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(54) REFLECTOR FOR LIGHTING SOURCE AND LIGHTING DEVICE COMPRISING THE SAME

REFLEKTOR FÜR BELEUCHTUNGSQUELLE UND BELEUCHTUNGSVORRICHTUNG DAMIT

RÉFLECTEUR POUR LA SOURCE LUMINEUSE ET DISPOSITIF D'ÉCLAIRAGE LE COMPRENANT

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(56) References cited:
EP-A1- 2 713 094
EP-A2- 2 312 201
EP-A2- 2 354 642
AU-B2- 496 079
DE-A1-102009 047 493
DE-A1-102011 004 683
DE-U1-202011 107 052
JP-A- 2011 129 405
US-A1- 2009 231 856
US-B1- 8 845 129

EP 3 312 502 B1

Description

Technical Field of the Invention

[0001] This invention relates to the field of lighting device. More specifically, this invention relates to a reflector for lighting source, and a lighting device comprising the reflector with low Unified Glaring Rating (UGR) while maintaining high luminous efficiency.

Background of the Invention

[0002] As a solid state light-emitting light source possessing huge development potential, the LED has been attracting more and more attention due to its advantages such as long lifespan, firm structure, low power consumption, flexible dimensions, etc., and has been gradually replacing the conventional fluorescent and high-pressure halogen lamp in various lighting fields. However, LEDs have characteristics of high lumen output and small luminous area, so that in an illumination space the LEDs are prone to cause problems as associated with glare and excessive difference in illumination uniformity, decreasing the degree of comfort in the space. Severe glare causes human eyes to have visual fatigue and discomfort, lowering production efficiency of workers.

[0003] Visual comfort is of utmost importance to the interior lighting design applications in an office or a commercial place due to the large number of people occupying such space for a prolonged period of time. To realize this, products of reduced direct glare and reflected glare are desirable. Glare's effect on people or glare's damage to human eyes can be reduced by placing a light fixture correctly in the work place and by using optical elements that can reduce direct glare and reflected glare.

[0004] The degree of discomfort glare is measured by "Unified Glare Rating" (UGR). The UGR usually ranges from 10 to 30. A high UGR value represents a high degree of discomfort glare; a low UGR value represents a low degree of discomfort glare. A UGR value lower than 10 represents no discomfort glare. The International Standard EN 12461-1: 2011-08 defines the following UGR standard for a lighting system.

UGR	Level of glare discomfort
10	Imperceptible
13	Just perceptible
16	Perceptible
19	Just acceptable
22	Just uncomfortable
25	Uncomfortable
28	Unacceptable

[0005] To obtain a low UGR, it is desirable to provide uniform direct light beams and avoid light beams parallel to the horizontal plane of a lighting space whenever possible. For the existing ceiling lights, this is accomplished by use of a reflective plate or a shield to prevent the light beams towards an undesired direction, or by increasing the shielding angle of the lights (i.e. the angle between an illumination beam and the horizontal plane). Another method is to use diffusers to cover bright light beams. However, these installations are very expensive.

[0006] Apart from the above, Chinese patent application no. 201280040123.7 provides a lighting device for reducing the UGR. The lighting device is equipped with a lighting means comprising a plurality of laminated plates with air gaps formed therebetween. The reduction in the UGR is accomplished by providing a patterned layer formed with an adhesive material around the air gap to increase reflection efficiency and at the same time removing patterns of a specific structure.

[0007] Another Chinese patent application no. 201110299984.4 discloses a light device for reducing glare comprising a first prism plate and a second prism plate. The second prism plate is arranged so that a longitudinal direction of a prism pattern formed on the second prism plate and a longitudinal direction of a prism pattern on the first prism plate intersect, and the prism patterns of the first prism plate and second prism plate both have an equilateral triangular cross section having a height H and a bottom side length L with the relation $0.1 \leq H \leq 0.2L$.

[0008] The technical solutions of the above two Chinese patent applications both involve specific patterns formed on a lighting means, which is complicated and expensive to manufacture.

[0009] Thus, there is a need to improve the existing LED lighting devices for lighting purpose, simplify their structure and reduce their production costs. The improved lighting devices are able to reduce discomfort glare experienced by human eyes, avoid glare interference to people and possible damage to human eyes, and have increased light-emission efficiency and increased luminous flux.

[0010] US 2009/231856 discloses a lighting system that includes an inner reflector extending from a proximal end to a distal end along an axis, where the proximal end is adapted to receive light from a light source and the distal end provides an exit opening (aperture) for the received light. The system can further include an outer reflector that is axially positioned relative to the inner reflector. The outer reflector extends from a proximal end adapted to receive light from the light source to a distal end that provides an exit opening (aperture) for the received light. The inner and outer reflectors are axially movable relative to one another and are configured such that, beginning in a position with the inner reflector nested within the outer reflector, distal movement of the outer reflector (that is, a movement away from the inner reflector) along the axis about which the reflectors are disposed progressively reduces a flood spread produced by the

lighting system.

[0011] US 8845129 discloses a method and system for providing an array of illumination modules. A modular illumination system can comprise a one-dimensional array, a two-dimensional array, or other shapes and arrangements of the illumination modules. Adjacent illumination modules in the array can be attached to one another via a system of connectors. Each illumination module can comprise at least two connectors, one feeding electricity to a neighboring illumination module and one receiving electricity from a power source. The power source can comprise another neighboring illumination module or a power supply circuit that feeds the array of illumination modules or a subset of illumination modules in the array. Each illumination module can comprise a circuit board, at least one LED, and an optical system that manages light.

[0012] JP2011129405 discloses a lighting system in which dazzlement of a light source is alleviated by maintaining the interval between the light sources narrow and the interval between the light source and a diffusion cover wide, while containing a light shielding angle determined by the shape of a reflector at a desired angle. The inner wall of a reflector 14 has reflecting surfaces 14X, 14Y in a linear lighting system 10. The reflecting surface 14X is formed so that the light shielding angle of light emitted from a corresponding LED 11 may be a specification value ω. Furthermore, the reflecting surface 14X is formed so that the end part on a far side from the corresponding LED 11 may be separated from the diffusion cover 15. Then, the reflecting surface 14X is formed so that the end parts may approach each other between the reflecting surfaces 14X corresponding to the adjoining LEDs 11. The reflecting surface 14Y is formed so that the light shielding angle of light emitted from the corresponding LED 11 may be the specification value ψ, however, the end parts on the far side from the corresponding LED 11 may be in contact with the diffusion cover 15. AU 496.079 discloses a reflector according to the preamble of claim 12.

Summary of the Invention

[0013] The invention provides a reflector intended for lighting source in accordance with claim 12 of the appended claims. The invention further provides a lighting device comprising one or more of the claimed reflectors.

[0014] An object of the present invention is to overcome the aforementioned drawbacks of prior art by providing a novel lighting device that does not only have good light-emission efficiency and high luminous flux, but also reduces the UGR value, simplifies the structure and structurally solve the glare problem of the LED light sources, thereby preventing strong light emitted from the LEDs from causing discomfort and possible damage to human eyes.

[0015] The object of the present invention is achieved by providing a reflector according to claim 12.

[0016] A ratio h/H of the height h of the side walls to the height H of the parabola is between 0.55 and 0.75.

[0017] In a preferred embodiment of the present invention the ratio h/H of the height h of the side walls to the height H of the parabola is between 0.6 and 0.7.

[0018] According to the present invention, the reflector body is formed by four side walls bounding around, and the reflector body has a trapezoidal configuration in a longitudinal section thereof, wherein the bottom opening is greater than the top opening. Two opposite ones of the four side walls are symmetrically arranged relative to a centrally vertical axis of the reflector body, and the two opposite side walls have respective inner surfaces configured to correspond to two symmetrical halves of the light-reflective parabolic surface.

[0019] The bottom opening is configured to be a rectangular opening or a square opening, and the length of the bottom opening comprises a length or a width of the rectangular opening or a side length of the square opening.

[0020] In certain situations, the inner surface of each of the side walls comprises the parabolic surface extending in a direction from the bottom opening toward the top opening, and one or more circular-arc-shaped surfaces of different radii, extending from the parabolic surface to the top opening. In an embodiment of the present invention, the inner surface of the side wall consists of one circular-arc-shaped surface and the parabolic surface, wherein the circular-arc-shaped surface extends from the top opening to between 1/5 and 1/3 of the height of the side wall, and the parabolic surface, which is the one mentioned above, extends from the circular-arc-shaped surface to the bottom opening.

[0021] A second aspect of the present invention provides a lighting device comprising

a light source unit comprising one or more LED light sources;
a wiring substrate on which the one or more LED light sources are mounted;
one or more diffusers for scattering light emitted from the light source unit;
characterized in that the lighting device further comprises a corresponding number of the reflectors of the present invention as the number of the diffusers, wherein each of the diffusers is mounted between the LED light sources and a corresponding reflector in a way such that the diffuser closes a top opening of the corresponding reflector to allow for reflection of the light scattered by the diffuser through the inner surface of the reflector to the outside of the lighting device.

[0022] Preferably, the diffuser is a sheet having a central portion of dome shape, the diffuser is mounted in such a manner that a central axis of the diffuser is coincident with a central axis of the corresponding reflector and the dome-shaped central portion projects toward an

inner cavity bounded by the side walls of the corresponding reflector.

[0023] According to the present invention, the reflector of the lighting device is configured in such a way that the reflector body is formed by four side walls bounding around and the reflector body has a trapezoidal configuration in a longitudinal section thereof, wherein the bottom opening is greater than the top opening; and two opposite ones of the four side walls are symmetrically arranged relative to a centrally vertical axis of the reflector body, and the two opposite sides walls have respective inner surfaces configured to correspond to two symmetrical halves of the light-reflective parabolic surface. Accordingly, the diffuser is configured as a quadrilateral designed to fit into the top opening, the quadrilateral having a central portion projecting to form a dome shape, wherein a constraint is provided at the top opening to securely clamp the diffuser on the top opening of the reflector.

[0024] Preferably, the constraint comprises a tab provided on each of two opposite edges of the top opening for clamping edges of two respective sides of the diffuser; and a wing extends from a respective one of the other two side edges of the diffuser toward the bottom opening of the reflector, the wing being configured to be attached to an outer surface of a respective side wall of the reflector, thereby to position and securely clamp the diffuser on the top opening.

[0025] Moreover, a vertical wall parallel to the central axis of the reflector extends from an edge of each of two opposite sides of the bottom opening of the reflector toward the top opening, and one or more lateral projecting portions are formed on each of the vertical walls and are engageable with respective apertures formed through a housing of the lighting device so as to position the reflector on the lighting device. The vertical wall has a height that is 0.25 to 0.35 times of a height of the reflector.

[0026] Preferably, a hook and a lug engageable with each other are provided respectively on edges of the other two opposite sides of the bottom opening of the reflector, through the engagement of the hook with the lug two of the reflectors that adjoin are coupled together. Moreover, the two vertical walls each have an extension portion extending toward a same side wall of the reflector, an insert hole being provided on each of the two extension portions; and a corresponding insert pin being positioned on each of the two vertical side walls and opposite to the side wall of the reflector toward which the extension portions extend, wherein insertion of the insert pin of one reflector into the insert hole of another reflector enables coupling of the two reflectors that adjoin.

[0027] The wiring substrate that the lighting device of the present invention uses can be a printed circuit board (PCB) or a metal core printed circuit board (MCPCB) on which a plurality of LED light sources are mounted, the plurality of LED light sources are respectively equipped with a plurality of the reflectors coupled to one another through the engagement of the hooks and the lugs to form a light source array. The light source array is selected from a group consisting of linear array, rectangular array, square array, triangular array, polygonal array and zigzag array.

[0028] The inner surface of the reflector of the present invention can be coated with a light reflecting material. The diffuser is made from a material having a transmittance in the range of 82% to 95%.

[0029] Unlike the lighting devices of prior art, the lighting device of the present invention is equipped with a reflector of unique structure according to the present invention, which is designed to fulfill a specific requirement in terms of dimensions of the side wall height, the length of the bottom opening and the length of the top opening. It has been found that the lighting device of the invention having the specific ratios among the above parameters allows the light that is emitted from an LED light source to pass through the diffuser and then get reflected by the inner surface of the reflector. The illumination light beam exhibits a cardioid or batwing illumination pattern having a beam width of around 90° to 120°. Thus, the lighting device of the present invention effectively reduces the UGR value to be equal to or smaller than 19 while maintaining the illumination intensity.

[0030] To have a better understanding of the objects, characteristics and effects of the present invention, the concepts, specific structure and technical effects thus produced of the present invention are further explained below in conjunction with the accompanying drawings.

Brief Description of the Drawings

[0031]

FIG. 1A is a perspective bottom view of a reflector constructed consistent with the first embodiment of the present invention.

FIG. 1B is a perspective top view of the reflector shown in FIG. 1A.

FIG. 2 is a bottom view of the reflector shown in FIG. 1A.

FIG. 3 is a front view of the reflector shown in FIG. 1A.

FIG. 4 is a cross-sectional view taken along line A-A in FIG. 2.

FIG. 5 is a cross-sectional view taken along line B-B in FIG. 2.

FIG. 6 is a front view showing two reflectors connected with each other.

FIG. 7 is a perspective view of a diffuser constructed according to the present invention.

FIG. 8 is a front view of the diffuser shown in FIG. 7.

FIG. 9 is a top view of the diffuser shown in FIG. 7.

FIG. 10 is a bottom view of the diffuser shown in FIG. 7.

FIG. 11 is a perspective top view of an assembly of the reflector shown in FIG. 1A and the diffuser shown in FIG. 7.

FIG. 12 is a plan cross-sectional view of the assembly shown in FIG. 11.

FIG. 13 is a perspective cross-sectional view of the assembly shown in FIG. 11.

FIG. 14 is a perspective view showing multiple reflector modules comprising a plurality of the reflectors constructed consistent with the present invention before they are assembled together.

FIG. 15 is a perspective view showing the reflector modules of FIG. 14 after they are assembled together.

FIG. 16 is a perspective bottom view of a reflector constructed consistent with the second embodiment of the present invention.

FIG. 17 is a bottom view of the reflector shown in FIG. 16.

FIG. 18 is a front view of the reflector shown in FIG. 16.

FIG. 19 is a cross-sectional view taken along line A-A in FIG. 17.

FIG. 20 is a cross-sectional view taken along line B-B in FIG. 17.

FIG. 21 is a view showing schematics of light reflection of the reflector shown in FIG. 16.

FIG. 22 is a perspective exploded view of a LED lighting device constructed consistent with an embodiment of the present invention.

FIG. 23 is an illumination pattern of the light beam obtained from the LED lighting device shown in FIG. 16.

[0032] In the various figures of the drawings, like reference numbers are used to designate like parts.

Detailed Description of the Invention

[0033] While this invention is illustrated and described in preferred embodiments, the reflector and diffuser of the present invention may be produced in a number of various configurations, sizes and forms from many different materials.

[0034] Referring now to the drawings, FIG. 1A, FIG. 1B, and FIG. 2 to FIG. 5 show a reflector 100 constructed according to the first embodiment of the present invention. In this embodiment, the reflector 100 comprises a reflector body 110 comprising a top opening 120 and a bottom opening 140 provided respectively on its top and bottom. The reflector body 110 is formed by four side walls 130A, 130B, 130C and 130D bounding around, and the thus-formed reflector body has a longitudinal trapezoidal configuration in a longitudinal section thereof, wherein the bottom opening 140 is greater than the top opening 120. Two opposite side walls 130A and 130B are arranged symmetrically relative to a centrally vertical axis Z of the reflector body 110, and the two opposite side walls 130A and 130B have respective inner surfaces configured to correspond to two symmetrical truncated halves of the light-reflective parabolic surface formed by extension of parabolas. As shown in FIG. 5, the symmetrical halves respectively have end points extending from an edge of the bottom opening 140 to the top opening 120 to protrude beyond the top opening 120 until they intersect to form a parabola vertex. In this embodiment, a connecting line of the end points of each of the two symmetrical halves is located on a plane where the bottom opening 140 is located. Thus, the parabola has a height H defined by a distance between the plane of the bottom opening 140 and the parabola vertex.

[0035] Like the two side walls 130A and 130B, two opposite side walls 130C and 130D are arranged symmetrically relative to a centrally vertical axis Z of the reflector body, and the two opposite side walls 130C and 130D have respective inner surfaces configured to correspond to two symmetrical truncated halves of the light-reflective parabolic surface formed by extension of parabolas, which will not be elaborated herein.

[0036] As shown in FIG. 2 to FIG. 6, the top opening 120 is a square opening with a side length I; the bottom opening is a rectangle with a length L and a width W. Of course, the top opening can also be in the form of a rectangular opening and the bottom opening is in the form of a square opening, or both openings can be of any appropriate shape.

[0037] The inventor of the present application has found that, if the reflector is configured to have a ratio of a height h of the side walls of the reflector 100 to the length of the bottom opening 140 in a certain range, the light emitted from a light source enters from the top opening 120 into an inner cavity formed by the four side walls 130A, 130B, 130C and 130D bounding around, and is reflected by the reflective inner surfaces of the four side walls, the resultant light will have reduced UGR while maintaining uniform light intensity, i.e. the light beam exhibits an ideal illumination pattern. The length of the bottom opening can be the length L or the width W of the rectangle. Specifically, if the ratio of the height h of the

side walls of the reflector 100 to the length of the bottom opening 140 (e.g. h/L) is set to around between 0.4 and 0.7, preferably around between 0.45 and 0.55, most preferably around 0.5, a more desirable illumination pattern will be obtained, as shown in FIG. 23 .

[0038] The inventor of the present application has also found that, if the reflector is configured to have a ratio of the height h of the side walls to the height H of the parabola around between 0.55 and 0.75, preferably around between 0.6 and 0.7, most preferably around 0.65, the lighting beam distribution curve obtained will be a heart shape or a batwing shape (i.e. UGR lower than 19), which is more desirable, while relatively high light output, desired beam width and relatively high light-emission efficiency can be maintained.

[0039] The inner surfaces of the side walls 130A, 130B, 130C and 130D of the reflector 100 are glossy parabolic surfaces and can be coated with a light reflecting material to enhance the luminous efficacy. The light emitted from the light source is reflected to the inner surface of the reflector, and is then irradiated through the bottom opening 140 to the outside of the lighting device.

[0040] Referring to FIG. 1B and FIG. 4, a constraint is provided on the top opening 120 to constrain a diffuser of the lighting device on the top opening 120 of the reflector. As shown, the constraint comprises a tab 121 provided on each of two opposite edges of the top opening 120. The tab 121 is used for clamping edges of two respective sides of the diffuser, which will be described in details below.

[0041] Referring to FIG. 1A, FIG. 2 and FIG. 3, a vertical wall 160 parallel to the central axis Z of the reflector extends from an edge of each of two opposite sides 130A, 130B of the bottom opening 140 of the reflector 100 toward the top opening 120, and one or more lateral projecting portions 161 are formed on each of the vertical walls 160, the lateral projecting portions 161 are engageable with respective apertures formed on a side plate in a housing of the lighting device (see FIG. 22) so as to position the reflector 100 on the lighting device. In this embodiment shown, the height of the vertical wall 160 is set to 0.25 to 0.35 times of the height of the reflector 100.

[0042] As shown in FIG. 1B, FIG. 2 and FIG. 5, a hook 151 and a lug 152 engageable with each other are provided respectively on edges of the other two side walls 130C, 130D of the bottom opening 140 of the reflector 100, through the engagement of the hook 151 with the lug 152 two of the reflectors 100 that adjoin are coupled together (as shown in FIG. 6). Moreover, two vertical walls 160 each have an extension portion 162 extending toward the same side wall 130D, an insert hole 163 being provided on each of the two extension portions 162; and a corresponding insert pin 164 being positioned on each of the two vertical walls and at a position close to the side wall 130C (as shown in FIG. 1B and FIG. 3), wherein the insert pin 164 and the insert hole 163 match each other so that the insertion of the insert pin 164 of one reflector into the insert hole 163 of another reflector enables coupling of the two reflectors together.

[0043] Now referring to FIG. 7 to FIG. 10, there is illustrated a diffuser 200 adapted to be used in cooperation with the reflector 100 described above. The base of the diffuser 200 is a piece of rectangular sheet, whose size can close the square top opening 120 of the reflector 100 to direct and scatter the light emitted from the light source to the inner cavity of the reflector body of the reflector 100 and reflect the light scattered by the diffuser through the side wall of the reflector body to the outside of the lighting device. As shown in FIG. 7, a central portion 210 of the diffuser 200 has a dome shape, the dome-shaped central portion 210 being bounded by four edges 220. The four edges 220 form a stand-off zone between a vertical side wall 212 of the dome-shaped central portion 210 of the diffuser 200 and the four side walls 130A, 130B, 130C, 130D of the reflector 100. Setting the stand-off zone reduces scattered light to be irradiated from the dome-shaped central portion 210 toward the reflector 100, which is advantageous to forming a desired illumination pattern. The stand-off zone and the height of the dome-shaped central portion 210 cooperate for fine-tuning a central area of an illumination pattern. Setting the stand-off zone either too large or too small will reduce the overall output of light intensity. Furthermore, there is a certain requirement for the height of the dome-shaped central portion 210. If the height is too high, the final UGR will be affected. For instance, in the case of the dome-shaped central portion 210 having an area of 20 x 20 mm and a height of 6.5 - 7 mm, it has been proven that a good illumination pattern can be obtained if the width of each stand-off zone is set to around 5 mm. A wing 230 extends from a respective one of the two opposite edges 240C, 240D of the diffuser 200 toward the dome-shaped central portion 210. The wing 230 is configured to be attached to an outer surface of a respective one of the two side walls 130C, 130D of the reflector 100, thereby to position and securely clamp the diffuser 200 on the top opening 120 of the reflector 100.

[0044] The diffuser 200 of the above embodiment is molded from translucent plastic having a transmittance of between 82% and 95%. The selected plastic can have a scattering rate of between 5% and 15% at a thickness of 1 mm.

[0045] FIG. 11 to FIG. 13 show schematic views of an assembly of the reflector 100 and the diffuser 200. As shown, the diffuser 200 is mounted in such a manner that a central axis Y of the diffuser 200 is coincident with the central axis Z of the reflector 100; the diffuser 200 tightly closes the top opening 120 of the reflector 100 and its dome-shaped central portion 210 projects toward a reflective inner cavity of the reflector 100. The other two edges 240A, 240B of the diffuser 200 are clamped by the tabs 121 on the two opposite edges of the top opening 120 of the reflector 100 so that the entire diffuser 200 is securely clamped on the top opening 120. Referring to FIG. 9 and FIG. 10, the edges 240C, 240D of the diffuser 200 are also respectively provided with a lateral position-

ing groove 250, a lateral positioning block 122 (see FIG. 1B) mutually cooperating with the lateral positioning groove 250 is provided on a corresponding position of the top opening 120. Engaging the lateral positioning groove 250 with the lateral positioning block 122 is not only advantageous to the positioning of the diffuser 200, but also strengthens the secure clamping of the diffuser 200.

[0046] As discussed above, the structure of the reflector of the present invention allows a plurality of the reflectors to be assembled. FIG. 14 shows a top view of one reflector module 300 comprising four reflectors. The reflector module 300 is an integral prefabricated module, wherein a hook 151 is provided on the side wall 130C of the leftmost reflector and an insert pin 164 is provided at a position adjacent to the side wall 130C, while an lug 152 is provided on the side wall 130D of the rightmost reflector and an insert hole 163 is provided at a position adjacent to the side wall 130D. By engaging the hook 151 and the insert pin 164 of one reflector module 300 with the lug 152 and the insert hole 163 of another reflector module 300 respectively, the two reflector modules 300 can be coupled together, as the bottom view of the assembled reflector modules shown in FIG. 15. In this way, according to actual needs, a plurality of LED light sources equipped with the reflectors 100 can be flexibly assembled into various light source arrays, including but not limited to linear array, rectangular array, square array, triangular array, polygonal array, zigzag array, etc. In order to cooperate with the reflector module 300, preferably a plurality of diffusers 200 in number corresponding to the number of the reflector 100 of the reflector module 300 are prefabricated as one piece which is adapted to fit onto the prefabricated reflector module 300.

[0047] What is shown in FIG. 16 to FIG. 20 is a reflector 400 of the second embodiment of the present invention. The major difference between this embodiment and the first embodiment is that the inner surface of each side wall 430A, 430B, 430C, 430D consists of a circular-arc-shaped surface 431 and a parabolic surface 432. The circular-arc-shaped surface 431 and the parabolic surface 432 are configured to have the same reflective material layer. The circular-arc-shaped surface 431 extends from the top opening 420 to around 1/5 of the height of the side wall; the parabolic surface 432 extends from the circular-arc-shaped surface 431 to the bottom opening 440. The structure of the parabolic surface 432 is basically the same as the parabolic surface of the first embodiment, the description of which can be made reference to the above and is not repeated here. The roundness or radius R of the circular-arc-shaped surface 431 is related to the size of the top opening: the smaller the top opening, the greater the roundness of the circular-arc-shaped surface 431; the bigger the top opening, the smaller the roundness of the circular-arc-shaped surface 431. A skilled person in the art should understand that two or more circular-arc-shaped surfaces can be arranged between the top opening 420 and the parabolic surface 432, depending on the height of the side wall of the reflector and/or the size of the top opening.

[0048] Provision of a circular-arc-shaped surface between the top opening of the reflector and the parabolic surface of the side wall is to cater for some scenarios. Under some circumstances, it is necessary to connect a plurality of reflectors together for a large light fixture which requires an enormous amount of reflectors; and under certain circumstances, it is desirable to reduce the number of reflectors for cost-effective purpose, which inevitably makes it necessary to increase the size of a reflector to meet the design goal. However, it is not possible for the light fixture to have a large height due to the limitation on ceiling mount while it is desirable to achieve a low UGR. If the dimension ratio of the reflector as discussed above is to be kept, the length of the bottom opening of the reflector has to be increased, which necessarily increases the height of the reflector. In order to keep the ratio of the height of the side walls of the reflector to the bottom opening within the range mentioned above, it is necessary to structurally modify the reflector around the top opening thereof, i.e. by configuring the parabolic surface of the side wall of the reflector at a level higher than 1/5 to 1/3 of the height of the side wall from the top opening, and providing one or more circular-arc-shaped surfaces between the parabolic surface and the top opening for connecting the parabolic surface and the top opening. The greater the curvature of the circular-arc-shaped surface is, the shorter the distance between the parabolic surface and the top opening becomes. The reflective zone defined by the circular-arc-shaped surface only occupies around 20% to 25% of the area of the entire inner surface of the reflector. The advantage of such an arrangement is that the circular-arc-shaped surface is able to reflect more light emitted from the dome-shaped central portion 210 of the diffuser 200 to a center of the light beam. However, since the area of the circular-arc-shaped surface is limited and the light source basically emit the light toward the central portion of the diffuser 200, the reflected light from the circular-arc-shaped surface has little effect on the entire illumination pattern which remains the preferred cardioid or batwing shape, as shown in FIG. 23.

[0049] FIG. 21 is a view showing schematics of light reflection of the reflector constructed consistent with the second embodiment of the invention. FIG. 21 clearly illustrates that the light emitted from the light source 520 is scattered by the dome-shaped central portion 210 of the diffuser 200 to the reflective inner surface of each side wall of the reflector 100, with a small portion of the light scattered onto the circular-arc-shaped surface 431 and a major portion of the light scattered onto a shallow parabolic surface 432 of the reflector. As shown, both the light from the circular-arc-shaped surface 431 and the light from the shallow parabolic surface 432 fall onto the zone between the light beam center and the shielding angle. Therefore, the lighting device produces substan-

tially reduced glare.

[0050] FIG. 22 shows a perspective exploded view of an LED lighting device 500 constructed consistent with a preferred embodiment of the present invention, comprising the reflector 100 and the diffuser 200 of the first embodiment of the present invention. As shown, the LED lighting device 500 comprises a plurality of the reflectors 100 connected to form a linear array, a plurality of diffusers 200 corresponding to the number of the reflectors 100, a wiring substrate 510, a plurality of LED light sources 520 mounted on the PCB substrate 510, a power supply unit 530, a lower half housing 540, an upper half housing 550, a support block 560, screws 570, a heat sink and a control circuit.

[0051] The lower half housing 540 and the upper half housing 550 are coupled to form a housing of the lighting device 500, in which various electronic and mechanical elements are accommodated. The lower half housing 540 is provided with a longitudinal through slot 542 that is able to allow for emission of the reflected light to the outside. On both sides of the through slot 542 are respectively provided side panels 541 extending inward from an inner surface of the lower half housing 540 to engage with the lateral projection 161 on the respective side wall of the reflector 100 so as to position the reflector 100 inside the housing. The lower half housing 540 can be colored to match the ceiling to blend the lighting device better with the indoor environment in which the lighting device is located. The power supply unit 530 can be the one which is conventional in prior art. The support block 560 is provided for supporting and fixing the power supply unit 530.

[0052] The control circuit of the lighting device 500 is not shown. The control circuit can be mounted on the wiring substrate 510 integrally with the lighting device 500, or separately from the lighting device 500. In the latter case, the control circuit has a pluggable connector to connect with the lighting device 500. The control circuit and the heat sink are not essence of the present invention and are not described in details.

[0053] The LED light sources 520 can be in the form of LED chips, LED packages or LED arrays. All LED light sources 520 can be connected in series and/or in parallel, but are mounted on the wiring substrate 510 axially in linear manner. Such a linear arrangement of the LED light sources is cost-effective and may result in increased heat dissipation capacity of the heat sink and improved light output efficiency of the lighting device, In this embodiment, each LED light source 520 consists of four to five LED chips and is mounted inside the cavity bounded by the dome-shaped central portion 210 of the diffuser 200. The LED light sources 520 may be provided in the form of LED packages (COB) in some scenarios requiring high power luminous output.

[0054] The wiring substrate 510 is formed by electrically coupling two printed circuit boards (PCB). The copper foil of the printed circuit board has good heat dissipation capacity, on which mounting of the LED light sources 520 allows heat generated from the LED light sources 520 to be transferred to a bigger area of the printed circuit board and then dissipated. The wiring substrate 510 can be a conventional FR4-type or CEM-type, or a metal core printed circuit board (MCPCB) having better heat management capacity. As shown, the wiring substrate 510 is mounted at the top opening 120 of the reflector 100, and the diffuser 200 is located between the top opening 120 and the LED light sources 520, so that the LED light sources 520 are completely inside the cavity bounded by the dome-shaped central portion 210 of the diffuser 200.

[0055] The coupling of the reflector 100 with the diffuser 200 is illustrated in FIG. 11 to FIG. 13 and described above. In the lighting device 500, the bottom opening 140 of the reflector 100 faces toward the lower half housing 540. The LED light sources 520 emit light toward the diffuser 200 where the light is scattered into the reflective cavity of the reflector 100 through the top opening 120 and is then reflected by the reflective inner surface of each side wall of the reflector to pass through the bottom opening 140 and the lower half housing 540 in succession to the outside of the lighting device 500.

[0056] It is well-known that glare control requires the manipulation of the light beam distribution of a lighting device, in particular the cut-off angle of the light beam. An excessively large beam angle not only generates direct glare to human eyes, but also results in decreased light intensity caused by illuminating a large illumination area. An excessively small beam angle, which illuminates a small area, is prone to become a point light source and causes uneven light distribution, accompanied by glare problems associated with a point light source. Thus, it is ideal for interior lighting that the light beam is distributed in a cardioid or batwing illumination pattern, which has a beam angle of around 90° to ensure that the light beam is directed to a target area while there is adequate light intensity in the target area and its surrounding areas. In general, the cut-off angle of the light beam is around 120° to satisfy the requirement for the shielding angle. The high luminous output obtained in the two wing zones of the cardioid or batwing illumination pattern substantially intensifies the light reflection from the surrounding walls and the floor, which in turn increases the intensity of background light of the indoor space to make it possible that the overall illumination in the indoor space becomes more uniform. Therefore the cardioid or batwing illumination pattern is an ideal pattern for interior lighting.

[0057] FIG. 23 shows an illumination pattern of the light beam obtained from the LED lighting device 500. As shown, the light beam produces a cardioid or batwing illumination pattern, with two wing zones having high light intensity. The light beam center is positioned at around 500 cd/klm, the two wing zones are positioned around 650 cd/klm with a wing vertex around 15° in the respective wing. The half power beam angle is within around 45°.

[0058] According to a tabular method (CIE 117-1995) established by the International Commission on Illumi-

nation (CIE), it has been found that the LED lighting device 500 of the present invention achieves a UGR lower than 19 in all standard combinations of room sizes, ceiling, wall and floor reflection indexes.

[0059] This reveals that the lighting device, which comprises the reflectors of the present invention and is provided with the diffusers cooperating with the reflectors, produces a cardioid or batwing illumination pattern while maintaining the illumination intensity. Namely, the lighting device according to the invention is able to maintain a high luminous efficiency and achieve a low Unified Glare Rating (UGR), providing comfortable lighting.

[0060] Having sufficiently described the nature of the present invention according to some preferred embodiments, the invention, however, should not be limited to the structures and functions of the embodiments and drawings. It is stated that insofar as its basic principle is not altered, changed or modified it may be subjected to variations of detail. Numerous variations and modifications that are easily obtainable by means of the skilled person's common knowledge without departing from the scope of the invention should fall into the scope of this invention.

Claims

1. A lighting device (500), comprising:

a light source unit comprising one or more LED light sources (520);
a wiring substrate (510) on which the one or more LED light sources (520) are mounted; the lighting device (500) further comprises one or more reflectors (100, 400) comprising:

a reflector body (110) having four reflective side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) bounding around and having a height h, a top opening (120, 420) formed by upper portions of the reflective side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) and having a length *l*, and a bottom opening (140, 440) formed by lower portions of the reflective (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) side walls and having a length L;
wherein the four reflective side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) have an inner surface configured to be one or more light-reflective parabolic surfaces (432) formed by extension of parabolas, each of the parabolic surfaces (432) having two end points and a parabola vertex and arranged such that the parabola vertex is positioned closer to the top opening (120, 420) with respect to the bottom opening (140, 440), and the parabola has a height H defined by a distance between a connection line connecting the two end points of the parabola and the parabola vertex; and
a ratio h/L of the height h of the side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) to the length L of the bottom opening (140, 440) is between 0.4 and 0.7, preferably between 0.45 and 0.55, and
wherein the reflector body (110) has a trapezoidal configuration in a longitudinal section thereof, wherein the bottom opening (140, 440) is greater than the top opening (120, 420), preferably two opposite ones of the four side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) are symmetrically arranged relative to a centrally vertical axis Z of the reflector body (110), and the two opposite side walls have respective inner surfaces configured to correspond to two symmetrical halves of the light-reflective parabolic surface (432).

2. The lighting device (500) of claim 1, further comprising one or more diffusers (200) for scattering light emitted from the light source unit, wherein the number of reflectors (100,400) is the same as the number of the diffusers (200), and
wherein each of the diffusers (200) is mounted between the LED light sources (520) and a corresponding reflector (100, 400) in a way such that the diffuser (200) closes a top opening (120, 420) of the corresponding reflector (100, 400) to allow for reflection of the light scattered by the diffuser (200) through the inner surface of the reflector (100, 400) to the outside of the lighting device (500).

3. The lighting device (500) of claim 2, **characterized in that** the diffuser (200) is a sheet having a central portion (210) of dome shape, the diffuser (200) is mounted in such a manner that a central axis Y of the diffuser (200) is coincident with a central axis Z of the corresponding reflector (100, 400) and the dome-shaped central portion (210) projects toward an inner cavity bounded by the side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) of the corresponding reflector (100, 400), and the diffuser (200) is configured as a quadrilateral designed to fit into the top opening (120, 420), the quadrilateral having a central portion (210) projecting to form a dome shape, wherein a constraint is provided at the top opening (120, 420) to securely clamp the diffuser (200) on the top opening (120, 420) of the reflector (100, 400).

4. The lighting device (500) of claim 3, **characterized in that** the constraint comprises a tab (121) provided on each of two opposite edges of the top opening (120, 420) for clamping edges (240A, 240B) of two

respective sides of the diffuser (200); and a wing (230) extends from a respective one of the other two side edges (240C, 240D) of the diffuser (200) toward the bottom opening (140, 440) of the reflector (100, 400), the wing (230) being configured to be attached to an outer surface of a respective side wall (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) of the reflector (100, 400), thereby to position and securely clamp the diffuser (200) on the top opening (120, 420).

5. The lighting device (500) of claim 3, **characterized in that** a vertical wall (160) parallel to the central axis Z of the reflector (100, 400) extends from an edge of each of two opposite sides of the bottom opening (140, 440) of the reflector (100, 400) toward the top opening (120, 420), and one or more lateral projecting portions (161) are formed on each of the vertical walls (160) and are engageable with respective apertures formed through a housing of the lighting device (500) so as to fix the reflector (100, 400) on the lighting device, preferably the vertical wall (160) has a height that is 0.25 to 0.35 times of a height of the reflector (100, 400).

6. The lighting device (500) of claim 5, **characterized in that** a hook (151) and a lug (152) engageable with each other are provided respectively on edges of the other two opposite sides of the bottom opening (140, 440) of the reflector (100, 400), through the engagement of the hook (151) with the lug (152) two of the reflectors (100, 400) that adjoin are coupled together.

7. The lighting device (500) of claim 6, **characterized in that** the two vertical walls (160) each have an extension portion (162) extending toward a same side wall (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) of the reflector (100, 400), an insert hole (163) being provided on each of the two extension portions (162); and a corresponding insert pin (164) being positioned on each of the two vertical side walls (162) and opposite to the side wall (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) of the reflector (100, 400) toward which the extension portions (162) extend, wherein insertion of the insert pin (164) of one reflector (100, 400) into the insert hole (163) of another reflector (100, 400) enables coupling of the two reflectors (100, 400) that adjoin.

8. The lighting device (500) of claim 6, **characterized in that** the wiring substrate (510) is a printed circuit board or a metal core printed circuit board on which a plurality of LED light sources (520) are mounted, the plurality of LED light sources (520) are respectively equipped with a plurality of the reflectors (100, 400) coupled to one another through the engagement of the hooks (151) and the lugs (152) to form a light source array.

9. The lighting device (500) of any one of the preceding claims, **characterized in that** in the reflector body (110), a ratio h/H of the height h of the side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) to the height H of the parabola is between 0.55 and 0.75, preferably between 0.6 and 0.7.

10. The lighting device (500) of claim 9, **characterized in that** in the reflector body (110), the inner surface of each of the side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) comprises the parabolic surface (432) extending in a direction from the bottom opening (140, 440) toward the top opening (120, 420), and one or more circular-arc-shaped surfaces (431) of different radii, extending from the parabolic surface (432) to the top opening (120, 420).

11. The lighting device (500) of claim 10, **characterized in that** in the reflector body (110), the inner surface of the side wall (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) consists of one circular-arc-shaped surface (431) and the parabolic surface (432), wherein the circular-arc-shaped surface (431) extends from the top opening (120, 420) up to between 1/5 and 1/3 of the height of the side wall (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D), and the parabolic surface (432) extends from the circular-arc-shaped surface (431) to the bottom opening (140, 440).

12. A reflector (100, 400) intended for lighting source, comprising:

a reflector body (110) having four reflective side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) bounding around and having a height h, a top opening (120, 420) formed by upper portions of the reflective side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) and having a length /, and a bottom opening (140, 440) formed by lower portions of the reflective (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) side walls and having a length L;
the four reflective side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) have an inner surface configured to be one or more light-reflective parabolic surfaces (432) formed by extension of parabolas, each of the parabolic surfaces (432) having two end points and a parabola vertex and arranged such that the parabola vertex is positioned closer to the top opening (120, 420) with respect to the bottom opening (140, 440), and the parabola has a height H defined by a distance between a connection line connecting the two end points of the parabola and the parabola vertex; **characterized in that**

a ratio h/L of the height h of the side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) to the length L of the bottom opening (140, 440) is between 0.45 and 0.55.

13. The reflector (100, 400) of claim 12, **characterized in that** a ratio h/H of the height h of the side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) to the height H of the parabola is between 0.55 and 0.75, preferably between 0.6 and 0.7.

14. The reflector (100, 400) of claim 12 or claim 13, **characterized in that** the reflector body (110) is formed by four side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) bounding around, and the reflector body (110) has a trapezoidal configuration in a longitudinal section thereof, wherein the bottom opening (140, 440) is greater than the top opening (120, 420), preferably two opposite ones of the four side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) are symmetrically arranged relative to a centrally vertical axis Z of the reflector body (110), and the two opposite side walls have respective inner surfaces configured to correspond to two symmetrical halves of the light-reflective parabolic surface (432).

15. The reflector (100, 400) of claim 13, **characterized in that** the bottom opening (140, 440) is configured to be a rectangular opening or a square opening, and the length of the bottom opening (140, 440) comprises a length or a width of the rectangular opening or a side length of the square opening.

16. The reflector (100, 400) of claim 13, **characterized in that** the inner surface of each of the side walls (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) comprises the parabolic surface (432) extending in a direction from the bottom opening (140, 440) toward the top opening (120, 420), and one or more circular-arc-shaped surfaces (431) of different radii, extending from the parabolic surface (432) to the top opening (120, 420).

17. The reflector (100, 400) of claim 16, **characterized in that** the inner surface of the side wall (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) consists of one circular-arc-shaped surface (431) and the parabolic surface (432), wherein the circular-arc-shaped surface (431) extends from the top opening (120, 420) up to between 1/5 and 1/3 of the height of the side wall (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D), and the parabolic surface (432) extends from the circular-arc-shaped surface (431) to the bottom opening (140, 440).

18. A reflector module, comprising a prefabricated piece of the reflectors according to any one of claims 12 to 17.

Patentansprüche

1. Beleuchtungsvorrichtung (500), die Folgendes umfasst:

eine Lichtquelleneinheit, die eine oder mehrere LED-Lichtquellen (520) umfasst;
ein Verdrahtungssubstrat (510), auf dem die eine oder mehreren LED-Lichtquellen (520) montiert sind;
wobei die Beleuchtungsvorrichtung (500) ferner einen oder mehrere Reflektoren (100, 400) umfasst, die Folgendes umfassen:

einen Reflektorkörper (110) mit vier reflektierenden Seitenwänden (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D), die um ihn herum begrenzt sind und eine Höhe h aufweisen, eine obere Öffnung (120, 420), die durch obere Abschnitte der reflektierenden Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) gebildet ist und eine Länge / aufweist, und eine untere Öffnung (140, 440), die durch untere Abschnitte der reflektierenden Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) gebildet ist und eine Länge L aufweist;
wobei die vier reflektierenden Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) eine Innenfläche aufweisen, die dafür konfiguriert ist, eine oder mehrere lichtreflektierende parabolische Oberflächen (432) zu sein, die durch Ausdehnung von Parabeln gebildet werden, wobei jede der parabolischen Oberflächen (432) zwei Endpunkte und einen Parabelscheitelpunkt aufweist und so angeordnet ist, dass der Parabelscheitelpunkt näher an der oberen Öffnung (120, 420) in Bezug auf die untere Öffnung (140, 440) positioniert ist, und die Parabel eine Höhe H aufweist, die durch einen Abstand zwischen einer Verbindungslinie definiert ist, die die beiden Endpunkte der Parabel und des Parabelscheitelpunkts verbindet; und ein Verhältnis h/L der Höhe h der Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) zur Länge L der unteren Öffnung (140, 440) zwischen 0,4 und 0,7, vorzugsweise zwischen 0,45 und 0,55 liegt, und wobei der Reflektorkörper (110) eine trapezförmige Konfiguration in einem Längsschnitt davon aufweist; wobei die untere Öffnung (140, 440) größer ist als die obere Öffnung (120, 420), wobei vor-

zugsweise zwei gegenüberliegende der vier Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) symmetrisch relativ zu einer zentral vertikalen Achse Z des Reflektorkörpers (110) angeordnet sind, und die zwei gegenüberliegenden Seitenwände jeweilige Innenflächen aufweisen, die so konfiguriert sind, dass sie zwei symmetrischen Hälften der lichtreflektierenden parabolischen Oberfläche (432) entsprechen.

2. Beleuchtungsvorrichtung (500) nach Anspruch 1, die ferner einen oder mehrere Diffusoren (200) zum Streuen von Licht umfasst, das von der Lichtquelleneinheit emittiert wird, wobei die Anzahl der Reflektoren (100, 400) der Anzahl der Diffusoren (200) entspricht, und
wobei jeder der Diffusoren (200) in gewisser Weise zwischen den LED-Lichtquellen (520) und einem entsprechenden Reflektor (100, 400) angebracht ist, so dass der Diffusor (200) eine obere Öffnung (120, 420) des entsprechenden Reflektors (100, 400) verschließt, um die Reflexion des vom Diffusor (200) gestreuten Lichts durch die Innenfläche des Reflektors (100, 400) zur Außenseite der Beleuchtungsvorrichtung (500) zu ermöglichen.

3. Beleuchtungsvorrichtung (500) nach Anspruch 2, **dadurch gekennzeichnet, dass** der Diffusor (200) eine Folie mit einem zentralen Abschnitt (210) mit einer Kuppelform ist, der Diffusor (200) so montiert ist, dass eine Mittelachse Y des Diffusors (200) mit einer Mittelachse Z des entsprechenden Reflektors (100, 400) zusammenfällt, und der kuppelförmige zentrale Abschnitt (210) in Richtung eines inneren Hohlraums ragt, der durch die Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) des entsprechenden Reflektors (100, 400) und des Diffusors (200) eingegrenzt ist, und als Viereck konfiguriert ist, das in die obere Öffnung (120, 420) passt, wobei das Viereck einen zentralen Abschnitt (210) aufweist, der vorsteht, um eine Kuppelform zu bilden, wobei an der oberen Öffnung (120, 420) eine Einschränkung vorgesehen ist, um den Diffusor (200) sicher an der oberen Öffnung (120, 420) des Reflektors (100, 400) festzuklemmen.

4. Beleuchtungsvorrichtung (500) nach Anspruch 3, **dadurch gekennzeichnet, dass** die Einschränkung eine Lasche (121) umfasst, die an jeder der beiden gegenüberliegenden Kanten der oberen Öffnung (120, 420) zum Klemmen der Kanten (240A, 240B) von zwei jeweiligen Seiten des Diffusors (200) vorgesehen ist; und sich ein Flügel (230) von einer der beiden anderen Seitenkanten (240C, 240D) des Diffusors (200) zur unteren Öffnung (140, 440) des Reflektors (100, 400) erstreckt, wobei der Flügel (230) dafür konfiguriert ist, an einer Außenfläche einer jeweiligen Seitenwand (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) des Reflektors (100, 400) angebracht zu werden, um dadurch den Diffusor (200) an der oberen Öffnung (120, 420) zu positionieren und sicher festzuklemmen.

5. Beleuchtungsvorrichtung (500) nach Anspruch 3, **dadurch gekennzeichnet, dass** sich eine vertikale Wand (160) parallel zur Mittelachse Z des Reflektors (100, 400) von einer Kante von jeder von zwei gegenüberliegenden Seiten der unteren Öffnung (140, 440) des Reflektors (100, 400) zur oberen Öffnung (120, 420) hin erstreckt, und ein oder mehrere seitlich vorstehende Abschnitte (161) an jeder der vertikalen Wände (160) gebildet sind und mit entsprechenden Öffnungen in Eingriff gebracht werden können, die durch ein Gehäuse der Beleuchtungsvorrichtung (500) gebildet sind, um den Reflektor (100, 400) an der Beleuchtungsvorrichtung zu befestigen, wobei die vertikale Wand (160) vorzugsweise eine Höhe aufweist, die das 0,25- bis 0,35-fache der Höhe des Reflektors (100, 400) beträgt.

6. Beleuchtungsvorrichtung (500) nach Anspruch 5, **dadurch gekennzeichnet, dass** ein Haken (151) und eine Nase (152), die miteinander in Eingriff gebracht werden können, jeweils an Kanten der beiden anderen gegenüberliegenden Seiten der unteren Öffnung (140, 440) des Reflektor (100, 400) bereitgestellt sind, wobei durch den Eingriff des Hakens (151) mit der Nase (152) zwei der angrenzenden Reflektoren (100, 400) miteinander gekoppelt werden.

7. Beleuchtungsvorrichtung (500) nach Anspruch 6, **dadurch gekennzeichnet, dass** die beiden vertikalen Wände (160) jeweils Folgendes aufweisen: einen Verlängerungsabschnitt (162), der sich zu derselben Seitenwand (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) des Reflektors (100, 400) erstreckt, ein Einsatzloch (163), das an jedem der beiden Verlängerungsabschnitte (162) vorgesehen ist; und einen entsprechenden Einsatzstift (164), der an jeder der beiden vertikalen Seitenwände (162) und gegenüber der Seitenwand (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) des Reflektors (100, 400) positioniert ist, zu dem sich die Verlängerungsabschnitte (162) erstrecken, wobei das Einführen des Einführstifts (164) eines Reflektors (100, 400) in das Einsatzloch (163) eines anderen Reflektors (100, 400) das Koppeln der beiden benachbarten Reflektoren (100, 400) ermöglicht.

8. Beleuchtungsvorrichtung (500) nach Anspruch 6, **dadurch gekennzeichnet, dass** das Verdrahtungssubstrat (510) eine Leiterplatte oder eine Metallkern-Leiterplatte ist, auf der eine Vielzahl von LED-Lichtquellen (520) montiert sind, wobei die Vielzahl von

LED-Lichtquellen (520) jeweils mit einer Vielzahl von Reflektoren (100, 400) ausgestattet ist, die durch den Eingriff der Haken (151) und der Laschen (152) miteinander verbunden sind, um eine Lichtquellenanordnung zu bilden.

9. Beleuchtungsvorrichtung (500) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** im Reflektorkörper (110) ein Verhältnis h/H der Höhe h der Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) zur Höhe H der Parabel zwischen 0,55 und 0,75, vorzugsweise zwischen 0,6 und 0,7 liegt.

10. Beleuchtungsvorrichtung (500) nach Anspruch 9, **dadurch gekennzeichnet, dass** in dem Reflektorkörper (110) die Innenfläche jeder der Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) die parabolische Oberfläche (432) umfasst, die sich in einer Richtung von der unteren Öffnung (140, 440) zur oberen Öffnung (120, 420) erstreckt, und eine oder mehrere kreisförmige bogenförmige Oberflächen (431) mit unterschiedlichen Radien sich von der parabolischen Oberfläche (432) bis zur oberen Öffnung (120, 420) erstrecken.

11. Beleuchtungsvorrichtung (500) nach Anspruch 10, **dadurch gekennzeichnet, dass** in dem Reflektorkörper (110) die Innenfläche der Seitenwand (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) aus einer einzelnen kreisförmigen bogenförmigen Oberfläche (431) und der parabolischen Oberfläche (432) besteht, wobei sich die kreisförmige bogenförmige Oberfläche (431) von der oberen Öffnung (120, 420) bis zwischen 1/5 und 1/3 der Höhe der Seitenwand (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) erstreckt und sich die parabolische Oberfläche (432) von der kreisförmigen bogenförmigen Oberfläche (431) bis zur unteren Öffnung (140, 440) erstreckt.

12. Reflektor (100, 400) für eine Lichtquelle, der Folgendes umfasst:

einen Reflektorkörper (110) mit vier reflektierenden Seitenwänden (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D), die um ihn herum begrenzt sind und eine Höhe h aufweisen, eine obere Öffnung (120, 420), die durch obere Abschnitte der reflektierenden Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) gebildet ist und eine Länge / aufweist, und eine untere Öffnung (140, 440), die durch untere Abschnitte der reflektierenden Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) gebildet ist und eine Länge L aufweist;

wobei die vier reflektierenden Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) eine Innenfläche aufweisen, die dafür konfiguriert ist, eine oder mehrere lichtreflektierende parabolische Oberflächen (432) zu sein, die durch Ausdehnung von Parabeln gebildet werden, wobei jede der parabolischen Oberflächen (432) zwei Endpunkte und einen Parabelscheitelpunkt aufweist und so angeordnet ist, dass der Parabelscheitelpunkt näher an der oberen Öffnung (120, 420) in Bezug auf die untere Öffnung (140, 440) positioniert ist, und die Parabel eine Höhe H aufweist, die durch einen Abstand zwischen einer Verbindungslinie definiert ist, die die beiden Endpunkte der Parabel und des Parabelscheitelpunkts verbindet; **dadurch gekennzeichnet, dass** ein Verhältnis h/L der Höhe h der Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) zur Länge L der unteren Öffnung (140, 440) zwischen 0,45 und 0,55 liegt.

13. Reflektor (100, 400) nach Anspruch 12, **dadurch gekennzeichnet, dass** ein Verhältnis h/H der Höhe h der Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) zur Höhe H der Parabel zwischen 0,55 und 0,75, vorzugsweise zwischen 0,6 und 0,7 liegt.

14. Reflektor (100, 400) nach Anspruch 12 oder Anspruch 13, **dadurch gekennzeichnet, dass** der Reflektorkörper (110) durch vier umlaufende Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) gebildet ist und der Reflektorkörper (110) eine trapezförmige Konfiguration in einem Längsschnitt davon aufweist, wobei die untere Öffnung (140, 440) größer ist als die obere Öffnung (120, 420), wobei vorzugsweise zwei gegenüberliegende der vier Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) symmetrisch relativ zu einer zentral vertikalen Achse Z des Reflektorkörpers (110) angeordnet sind, und die zwei gegenüberliegenden Seitenwände jeweilige Innenflächen aufweisen, die so konfiguriert sind, dass sie zwei symmetrischen Hälften der lichtreflektierenden parabolischen Oberfläche (432) entsprechen.

15. Reflektor (100, 400) nach Anspruch 13, **dadurch gekennzeichnet, dass** die untere Öffnung (140, 440) als rechteckige oder quadratische Öffnung konfiguriert ist und die Länge der unteren Öffnung (140, 440) eine Länge oder eine Breite der rechteckigen Öffnung oder eine Seitenlänge der quadratischen Öffnung umfasst.

16. Reflektor (100, 400) nach Anspruch 13, **dadurch gekennzeichnet, dass** die Innenfläche jeder der Seitenwände (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) die parabolische Oberfläche (432) umfasst, die sich in einer Richtung von der unteren Öff-

nung (140, 440) in Richtung der oberen Öffnung (120, 420) erstreckt, und eine oder mehrere kreisförmige bogenförmige Oberflächen (431) mit unterschiedlichen Radien sich von der parabolischen Oberfläche (432) bis zur oberen Öffnung (120, 420) erstrecken.

17. Reflektor (100, 400) nach Anspruch 16, **dadurch gekennzeichnet, dass** die Innenfläche der Seitenwand (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) aus einer kreisförmigen bogenförmigen Oberfläche (431) und der parabolischen Oberfläche (432) besteht, wobei sich die kreisförmige bogenförmige Oberfläche (431) von der oberen Öffnung (120, 420) bis zwischen 1/5 und 1/3 der Höhe der Seitenwand (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) erstreckt und sich die parabolische Oberfläche (432) von der kreisförmigen bogenförmigen Oberfläche (431) bis zur unteren Öffnung (140, 440) erstreckt.

18. Reflektormodul, das ein vorgefertigtes Stück der Reflektoren nach einem der Ansprüche 12 bis 17 umfasst.

Revendications

1. Dispositif d'éclairage (500), comprenant :

une unité source lumineuse comprenant une ou plusieurs lumineuses LED (520) ; et
un substrat de câblage (510) sur lequel la ou les sources lumineuses LED (520) sont montées ;
le dispositif d'éclairage (500) comprenant en outre un ou plusieurs réflecteurs (100, 400) comprenant :

un corps de réflecteur (110) ayant quatre parois latérales réfléchissantes (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) liées autour et ayant une hauteur h, une ouverture supérieure (120, 420) formée par des parties supérieures des parois latérales réfléchissantes (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et ayant une longueur *l*, et une ouverture inférieure (140, 440) formée par des parties inférieures des parois latérales réfléchissantes (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et ayant une longueur L ;
les quatre parois latérales réfléchissantes (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) ayant une surface interne configurée pour être une ou plusieurs surfaces paraboliques réfléchissant la lumière (432) formées par extension de paraboles, chacune des surfaces paraboliques (432) ayant deux points extrêmes et un sommet de parabole et étant agencée de sorte que le sommet de parabole soit positionné plus près de l'ouverture supérieure (120, 420) par rapport à l'ouverture inférieure (140, 440) et que la parabole ait une hauteur H définie par une distance entre une ligne de connexion connectant les deux points extrêmes de la parabole et le sommet de parabole ; et un rapport h/L entre la hauteur h des parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et la longueur L de l'ouverture inférieure (140, 440) étant compris entre 0,4 et 0,7, de préférence entre 0,45 et 0,55, et le corps de réflecteur (110) ayant une configuration trapézoïdale dans une section longitudinale correspondante, l'ouverture inférieure (140, 440) étant plus grande que l'ouverture supérieure (120, 420), de préférence deux parois latérales opposées des quatre parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) étant agencées symétriquement par rapport à un axe vertical central Z du corps de réflecteur (110) et les deux parois latérales opposées ayant des surfaces internes respectives configurées pour correspondre à deux moitiés symétriques de la surface parabolique réfléchissant la lumière (432).

2. Dispositif d'éclairage (500) selon la revendication 1, comprenant en outre un ou plusieurs diffuseurs (200) pour diffuser la lumière émise par l'unité source lumineuse, le nombre de réflecteurs (100, 400) étant le même que le nombre de diffuseurs (200), et
chacun des diffuseurs (200) étant monté entre les sources lumineuses LED (520) et un réflecteur (100, 400) correspondant de sorte que le diffuseur (200) ferme une ouverture supérieure (120, 420) du réflecteur (100, 400) correspondant pour permettre la réflexion de la lumière diffusée par le diffuseur (200) à travers la surface interne du réflecteur (100, 400) vers l'extérieur du dispositif d'éclairage (500).

3. Dispositif d'éclairage (500) selon la revendication 2, **caractérisé en ce que** le diffuseur (200) est une feuille ayant une partie centrale (210) en forme de dôme, le diffuseur (200) est monté de manière à ce qu'un axe central Y du diffuseur (200) coïncide avec un axe central Z du réflecteur (100, 400) correspondant et la partie centrale en forme de dôme (210) se projette vers une cavité interne liée par les parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) du réflecteur (100, 400) correspondant, et le diffuseur (200) est configuré comme un quadrilatère conçu pour s'ajuster dans l'ouverture supérieure (120, 420), le quadrilatère ayant une partie centrale (210) se projetant pour former une forme

de dôme, une contrainte étant fournie au niveau de l'ouverture supérieure (120, 420) pour serrer fermement le diffuseur (200) sur l'ouverture supérieure (120, 420) du réflecteur (100, 400).

4. Dispositif d'éclairage (500) selon la revendication 3, **caractérisé en ce que** la contrainte comprend une attache (121) située sur chacun de deux bords opposés de l'ouverture supérieure (120, 420) pour serrer des bords (240A, 240B) de deux côtés respectifs du diffuseur (200) ; et une aile (230) s'étend depuis un bord latéral respectif des deux autres bords latéraux (240C, 240D) du diffuseur (200) vers l'ouverture inférieure (140, 440) du réflecteur (100, 400), l'aile (230) étant configurée pour être fixée à une surface externe d'une paroi latérale (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) respective du réflecteur (100, 400), de manière à positionner et serrer fermement le diffuseur (200) sur l'ouverture supérieure (120, 420) .

5. Dispositif d'éclairage (500) selon la revendication 3, **caractérisé en ce qu'**une paroi verticale (160) parallèle à l'axe central Z du réflecteur (100, 400) s'étend depuis un bord de chacun de deux côtés opposés de l'ouverture inférieure (140, 440) du réflecteur (100, 400) vers l'ouverture supérieure (120, 420), et une ou plusieurs parties saillantes latérales (161) sont formées sur chacune des parois verticales (160) et peuvent se loger dans des orifices respectifs formés dans un boîtier du dispositif d'éclairage (500) afin de fixer le réflecteur (100, 400) sur le dispositif d'éclairage, la paroi verticale (160) ayant de préférence une hauteur qui est 0,25 à 0,35 fois une hauteur du réflecteur (100, 400).

6. Dispositif d'éclairage (500) selon la revendication 5, **caractérisé en ce qu'**un crochet (151) et une patte (152) pouvant se solidariser l'un à l'autre sont situés respectivement sur des bords des deux autres côtés opposés de l'ouverture inférieure (140, 440) du réflecteur (100, 400), deux des réflecteurs (100, 400) qui sont contigus pouvant être accouplés ensemble par l'intermédiaire de la solidarisation du crochet (151) à la patte (152).

7. Dispositif d'éclairage (500) selon la revendication 6, **caractérisé en ce que** les deux parois verticales (160) ont chacune une partie d'extension (162) s'étendant vers une même paroi latérale (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) du réflecteur (100, 400), un trou d'insertion (163) étant situé sur chacune des deux parties d'extension (162) ; et une cheville d'insertion (164) correspondante étant positionnée sur chacune des deux parois latérales verticales (162) et opposée à la paroi latérale (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) du réflecteur (100, 400) vers laquelle les parties d'extension (162) s'étendent, l'insertion de la cheville d'insertion (164) d'un réflecteur (100, 400) dans le trou d'insertion (163) d'un autre réflecteur (100, 400) permettant l'accouplement des deux réflecteurs (100, 400) qui sont contigus.

8. Dispositif d'éclairage (500) selon la revendication 6, **caractérisé en ce que** le substrat de câblage (510) est une carte de circuit imprimé ou une carte de circuit imprimé à âme métallique sur laquelle une pluralité de sources lumineuses LED (520) sont montées, et la pluralité de sources lumineuses LED (520) sont équipées respectivement d'une pluralité des réflecteurs (100, 400) accouplés les uns aux autres par l'intermédiaire de la solidarisation des crochets (151) et des pattes (152) pour former un réseau de sources lumineuses.

9. Dispositif d'éclairage (500) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** dans le corps de réflecteur (110), un rapport h/H entre la hauteur h des parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et la hauteur H de la parabole est compris entre 0,55 et 0,75, de préférence entre 0,6 et 0,7.

10. Dispositif d'éclairage (500) selon la revendication 9, **caractérisé en ce que** dans le corps de réflecteur (110), la surface interne de chacune des parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) comprend la surface parabolique (432) s'étendant dans une direction allant de l'ouverture inférieure (140, 440) à l'ouverture supérieure (120, 420) et une ou plusieurs surfaces en forme d'arc circulaire (431) de différents rayons s'étendant de la surface parabolique (432) à l'ouverture supérieure (120, 420).

11. Dispositif d'éclairage (500) selon la revendication 10, **caractérisé en ce que** dans le corps de réflecteur (110), la surface interne de la paroi latérale (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) consiste en une surface en forme d'arc circulaire (431) et en la surface parabolique (432), la surface en forme d'arc circulaire (431) s'étendant depuis l'ouverture supérieure (120, 420) jusque entre 1/5 et 1/3 de la hauteur de la paroi latérale (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et la surface parabolique (432) s'étendant de la surface en forme d'arc circulaire (431) à l'ouverture inférieure (140, 440).

12. Réflecteur (100, 400) destiné à une source d'éclairage, comprenant :

un corps de réflecteur (110) ayant quatre parois latérales réfléchissantes (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) liées autour et

ayant une hauteur h, une ouverture supérieure (120, 420) formée par des parties supérieures des parois latérales réfléchissantes (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et ayant une longueur *l*, et une ouverture inférieure (140, 440) formée par des parties inférieures des parois latérales réfléchissantes (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et ayant une longueur L ;
les quatre parois latérales réfléchissantes (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) ayant une surface interne configurée pour être une ou plusieurs surfaces paraboliques réfléchissant la lumière (432) formées par extension de paraboles, chacune des surfaces paraboliques (432) ayant deux points extrêmes et un sommet de parabole et étant agencée de sorte que le sommet de parabole soit positionné plus près de l'ouverture supérieure (120, 420) par rapport à l'ouverture inférieure (140, 440) et que la parabole ait une hauteur H définie par une distance entre une ligne de connexion connectant les deux points extrêmes de la parabole et le sommet de parabole ;
le réflecteur étant **caractérisé en ce qu'**un rapport h/L entre la hauteur h des parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et la longueur L de l'ouverture inférieure (140, 440) est compris entre 0,45 et 0,55.

13. Réflecteur (100, 400) selon la revendication 12, **caractérisé en ce qu'**un rapport h/H entre la hauteur h des parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et la hauteur H de la parabole est compris entre 0,55 et 0,75, de préférence entre 0,6 et 0,7.

14. Réflecteur (100, 400) selon la revendication 12 ou revendication 13, **caractérisé en ce que** le corps de réflecteur (110) est formé par quatre parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) liées autour et le corps de réflecteur (110) a une configuration trapézoïdale dans une section longitudinale correspondante, l'ouverture inférieure (140, 440) étant plus grande que l'ouverture supérieure (120, 420), de préférence deux parois latérales opposées des quatre parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) étant agencées symétriquement par rapport à un axe vertical central Z du corps de réflecteur (110) et les deux parois latérales opposées ayant des surfaces internes respectives configurées pour correspondre à deux moitiés symétriques de la surface parabolique réfléchissant la lumière (432).

15. Réflecteur (100, 400) selon la revendication 13, **caractérisé en ce que** l'ouverture inférieure (140, 440) est configurée pour être une ouverture rectangulaire ou une ouverture carrée et la longueur de l'ouverture inférieure (140, 440) comprend une longueur ou une largeur de l'ouverture rectangulaire ou une longueur latérale de l'ouverture carrée.

16. Réflecteur (100, 400) selon la revendication 13, **caractérisé en ce que** la surface interne de chacune des parois latérales (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) comprend la surface parabolique (432) s'étendant dans une direction allant de l'ouverture inférieure (140, 440) à l'ouverture supérieure (120, 420) et une ou plusieurs surfaces en forme d'arc circulaire (431) de différents rayons s'étendant de la surface parabolique (432) à l'ouverture supérieure (120, 420).

17. Réflecteur (100, 400) selon la revendication 16, **caractérisé en ce que** la surface interne de la paroi latérale (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) consiste en une surface en forme d'arc circulaire (431) et en la surface parabolique (432), la surface en forme d'arc circulaire (431) s'étendant depuis l'ouverture supérieure (120, 420) jusque entre 1/5 et 1/3 de la hauteur de la paroi latérale (130A, 130B, 130C, 130D, 430A, 430B, 430C, 430D) et la surface parabolique (432) s'étendant de la surface en forme d'arc circulaire (431) à l'ouverture inférieure (140, 440).

18. Module réflecteur, comprenant une pièce préfabriquée des réflecteurs selon l'une quelconque des revendications 12 à 17.

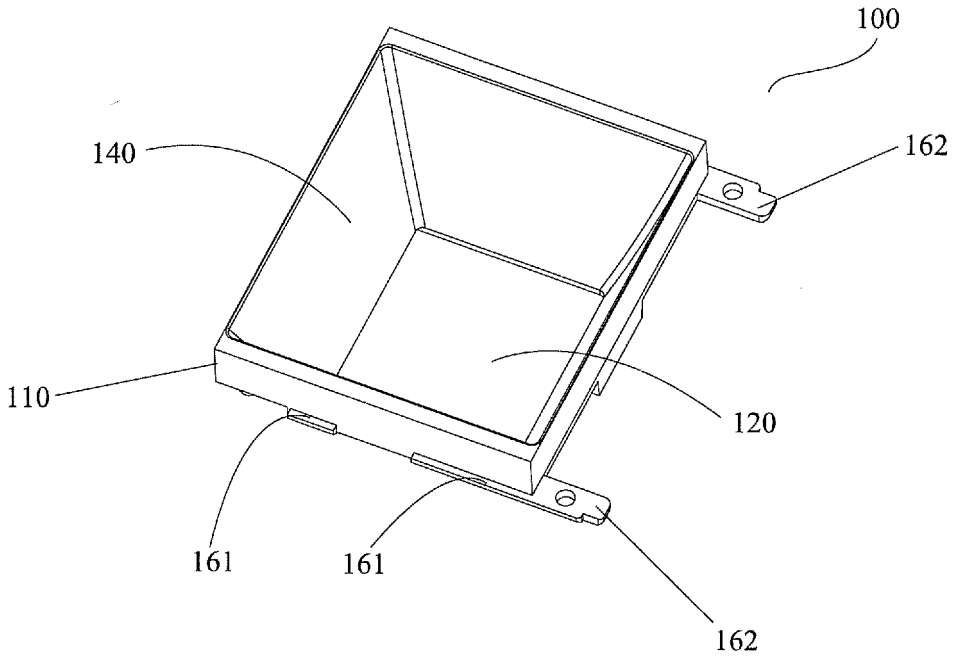
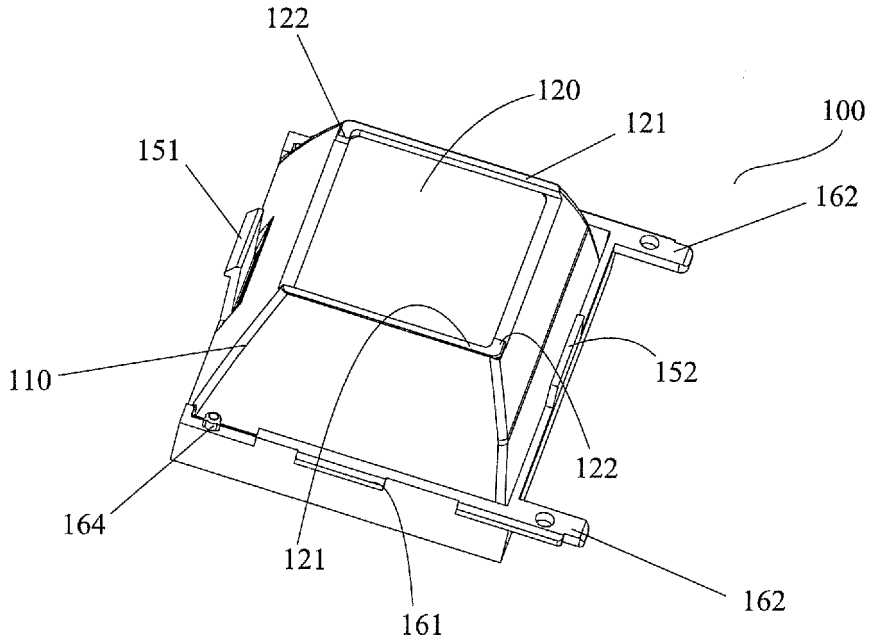

100
140
162
110
120
161
161
162

FIG. 1A


122
120
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100
151
162
110
152
122
164
121
161
162

FIG. 1B

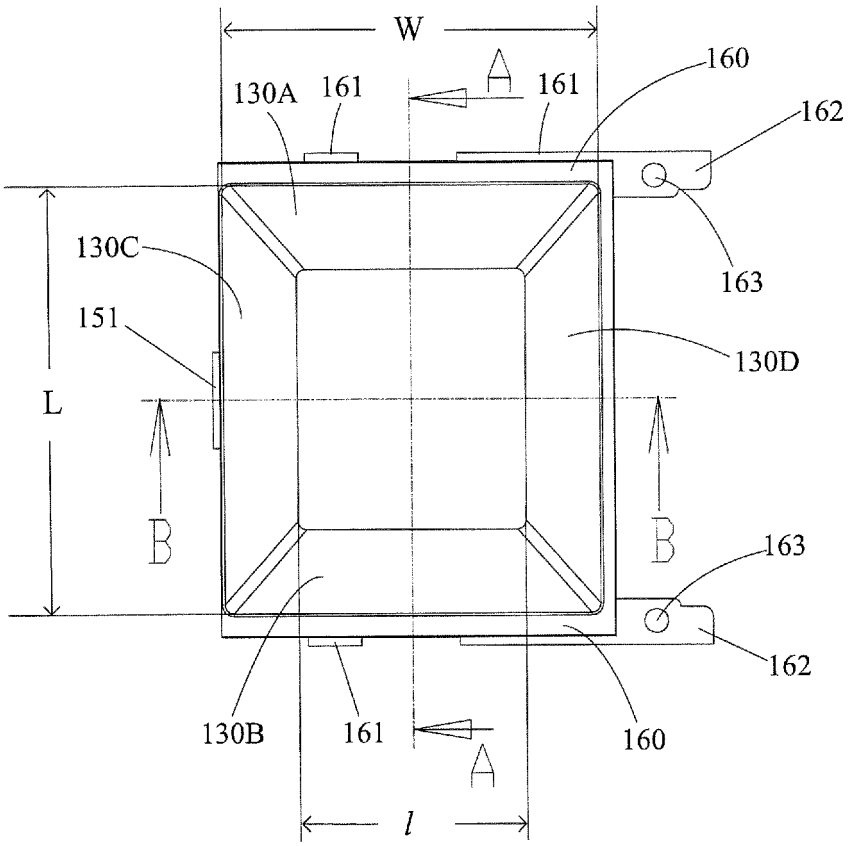

W
A
130A
161
161
160
162
130C
163
151
130D
L
B
B
163
162
130B
161
160
A
l

FIG. 2

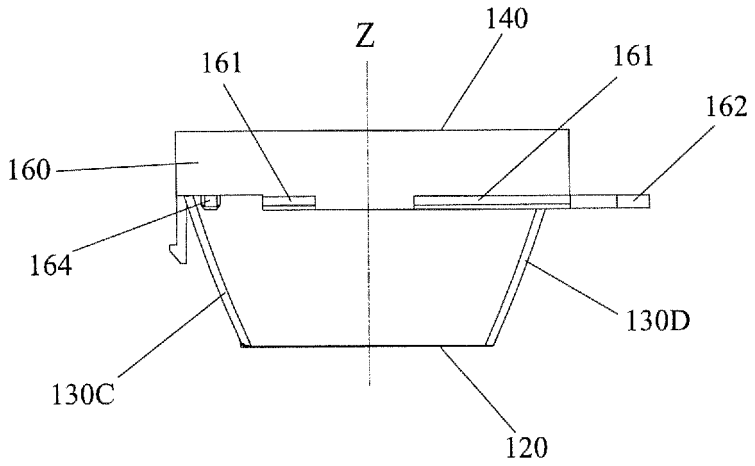

Z
140
161
161
162
160
164
130D
130C
120

FIG. 3

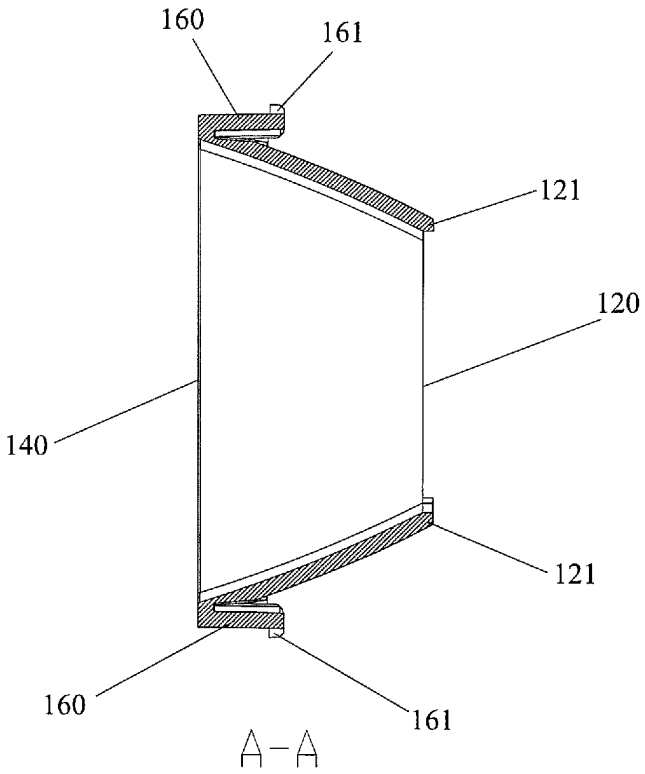


FIG. 4

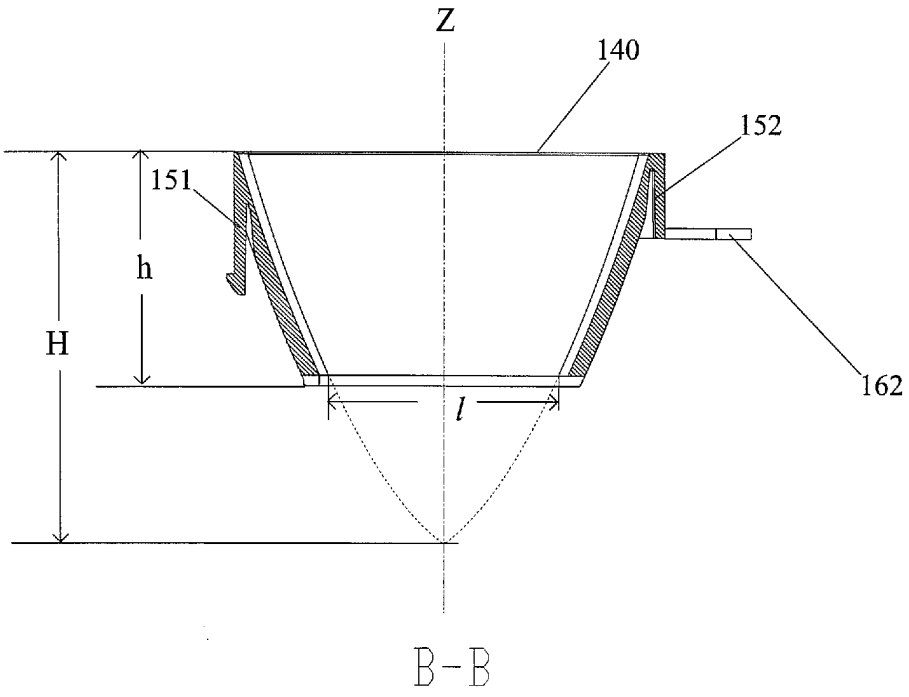


FIG. 5

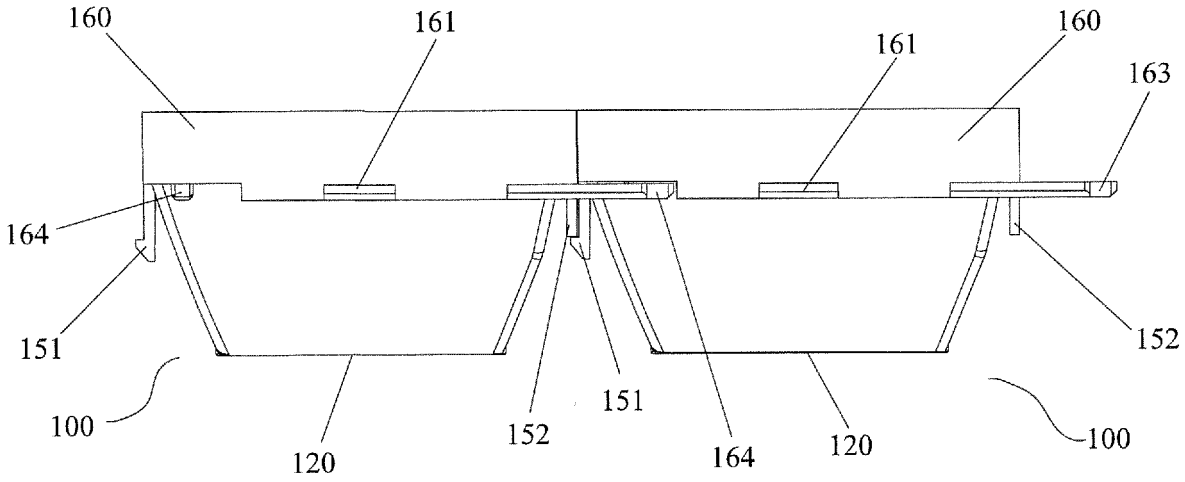

160
161
161
160
163
164
151
152
100
120
152
151
164
120
100

FIG. 6

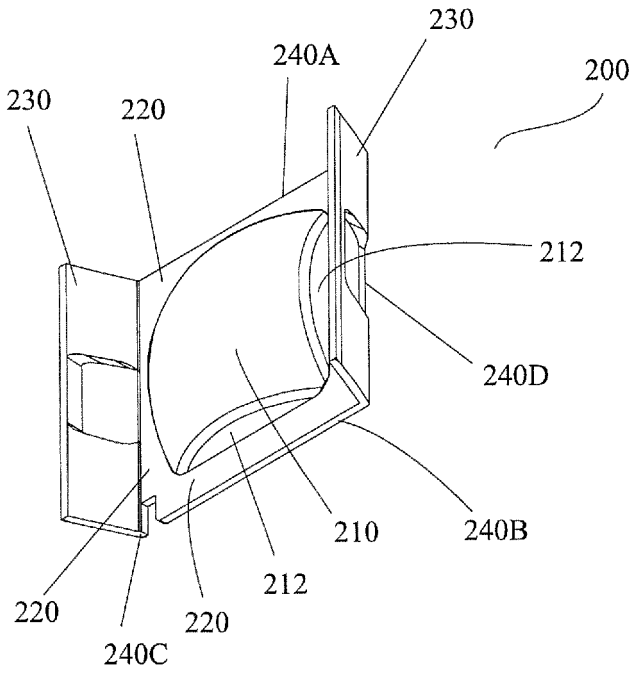

230
240A
200
230
220
212
240D
210
240B
212
220
220
240C

FIG. 7

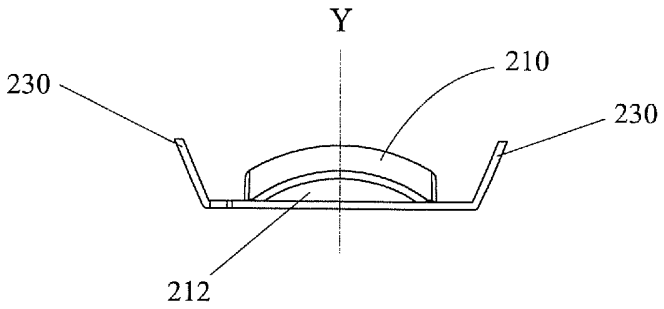


FIG. 8

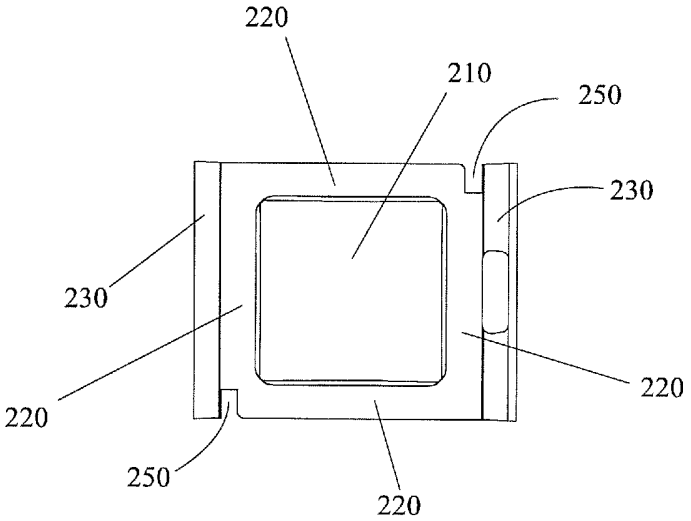


FIG. 9

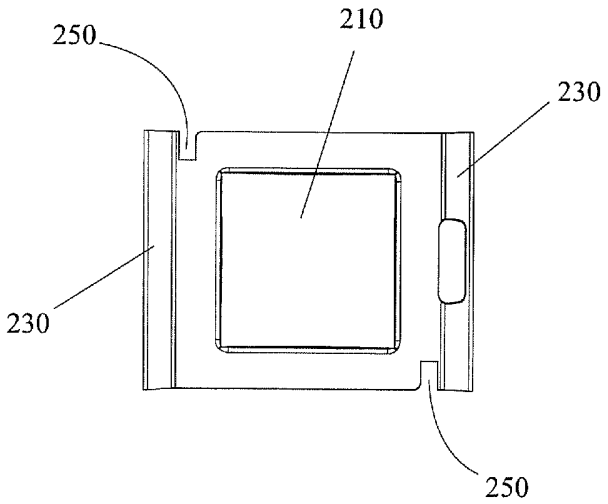
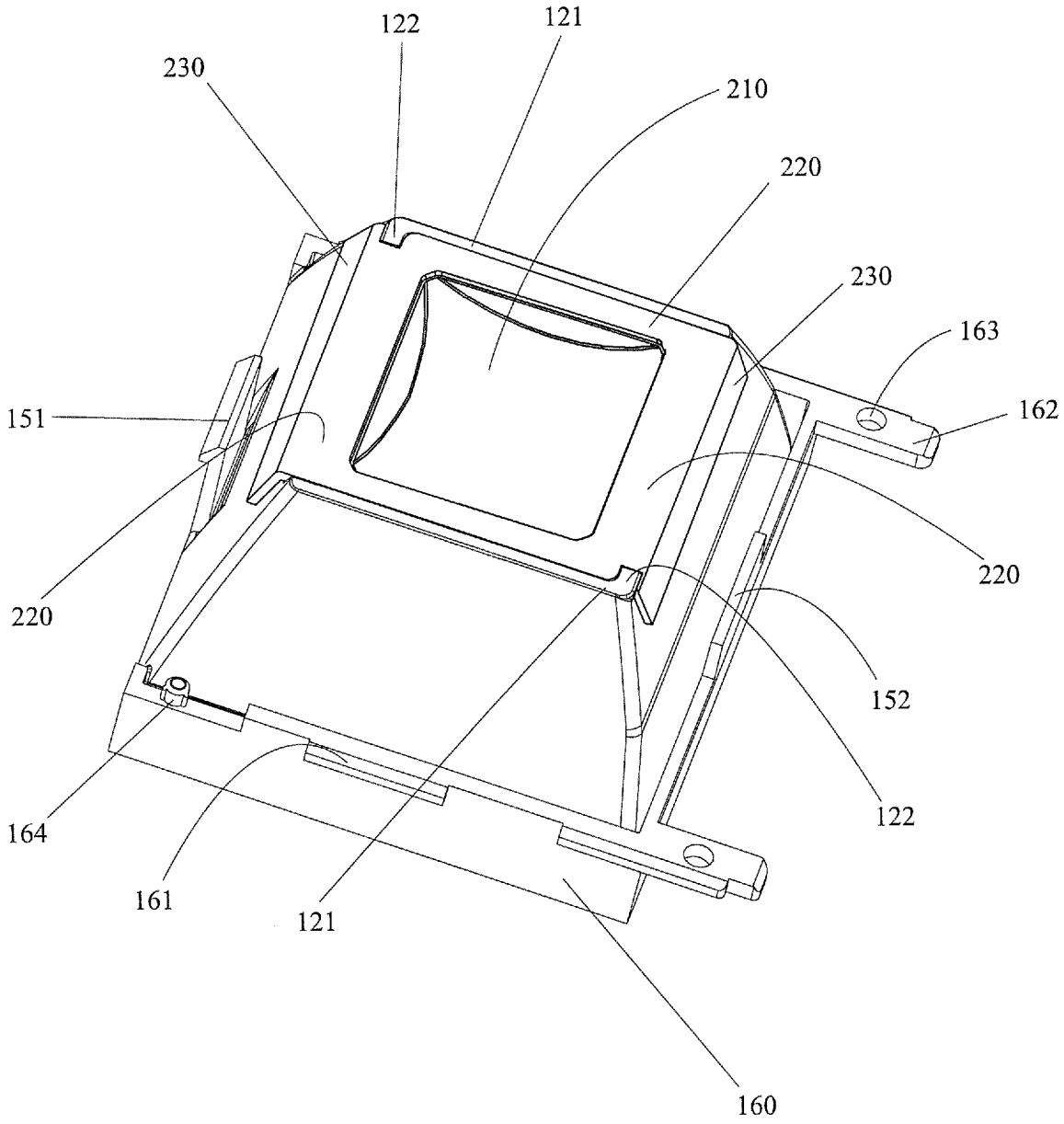


FIG. 10


122
121
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210
220
230
163
151
162
220
220
152
122
164
161
121
160

FIG. 11

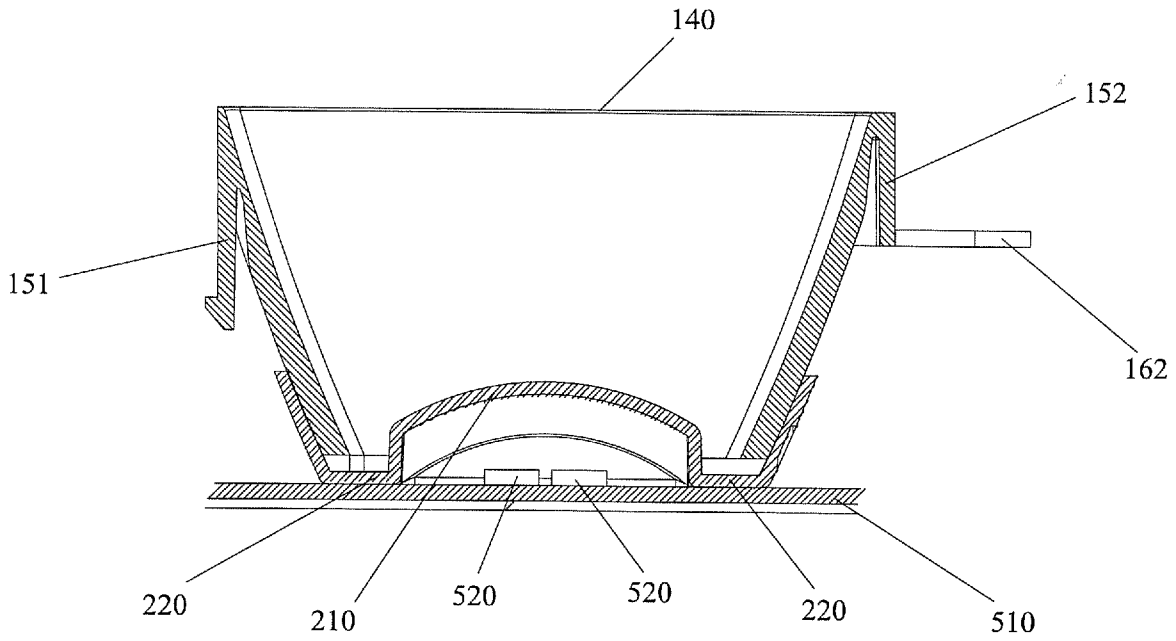
140
152
151
162
220
210
520
520
220
510

FIG. 12

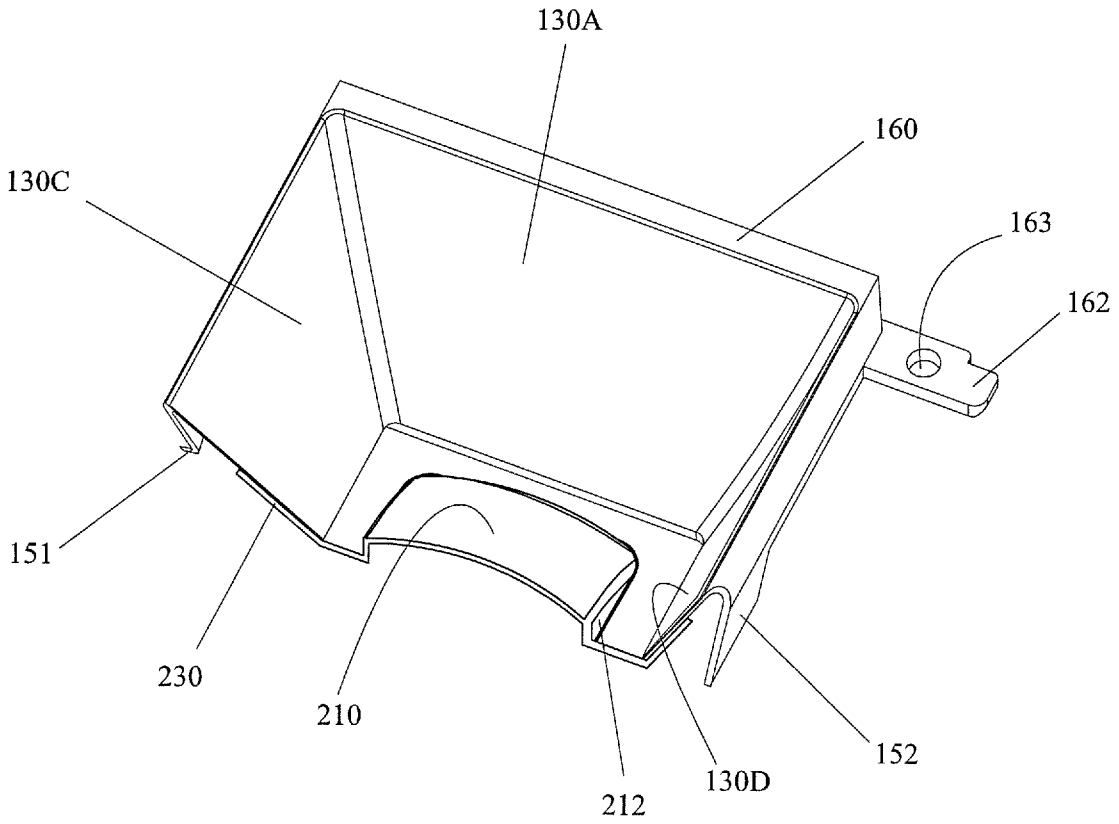
130A
160
130C
163
162
151
230
210
212
130D
152

FIG. 13

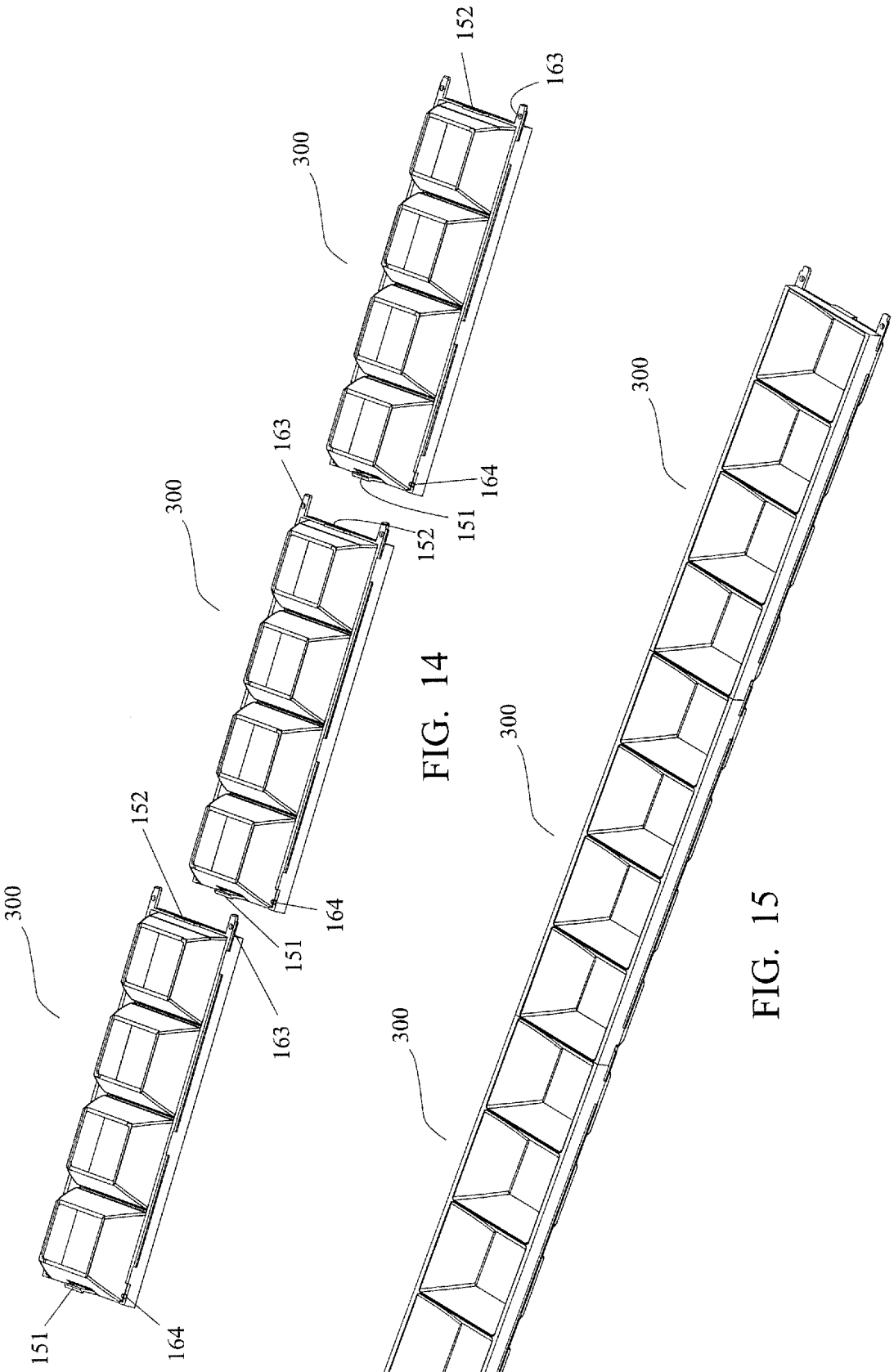
152
163
300
163
300
152
151
164
152
300
164
151
163
151
164

FIG. 14

300
300
300

FIG. 15

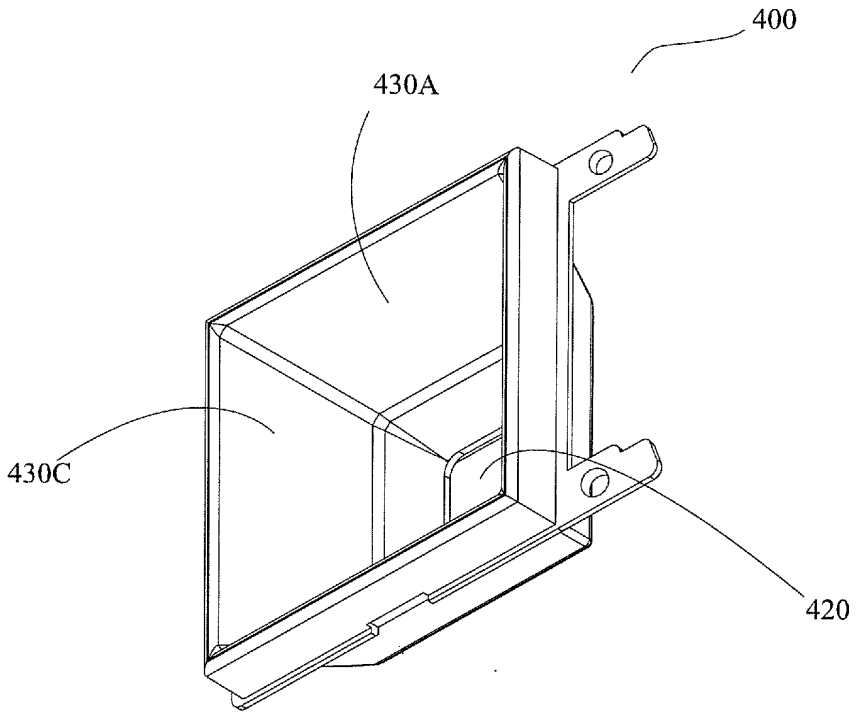

FIG. 16

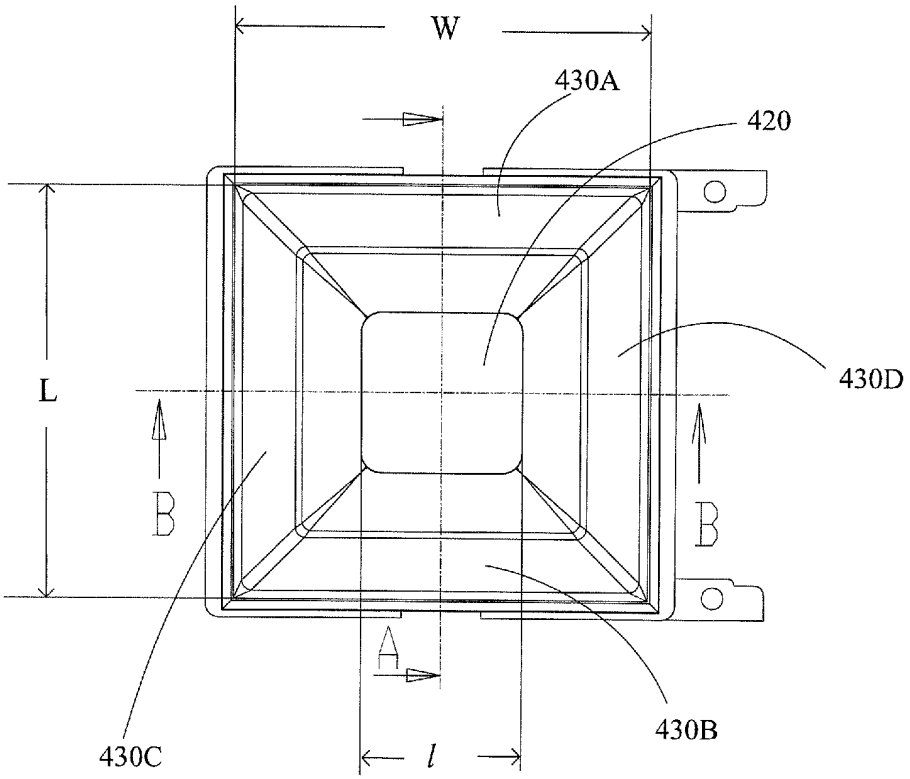

FIG. 17

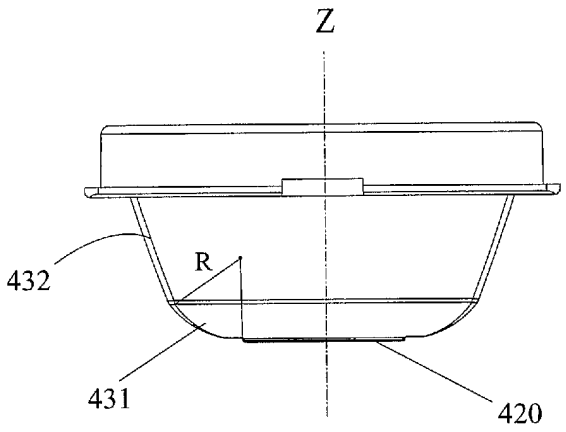

FIG. 18

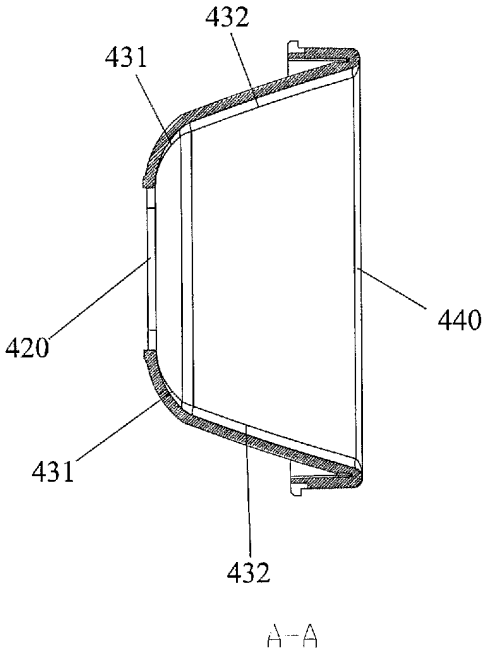

FIG. 19

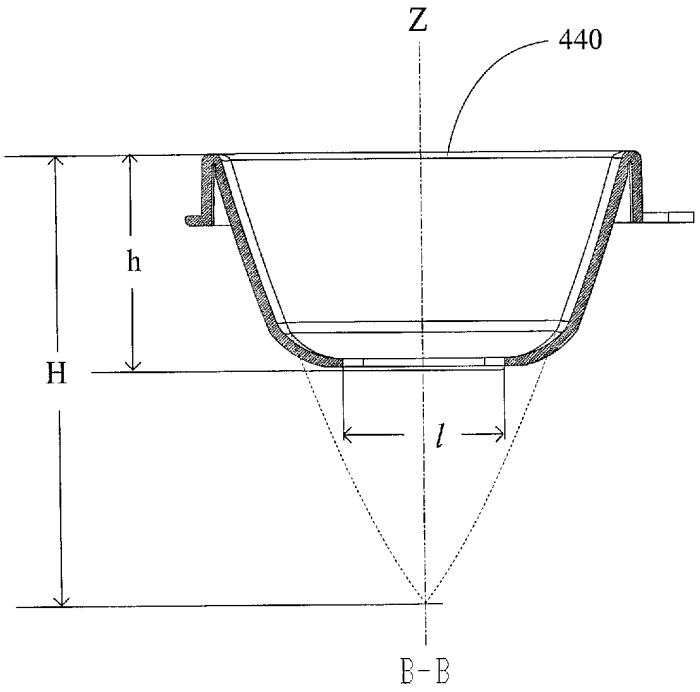

FIG. 20

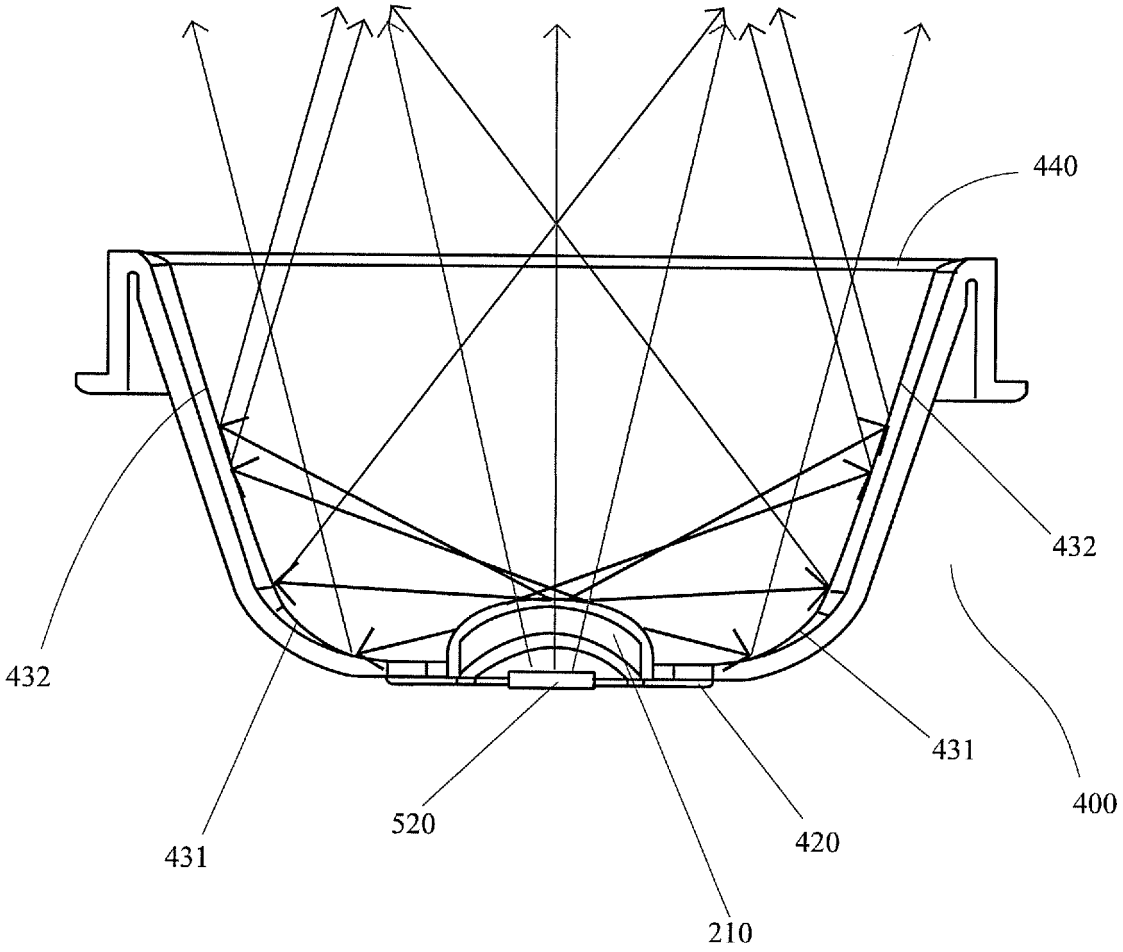

FIG. 21

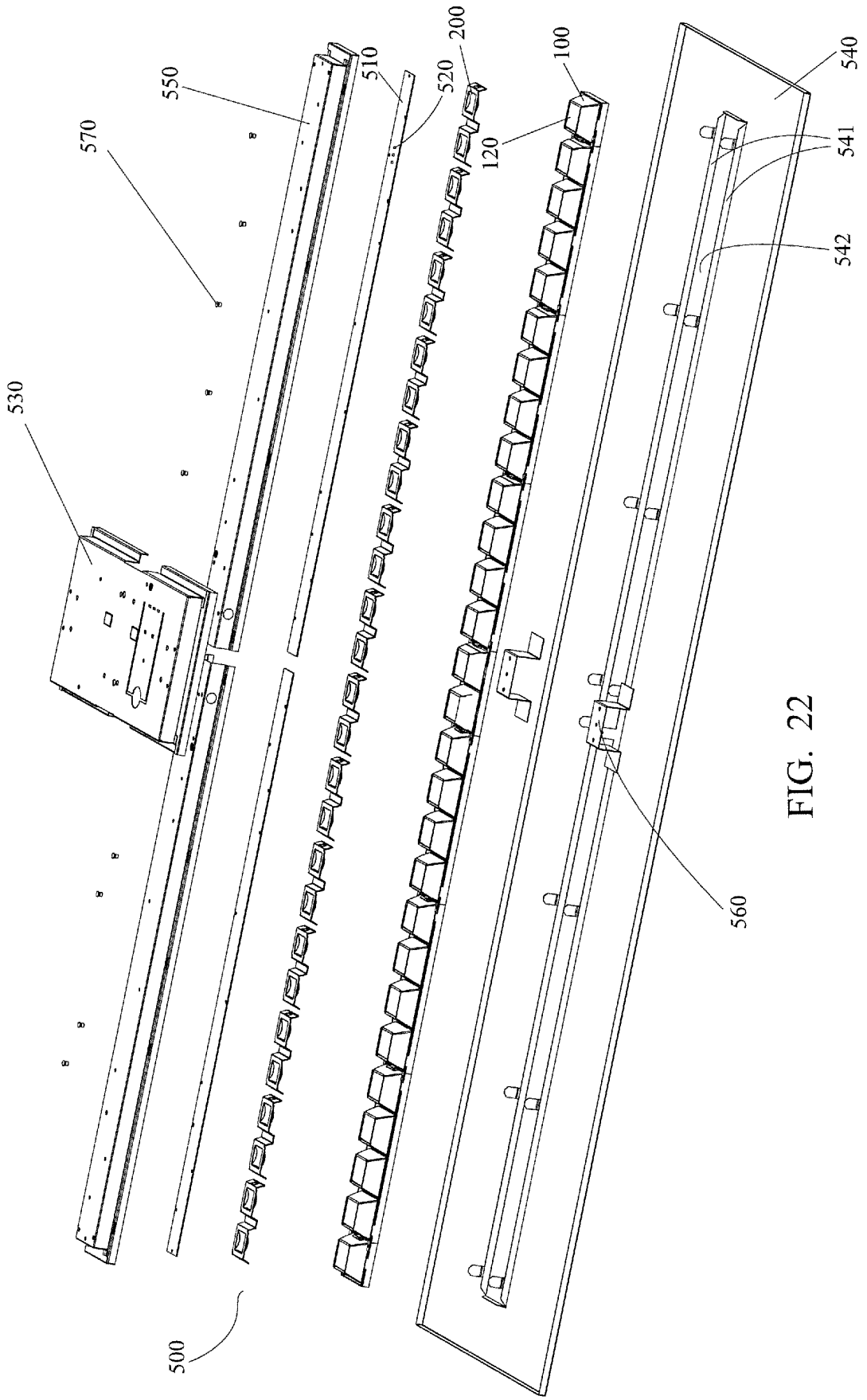

FIG. 22

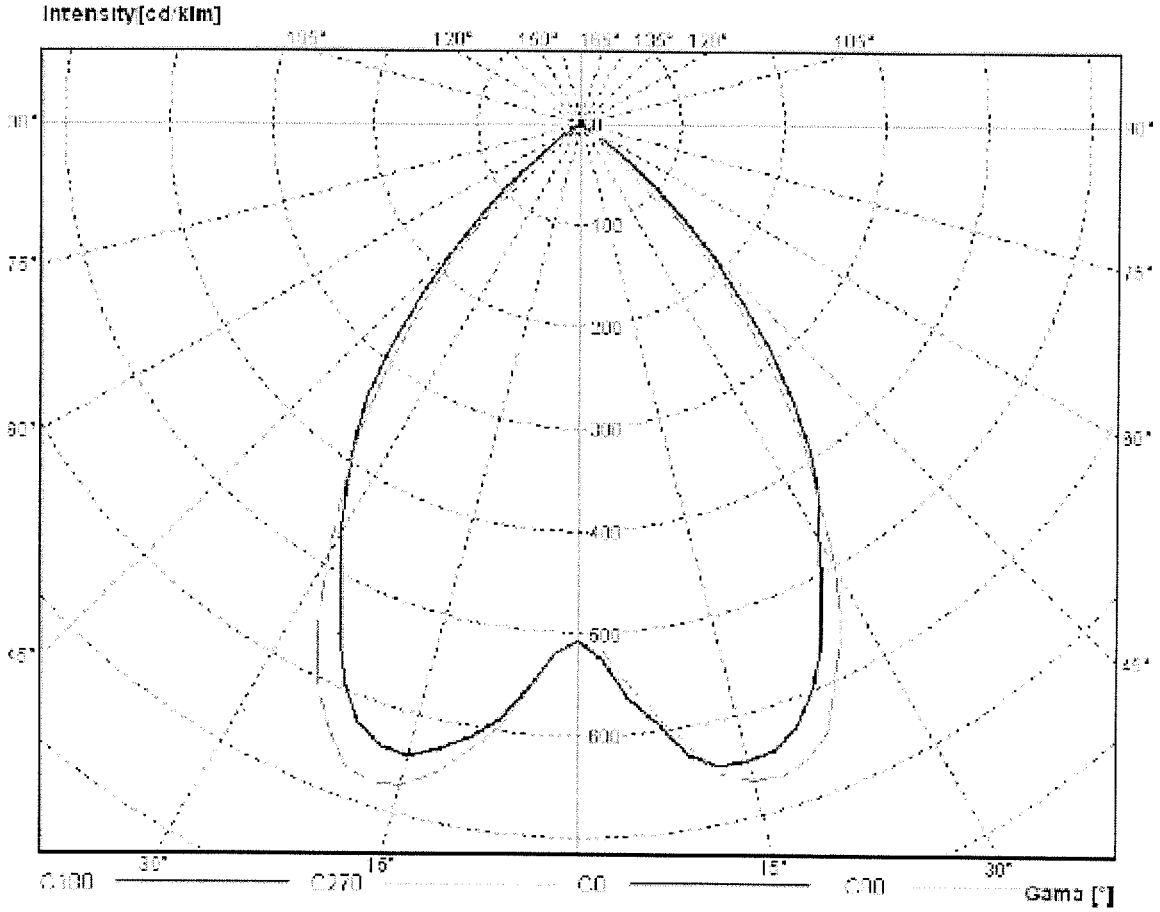
Intensity[cd/klm]
100
200
300
400
500
600
75°
60°
45°
30°
15°
C180
C270
C0
C90
Gama [°]

FIG. 23

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 201280040123 **[0006]**
- CN 201110299984 **[0007]**
- US 2009231856 A **[0010]**
- US 8845129 B **[0011]**
- JP 2011129405 B **[0012]**
- AU 496079 **[0012]**