that of the reflection members 5. The lamp unit 3 is fastened in the hole 523 of the bowl 52. The plate 1 and the reflection units 51 are threadedly secured together.

[0035] Referring to FIGS. 5 and 6 specifically, the lamp unit 3 comprises a metal seat 39 having a truncated conic cavity (not numbered) on a top formed as a cup 31, an LED chip 32 provided on a bottom of the cavity under a top of the cup 31, a reflection layer 35 coated on an area on a bottom of the cup 31 with the LED chip 32 secured onto the reflection layer 35, an adhesive layer 36 coated around the LED chip 32, and a mixture of adhesive and phosphorus powder 37 formed on the adhesive layer 36.

[0036] The seat 39 is secured by a support member 310. A globe-shaped lamp casing 33 is further secured onto the support member 310 for housing components of the lamp unit 3 described in the previous paragraph. An inert gas 34 is filled in a space defined in the lamp casing 33. Two leg members 311 each is extended through the support member 310 into the space filled with inert gas 34.

[0037] Preferably, the lamp casing 33 is formed of quartz or any other transparent materials. Preferably, the inert gas is nitrogen. Preferably, the reflection layer 35 is formed of a material selected from indium, aluminum, or copper in which indium is preferred.

[0038] Reflectivity of the reflection layer 35 is very high. Light emitted by the LED chip 32 is directed. With the provision of the reflection layer 35, illumination efficiency of the LED chip 32 is greatly increased.

[0039] The adhesive layer 36 can be a layer formed of PU (polyurethane), silver, insulative material, epoxy resin, or silicon in which PU is preferred.

[0040] Thickness of each of the adhesive layer 36 and the mixture of adhesive and phosphorus powder 37 is from about 0.05mm to about 0.2mm. Bottom of the LED chip 32 is secured to the cup 31 by the adhesive layer 36. Hence, the heat dissipation capability of the LED lighting device of the invention is greatly improved. Further, light attenuation of the LED chip 32 is greatly decreased. As a result, illumination is increased significantly. Moreover, the cup 31 has an excellent heat conduction capability, resulting in a quick removal of heat from the LED chips 32.

[0041] Referring to FIG. 7 specifically, the reflection member 5 comprises the reflection units 51 each having four bowls 52 formed together as a square, each bowl 52 having a concave surface 521. The lamp unit 3 is provided in a center of the bowl 52. A curved line is formed between any two adjacent bowls 52 with a peak 522 formed at a joining point of four curved lines.

[0042] Portions of light emitted by the lamp unit 3 directly passes through a top opening of the bowl 52 as indicated by arrows 532. Remaining portions of light are reflected by the concave surface 521 (as indicated by arrows 531) to focus on the peak 522 prior to emitting to the external as indicated by arrows 533. Hence, the peak 522 has the highest luminance.

[0043] The hole 523 on a center of the bowl 52 has a diameter slightly larger than that of the lamp casing 33 so as to allow the lamp casing 33 to insert and fasten therein. A top of the lamp casing 33 is under an opening of the bowl 52. A maximum illumination can be obtained by disposing the top of the lamp casing 33 under the opening of the bowl 52 by an optimum distance. Preferably, the concave surface 521 of the bowl 52 is plated with a reflective material such as silver or chromium. Size of the bowl 52 can be an optimum (i.e., portions of light are focused on the peak 522 prior to emitting to the external) based on LED chip type and optical properties.

[0044] Referring to FIG. 8 specifically, shapes of the bowls 52 are shown clearly.

[0045] Referring to FIGS. 9 to 11, the globe 6 comprises a rectangular bottom 61 having a concave inner surface, and a peripheral frame 62 having a corrugated inner surface. A plurality of longitudinal parallel members 63 are formed

on the inner surface of the bottom 61. Each member 63 comprises a central recess 64 and two toothed sections 63 on both sides. Each member 63 is disposed corresponding to a row of lamp units 3 and a row of reflection members 5.

[0046] An angle A of the recess 64 is from about 112° to about 120° (preferably, it is 117°). The number of the teeth of the toothed section 63 is about 9 or (preferably 10)

[0047] . An angle B of the tooth of the toothed section 63 is decreased from about 56° in the center to about 38° at the side. A pitch between two adjacent teeth is from 0.5mm to (preferably, about 0.6mm).

[0048] Referring to FIGS. 12 and 13, a lamp unit 3 according to a second preferred embodiment of the invention is shown. The lamp casing 33 is spherical with the cup 31 concealed therein. A cylindrical projection 313 is extended inward from a top of the lamp casing 33 to form an enlarged lower spherical surface 314 proximate the cup 31. A reflection layer is coated on the projection 313. Light emitted by the LED chip 32 travels to the surface of the projection 313 next either reflects out of the cup 31 directly or reflects between the surface of the projection 313 and the inner surface of the cup 31 for a number of times prior to leaving the cup 31.

[0049] Referring to FIGS. 14 to 18, a lamp unit 3 according to a third preferred embodiment of the invention is shown. A truncated cone 316 is formed on a bottom the cup 31. A plurality of concentric stages 317 are formed on an inner surface of the cone 316. A mixture of adhesive and phosphorus powder 315 is formed on a bottom of the cup 31 below the LED chip 32.

[0050] Alternatively, the cone 316 may have a shape of truncated pyramid other than above. Light emitted from a bottom of the LED chip 32 is reflected one or more times by the stages 317 and the mixture of adhesive and phosphorus powder 315 prior to leaving the cup 31.

[0051] Referring to FIGS. 19 and 20, each of two LED lighting devices of the invention is fastened by two brackets 7 which are in turn fixedly secured to a support arm 8 between the LED lighting devices. The support arm 8 is again fixedly secured to the pole of a street light.

[0052] FIGS. 21 to 23 are the sectional views of the heat conduction plate with heat pipe. Heat pipe is installed in heat conduction plate. Liquid with high conductivity may be filled in the heat pipe. A heat exchange device could be installed to connect with heat pipe outside street light. The heat exchange device could be heat pump, heatsink, water cooling radiator, air cooling radiator. Through the heat pipe installed on heat conduction plate and connected with outside environment for heat exchange, the heat of heat conduction plate could be conducted rapidly. Temperature of the heat conduction plate could be lowered down rapidly and then the temperature of LED could be rapidly lowered down.

[0053] Preferably, the specifications of the LED chips of the invention complies with light source of ϕ5.

[0054] The follow two tables are created based on a street light having a height of eight (8) meters and LED lighting devices in which the recess of the globe of the LED lighting device has an angle of 117°, the number of the teeth of the toothed section is 10, a pitch between two adjacent teeth is 0.55mm, and an angle of the tooth of the toothed section is decreased from 56° in the center to 38° at the side.

[0055]

Table 1

Light source	LED(ϕ5)
Number of LED chips	432
Luminous intensity of LED	2500-3500 mcd
Height of street light	8 m
Illuminance flux	2160 lm
Illuminance at center	50 lx
Total efficiency	≧85%
Power	25W
Uniformity	> 0.4
Light beam efficiency	≧80%
LED voltage	3.2V
LED current	0.018A

[0056]

Table 2

Serial number	1
Height of street light	8 m
Power	50W
Average illuminance	30 lx
Illuminance at a center of two street lights spaced 30m apart	5.6 lx

[0057] It is found that a street light of small power, high luminance, and uniform illuminance distribution can be obtained by incorporating the LED lighting device of the invention as light source.

[0058] While the invention herein disclosed has been described by means of specific embodiments, numerous modifications and variations could be made thereto by those skilled in the art without departing from the scope and spirit of the invention set forth in the claims.

Claims

1. An LED (light-emitting diode) lighting device mountable in a street light comprising: a metal substrate (1); a circuit board (2) mounted on the substrate (1); a plurality of integral reflection members (5) arranged in rows mounted on the circuit board (2); a plurality of lamp units (3) mounted on the circuit board (2); a heat conduction plate (4) mounted under the substrate (1); and a transparent globe (6) releasably secured to the heat conduction plate (4) for housing the substrate (1), the circuit board (2), the reflection members (5), and the lamp units (3), **characterized in that:** the reflection member (5) is of cup-shaped and comprises a bottom hole (523) for mounting the lamp unit (3) thereat; a peak (522) is formed at a joining point of four adjacent reflection members (5).

2. The LED lighting device of claim 1, **characterized in that** the lamp unit (3) comprises a cup (31), a reflection layer (35) coated on a bottom of the cup (31), an LED chip (32) mounted on the bottom of the cup (31), an adhesive layer (36) coated around the LED chip (32), a mixture of adhesive and phosphorus powder (37) formed on the adhesive layer (36), and a globe-shaped lamp casing (33) for sealingly housing the cup (31);

3. The LED lighting device of claim 1, **characterized in that** the lamp cup of LED lamp unit constitutes a lamp cover. The lamp cover is in form of an arc and surrounds the lamp cup.

4. The LED lighting device of claim 3, **characterized in that** in the middle of lamp cover exists a pillar object extending to lamp cup. The end of the pillar object close to the bottom of lamp cup is in form of arc.

5. The LED lighting device of claim 1, **characterized in that** the LED lamp unit includes the lamp cup formed on the metal cup base. LED chipset is installed on the bottom of lamp cup. Reflection layer is coated on the bottom of lamp cup and around the lamp cup. Taper objects are allocated on the bottom of lamp cup base of LED lamp unit. On the bottom of lamp cup, under the LED chipset, a layer of mixture of adhesive and phosphorus powder is coated.

6. The LED lighting device of claim 1, **characterized in that** a circuit board is installed on one side of metal substrate. LED lamp unit is set in the middle of reflection lamp cup and is connected to circuit board by connective line. LED lamp unit and reflection lamp cup are fastened on one side of metal substrate, on which there is no circuit board. Heat conduction plate is fastened on the other side of metal substrate. A cover is fastened on the heat conduction plate or metal substrate. LED lamp unit and reflection members are installed inside the cover. The above-mentioned reflection members includes plate. There are lamp cup with the same concavity on the plate. A reflection layer is coated on the concave side of lamp cup. A whole is installed in the bottom of the center of lamp cup. LED lamp is installed on the whole and in the center of lamp cup. The LED lamp unit includes the lamp cup formed on the metal cup base. LED chipset is installed on the bottom of lamp cup. Reflection layer is coated on the bottom of lamp cup and around the lamp cup. The lamp cup of LED lamp unit constitutes a lamp cover. The lamp cover is in form of an arc and surrounds the lamp cup. In the middle of lamp cover exists a pillar object extending to lamp cup. The end of the pillar object close to the bottom of lamp cup is in form of arc.

7. The LED lighting device of claim 1, **characterized in that** a circuit board is installed on one side of metal substrate. LED lamp unit is set in the middle of reflection lamp cup and is connected to circuit board by connective line. LED

lamp unit and reflection lamp cup are fastened on one side of metal substrate, on which there is no circuit board. Heat conduction plate is fastened on the other side of metal substrate. A cover is fastened on the heat conduction plate or metal substrate. LED lamp unit and reflection members are installed inside the cover. The above-mentioned reflection members includes plate. There are lamp cup with the same concavity on the plate. A reflection layer is coated on the concave side of lamp cup. A whole is installed in the bottom of the center of lamp cup. LED lamp is installed on the whole and in the center of lamp cup. The LED lamp unit includes the lamp cup formed on the metal cup base. LED chipset is installed on the bottom of lamp cup. Reflection layer is coated on the bottom of lamp cup and around the lamp cup. Taper objects are allocated on the bottom of lamp cup base of LED lamp unit. On the bottom of lamp cup, under the LED chipset, a layer of mixture of adhesive and phosphorus powder is coated.

8. The LED lighting device of claim 1, 6, 7, **characterized in that** an adhesive layer is coated on LED chipset. A mixture of of adhesive and phosphorus powder is coated on the said adhesive layer.

9. The LED lighting device of claim 1, 6, 7, **characterized in that** the said cover includes bottom side and around side. On the inner side of the bottom side, one or more than one light distribution surface are located with equal distance. A concave surface is formed in the middle of light distribution surface. On the both sides of the concave side, sawtooth sides are allocated symmetrically. Each light distribution surface has a line of LED lamp unit and reflection members, which are set in the middle of light distribution surface. There is corrugation formed on the around side of light distribution cover.

10. The LED lighting device of claim 9, **characterized in that** an angle of the recess (64) is from about 112° to about 120°; the number of the teeth of the toothed section (63) is 9 or 10; an angle of the tooth of the toothed section (63) is decreased from about 56° in the center to about 38° at the side; and a pitch between any two adjacent teeth of the toothed section (63) is from about 0.5mm to about 0.6mm.

11. The LED lighting device of claim 10, **characterized in that** the angle of the recess is 117°, the number of the teeth of the toothed section is 10, the pitch between any two adjacent teeth of the toothed section (63) is 0.55mm, and the angle of the tooth of the toothed section (63) is decreased from 56° in the center to 38° at the side.

12. The LED lighting device of claim 2, 6, 7, **characterized in that** a stand with legs is installed surrounding the metal cup base. The legs are welded in circuit board. The metal cup base is attached close to metal substrate.

13. The LED lighting device of claim 3, 6, 7, **characterized in that** a close lamp cover is formed outside the lamp cup and over the stand. Inert gas is filled inside the lamp cover.

14. The LED lighting device of claim 1, 6, 7, **characterized in that** heat conduction plate is fastened on the fastening stand via a fastener.

15. The LED lighting device of claim 8, **characterized in that** the thickness of each of the adhesive layer (36) and the mixture of adhesive and phosphorus powder (37) is from about 0.05mm to about 0.2mm.

16. The LED lighting device of claim 1, 6, 7, **characterized in that** heat pipe is installed on the heat conduction plate to connect with a heat exchanger outside the street light. Liquid with high conductivity could be filled in the heat pipe.

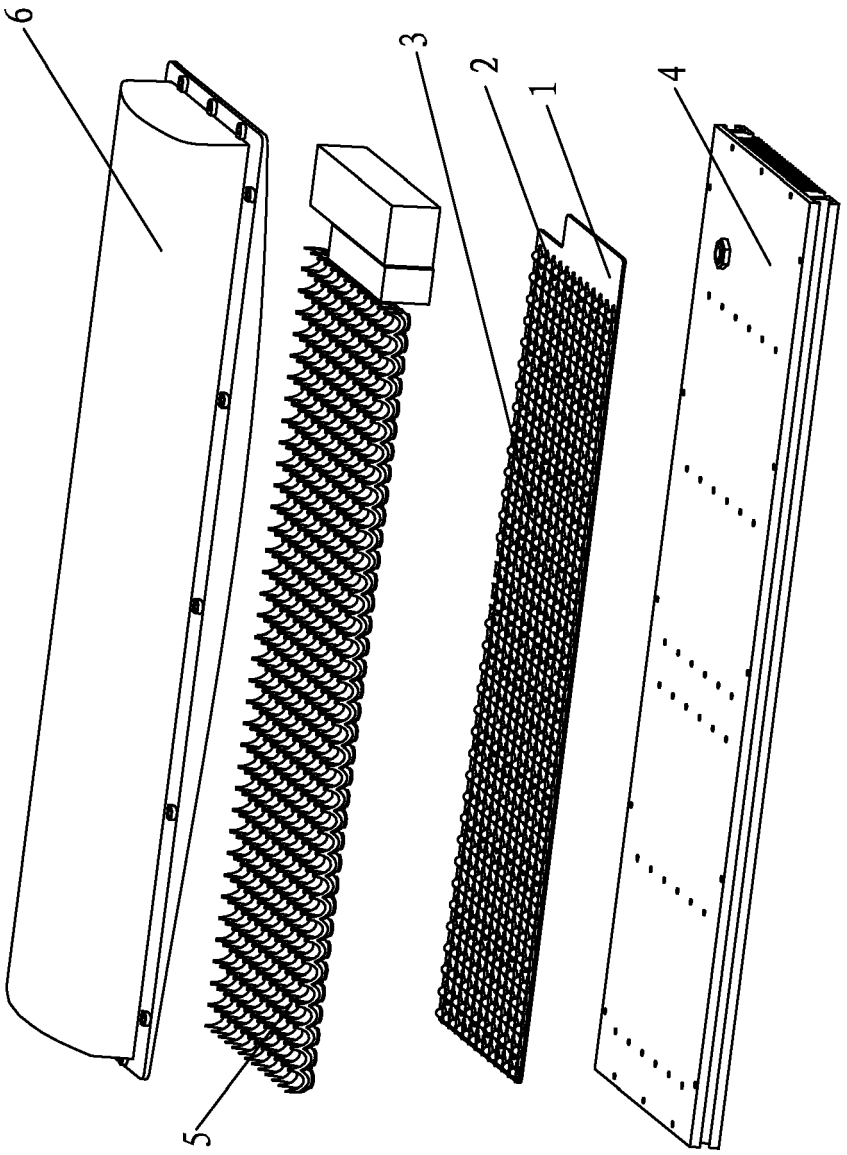

Fig. 1

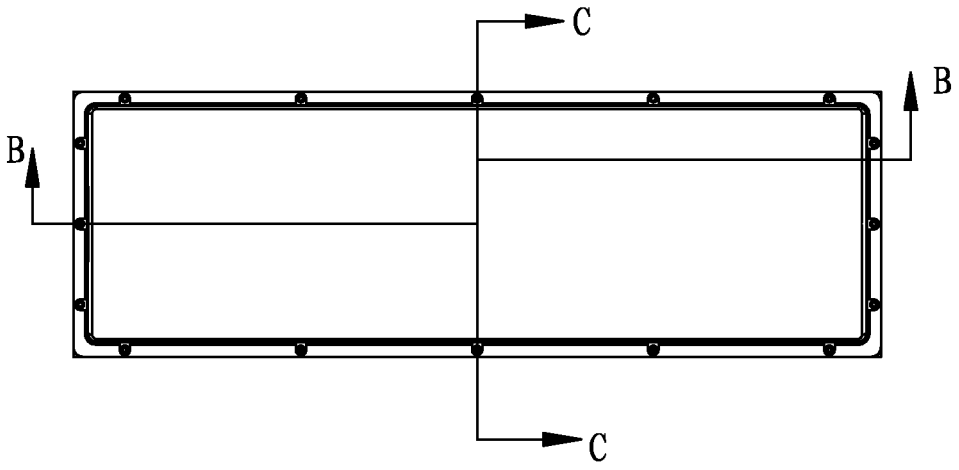

Fig. 2

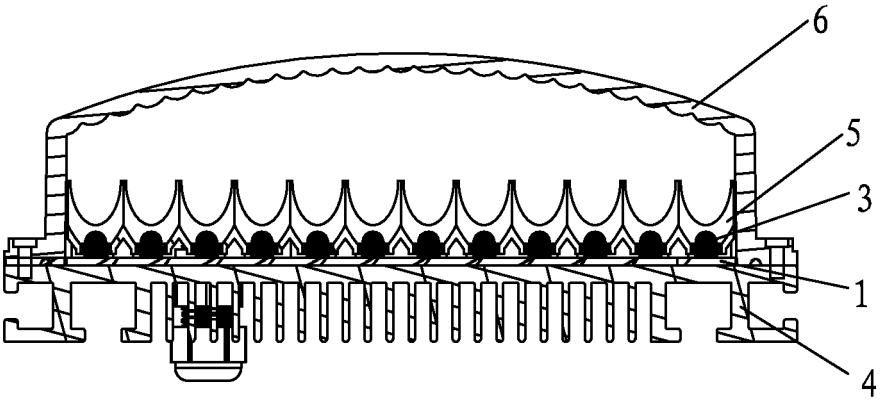

Fig. 3

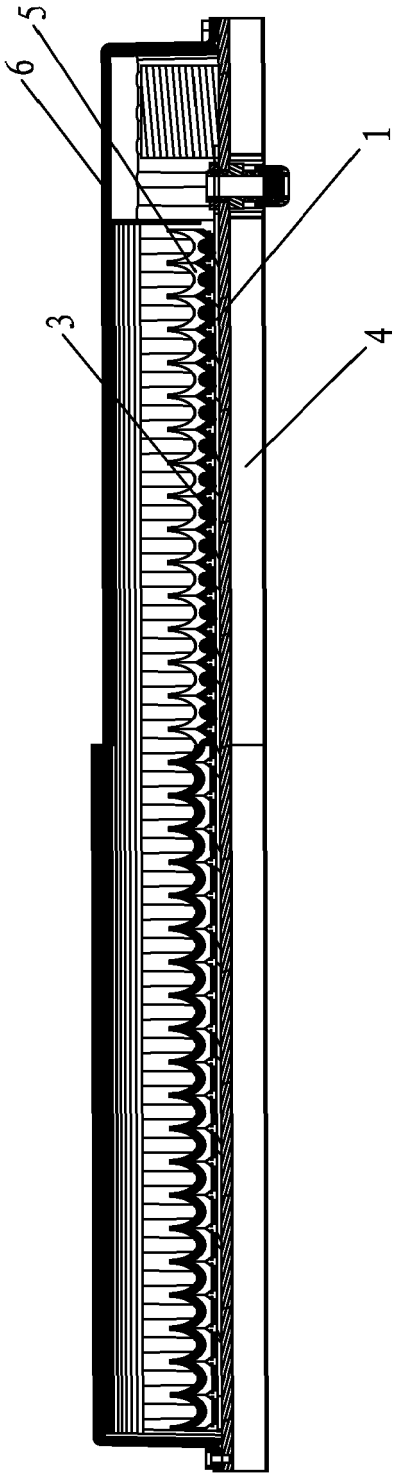

Fig. 4

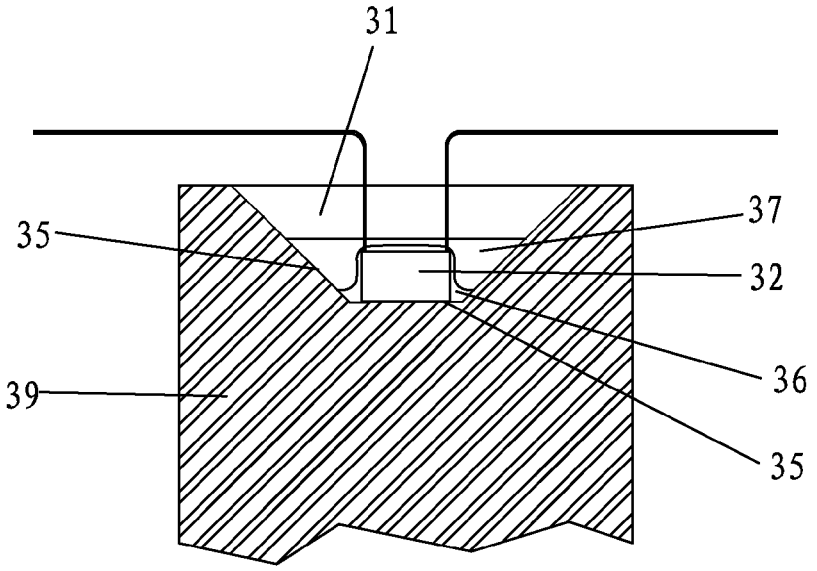

Fig. 5

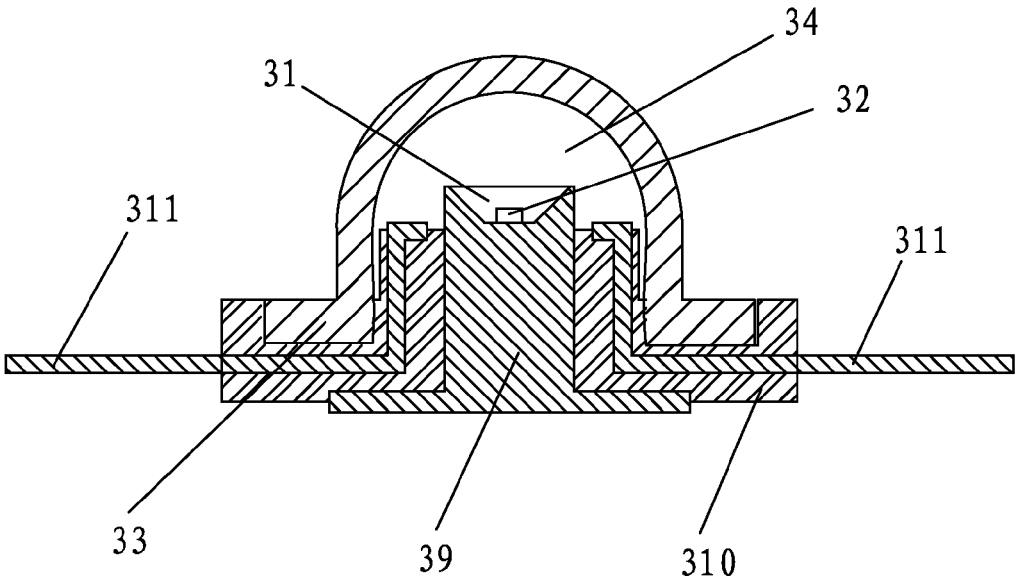

Fig. 6

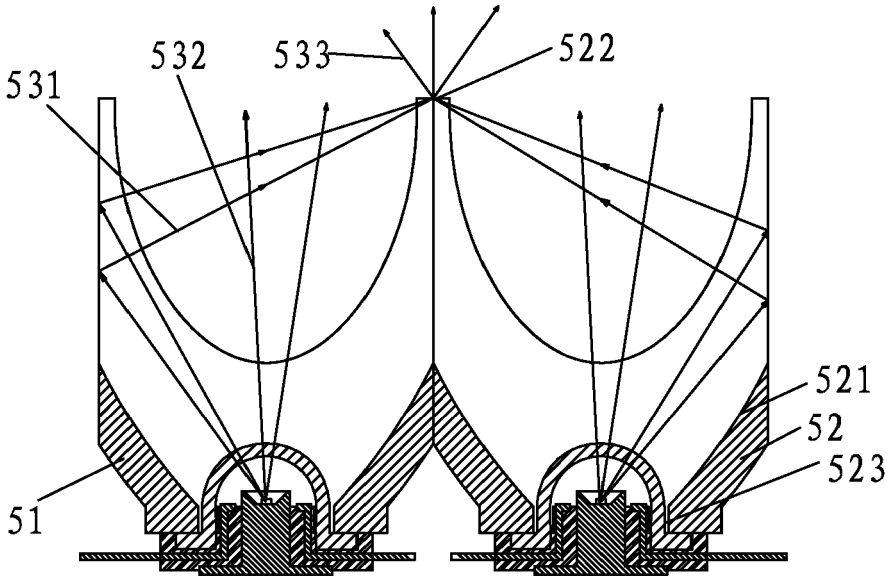

Fig. 7

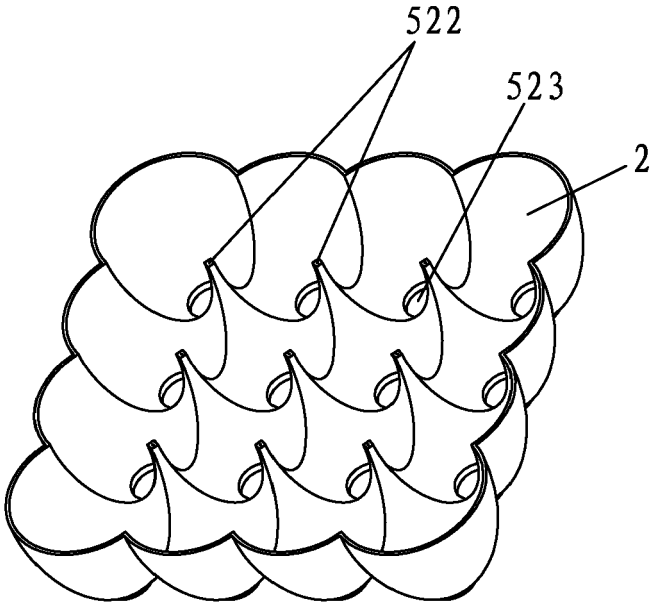

Fig. 8

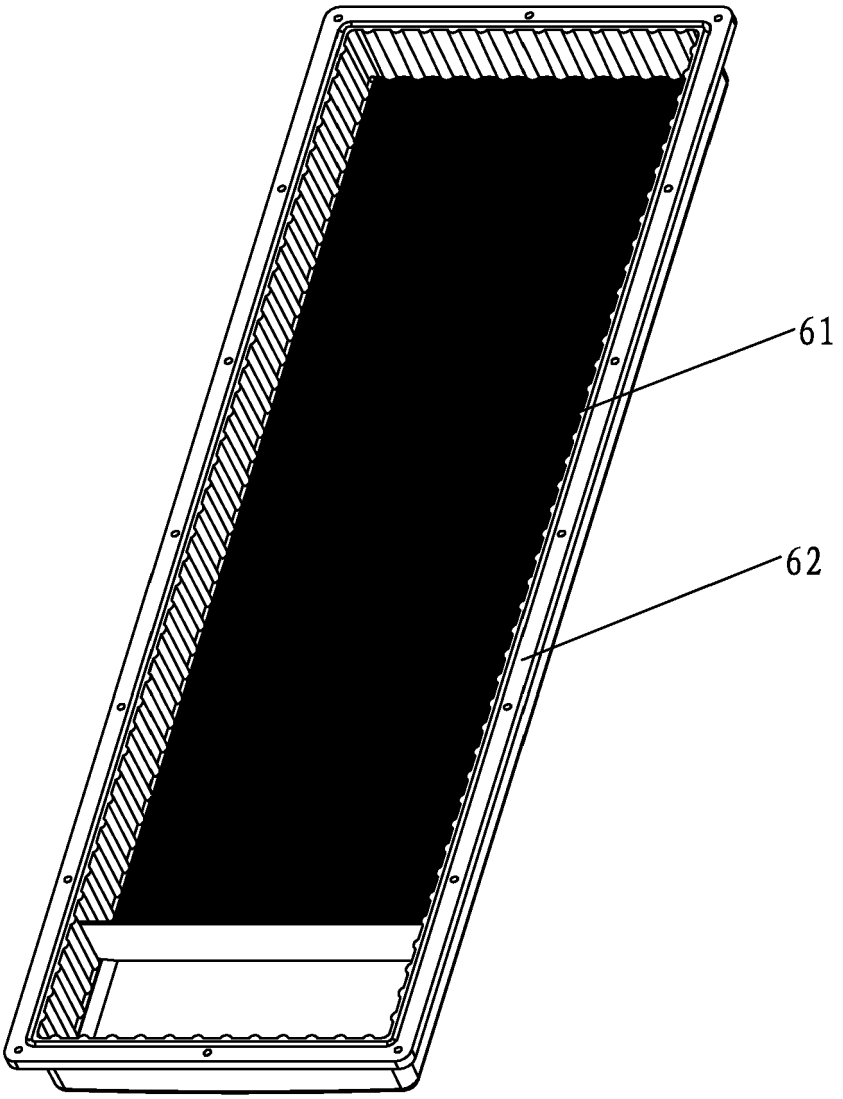

Fig. 9

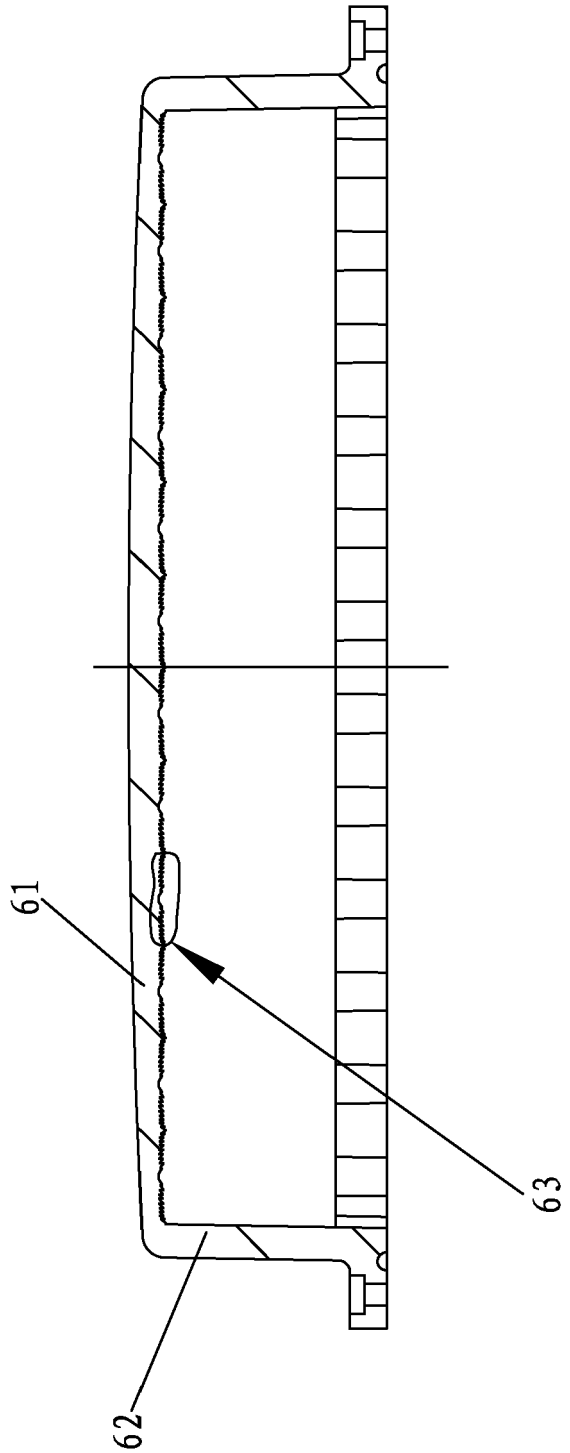

Fig. 10

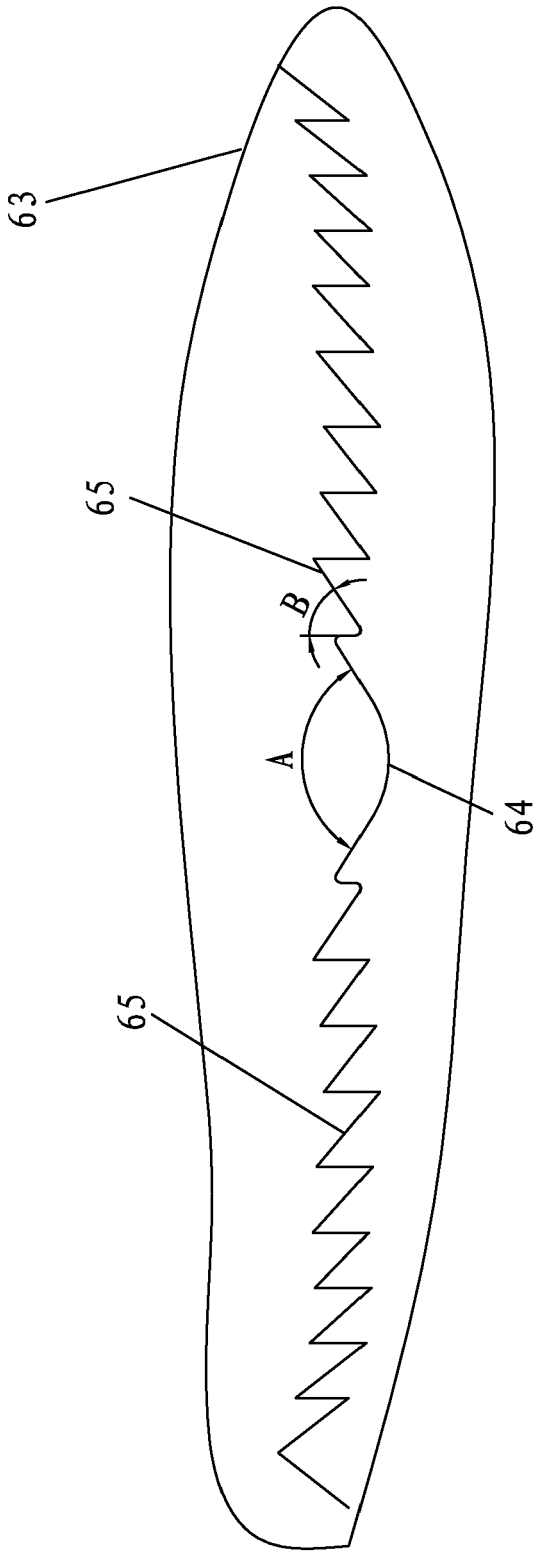

Fig. 11

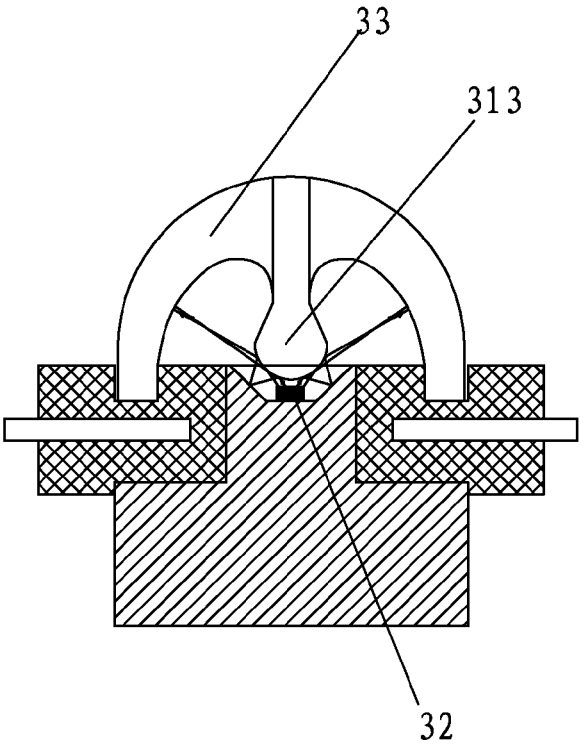

Fig. 12

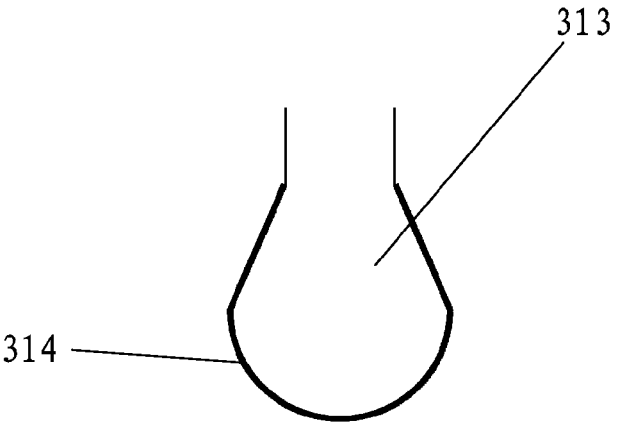

Fig. 13

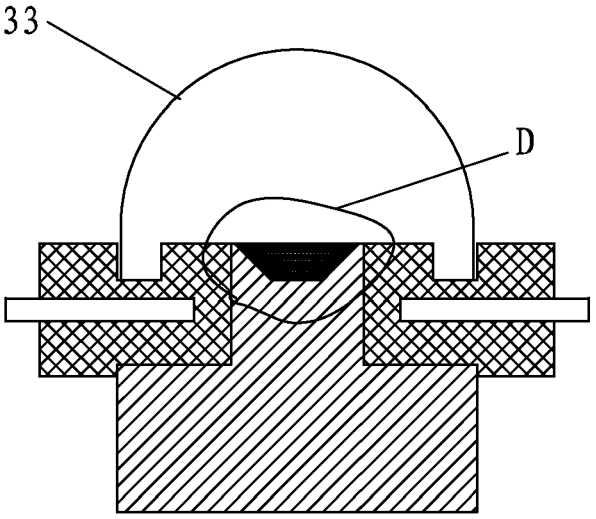

Fig. 14

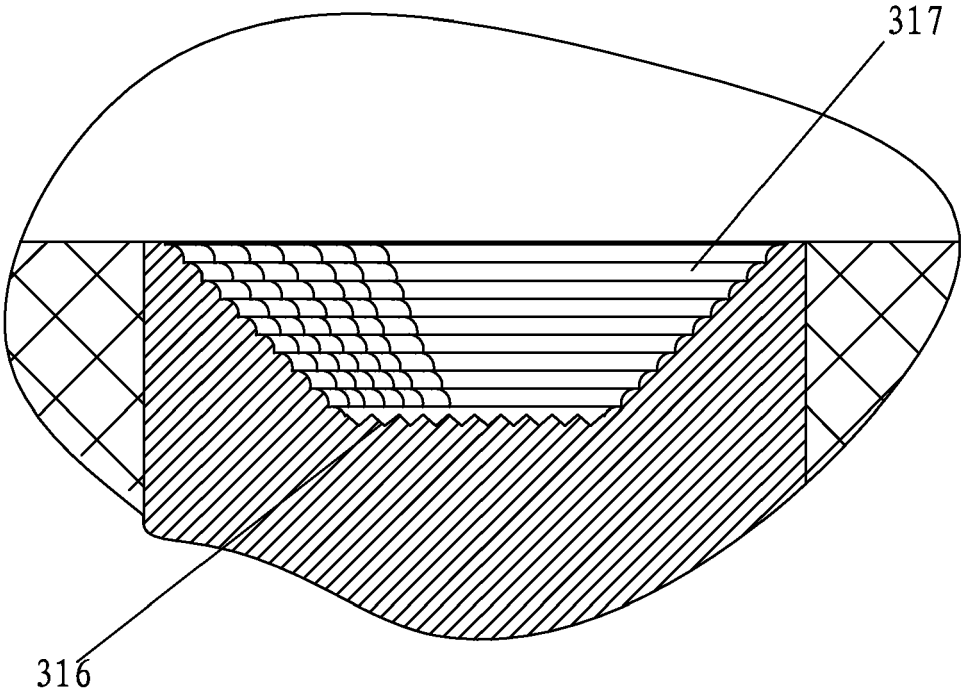

Fig. 15

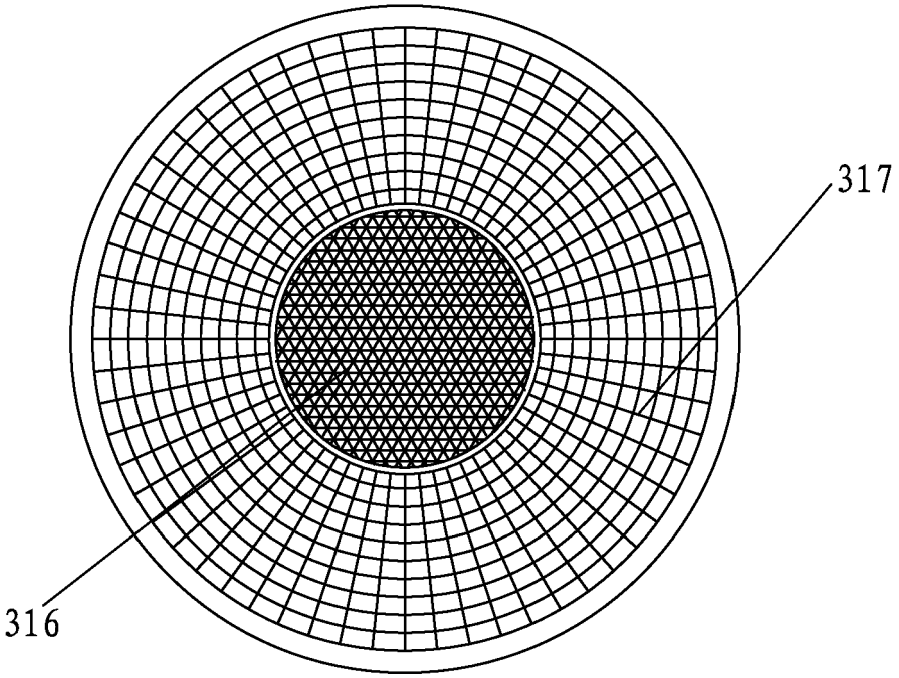

Fig. 16

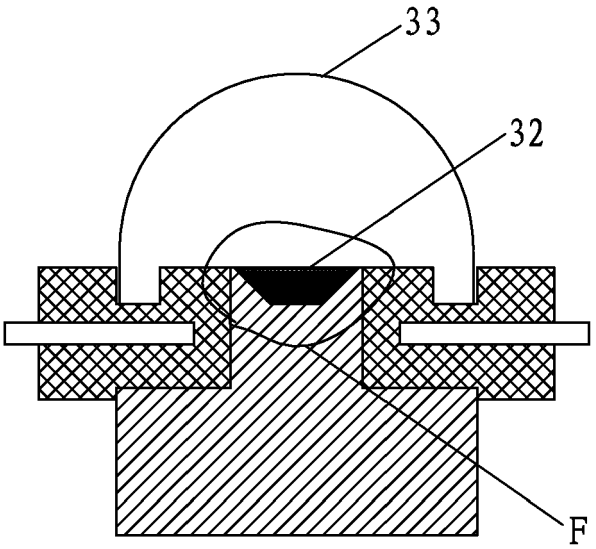

Fig. 17

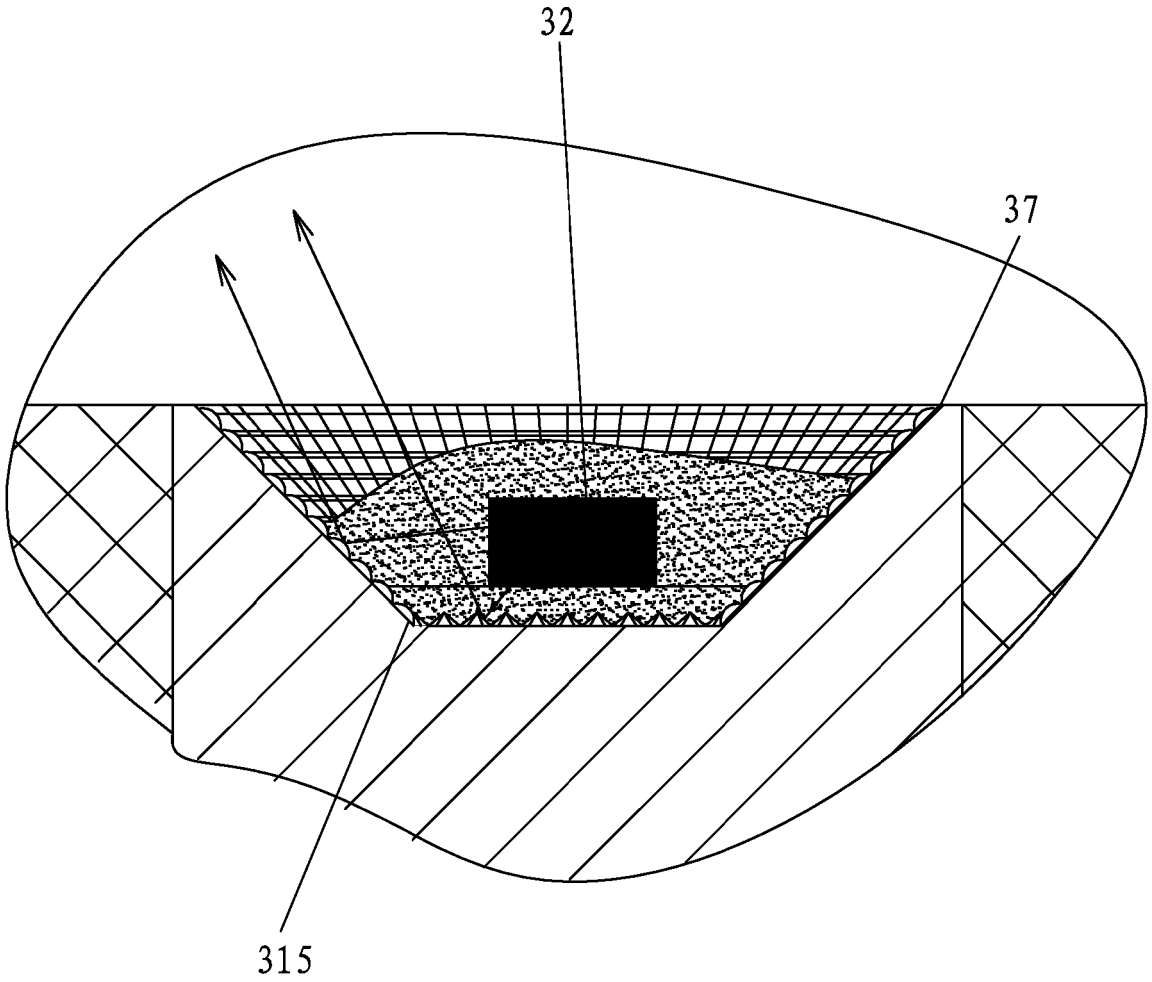

Fig. 18

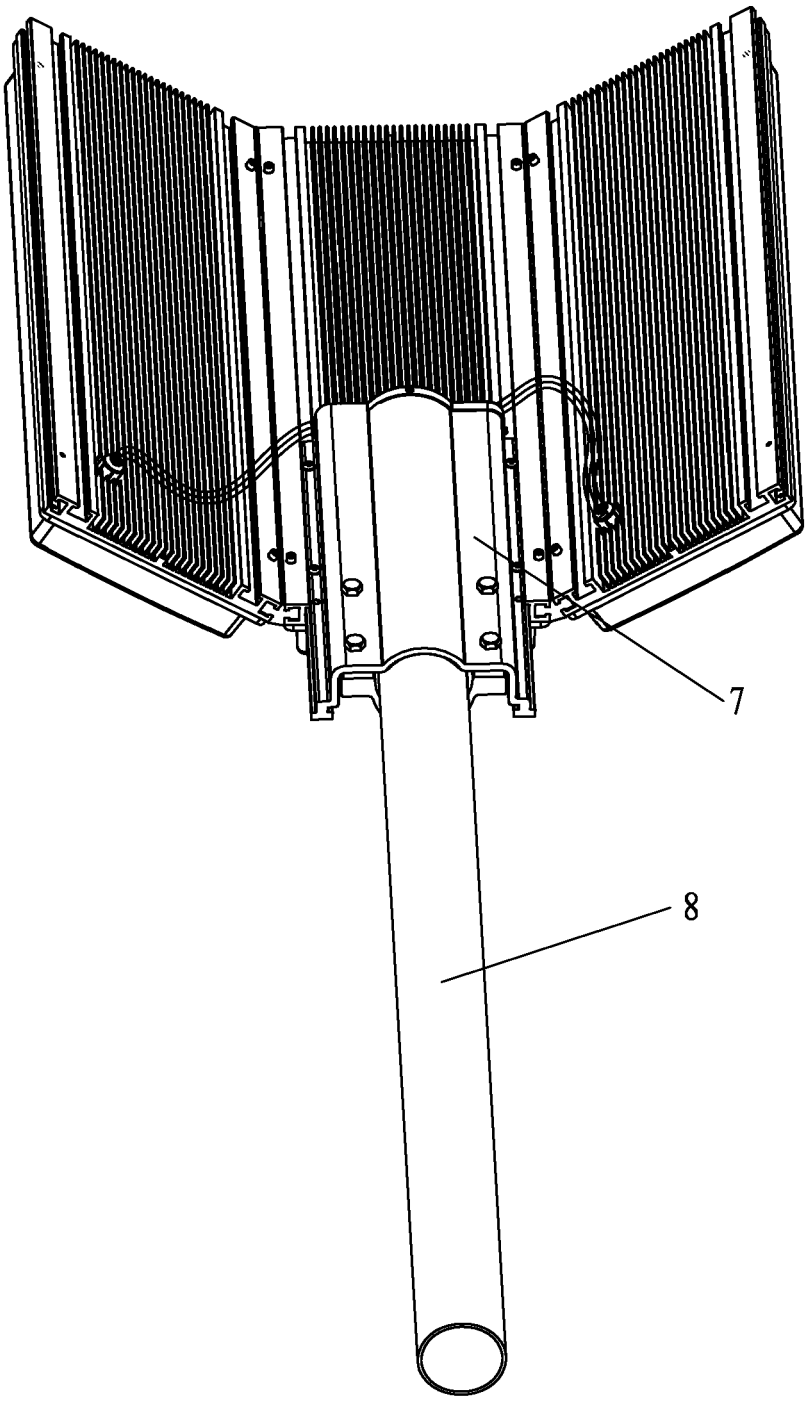

Fig. 19

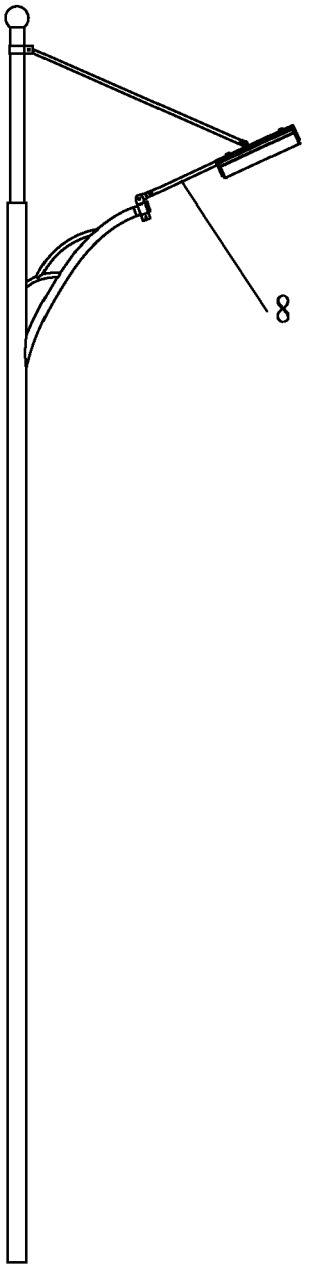

Fig. 20

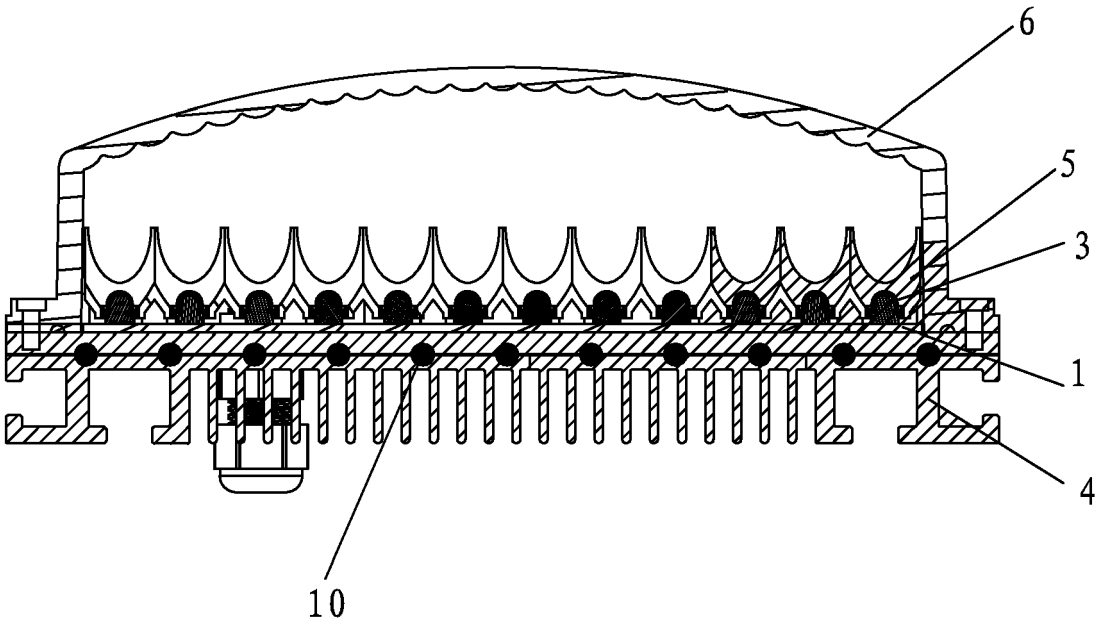

Fig. 21

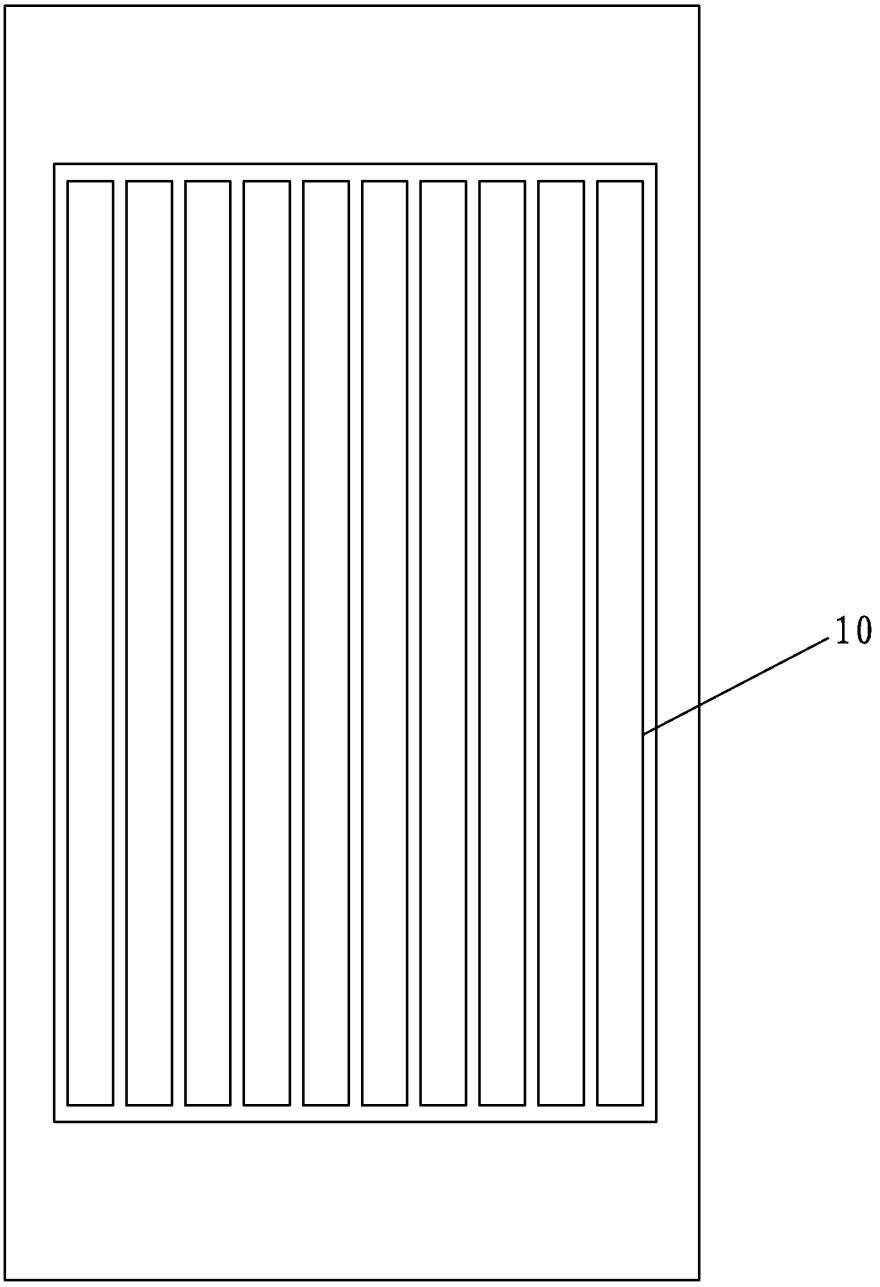

Fig. 22

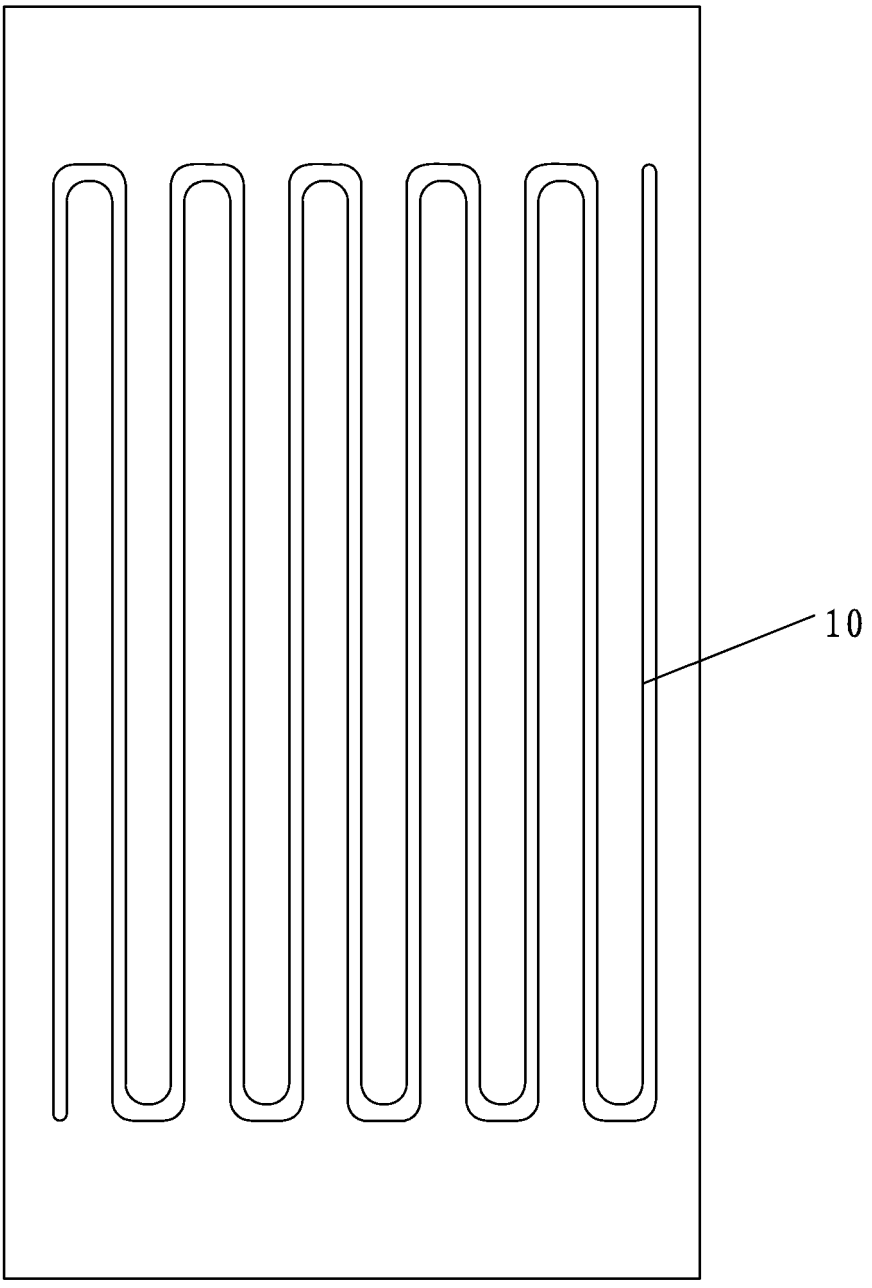

Fig. 23

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The Hague	14 February 2008	Blokland, Russell

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