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(54) **MULTI-LENS LED-ARRAY OPTIC SYSTEM**

OPTISCHES LED-ARRAYSYSTEM MIT MEHREREN LINSEN

SYSTÈME OPTIQUE À RÉSEAU DE DEL MULTILENTILLES

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Description

FIELD OF THE INVENTION

[0001] This invention relates generally to the field of LED lighting apparatus and, more particularly, to the field of LED-based optical systems for use in LED lighting fixtures for which there are particular light-distribution requirements, such as what is sometimes referred to as preferential-side light distribution - for roadway light fixtures and the like.

BACKGROUND OF THE INVENTION

[0002] In recent years, the use of light-emitting diodes (LEDs) for various common lighting purposes has increased, and this trend has accelerated as advances have been made in LEDs, LED arrays, and specific components. Indeed, lighting applications which previously had typically been served by fixtures using what are known as high-intensity discharge (HID) lamps are now being served by LED lighting fixtures. Such lighting applications include, among a good many others, roadway lighting, factory lighting, parking lot lighting, and commercial building lighting.

[0003] In many of such products, achieving high levels of illumination over large areas with specific light-distribution requirements is particularly important. One pertinent example is fixtures for roadway lighting, an application in which the fixtures are generally placed along roadway edges while light distribution is desired along a significant portion of roadway length and, of course, on the roadway itself - generally to the exclusion of significant light off the roadway.

[0004] Providing roadway light from light fixtures along the roadway may be referred to as "preferential-side" illumination. In such situations it is desirable to minimize the use of large complex reflectors and/or varying orientations of multiple light sources to achieve desired illumination patterns. Achieving preferential-side illumination, or other desired illumination patterns, by means of LED-based optical systems, particularly without resorting to large complex reflectors or other complex means is highly desirable.

US 2010/0302786 A1 discloses a lighting apparatus comprising the features of the preamble of claim 1.

SUMMARY OF THE INVENTION

[0005] The present invention is a multi-lens LED-array optical system and improved LED-based lighting apparatus which satisfies all of the above-noted objects and purposes.

[0006] According to this invention there is provided a lighting apparatus for preferential-side illumination having the features of claim 1. An embodiment includes optical surfaces as follows: (1) a first optical surface which is a first-lens outer surface configured to refract light from

the emitter; (2) a second optical surface which is a second-lens inner surface spaced from the first optical surface and having (a) a refracting portion surrounding the first optical surface and including front and back sectors configured differently from one another, and (b) a reflecting portion around the back sector, the reflecting portion positioned to receive light refracted by the back sector for total internal reflection (TIR) toward the preferential side; and (3) a third optical surface which is a second-lens outer surface configured to refract light from the second optical surface toward the preferential side.

[0007] In certain embodiments, the first lens is configured such that the first optical surface refracts LED-emitted light toward the preferential side. In some of such embodiments, the first optical surface is shaped for refraction of LED-emitted light toward the preferential side, while in others of such embodiments, the first optical surface has a centerline offset from the emitter axis toward the preferential side. In embodiments of the latter type, the first optical surface may be shaped for refraction of LED-emitted light toward the preferential side.

[0008] In certain embodiments, the front sector of the refracting portion of the second optical surface has a substantially smooth surface configuration extending to the juncture of the front and back sectors. In such situations, it is preferred that the back sector of the refracting portion of the second optical surface include at least a pair of surface portions transverse to each other.

[0009] In some embodiments, the back sector of the refracting portion of the second optical surface includes at least a pair of surface portions transverse to each other.

[0010] In some embodiments, the emitter includes an LED light source that includes a submount having an LED-populated area which has an aspect ratio greater than 1, and an array of LEDs on the LED-populated area, and the first lens is on the submount over the LED-populated area. The aspect ratio may be at least about 1.25, or even at least about 1.5, and even as much as at least about 2. The LED-populated area is preferably rectangular.

[0011] As used herein, the term "LED-populated area" means an area (*i.e.*, an area on the submount) the outer boundaries of which include the outermost edges of the outermost LEDs (of the LED array) in any direction. As used herein, the term "aspect ratio" means the ratio of the maximum cross-dimension of the LED-populated area to the maximum of the cross-dimensions orthogonal thereto.

[0012] As used herein, the term "emitter axis" means the line orthogonal to the plane defined by the LED-populated area and passing through the geometric center of the minimum-area rectangle bounding the LED-populated area, *i.e.*, the center of the rectangle of minimum area which includes all of the LED-populated area.

[0013] Another embodiment shows a lighting apparatus for preferential-side illumination, that includes: (1) a plurality of arrays of light-emitting diodes (LEDs) spaced

along a circuit board, each array having first and second maximum cross-dimensions orthogonal to one another, the first maximum cross-dimension being greater than the second maximum cross-dimension, and each LED array defining a light-emission axis; (2) a plurality of first lenses each over a corresponding array of LEDs, each first lens having an outer surface configured to refract light from its corresponding LED array; and (3) a plurality of second lenses each spaced over a corresponding one of the first lenses, each second lens having (a) an inner surface configured to direct light toward the preferential side from its corresponding first-lens outer surface, and (b) an outer surface configured to refract light toward the preferential side from the inner surface.

[0014] In such embodiments, each first lens preferably refracts LED-emitted light toward the preferential side. In some of such embodiments, each first lens is shaped for refraction of LED-emitted light toward the preferential side. In others of such embodiments, the outer surface of each first lens has a centerline offset from the corresponding light-emission axis toward the preferential side; in these embodiments, the outer surface of the first lens directs LED-emitted light toward the preferential side.

[0015] In most embodiments of this invention, each first lens is overmolded over its corresponding LED array, forming what is sometimes referred to as an LED package.

[0016] In certain embodiments, the plurality of LED arrays are mounted on a common submount. In certain other embodiments, LED array is on a submount and each of the submounts is mounted on the circuit board.

[0017] In certain embodiments, the plurality of second lenses are portions of a one-piece lensing member.

[0018] Referring again to the LED-populated areas, the spacing and arrangement of the LEDs on each LED-populated area may be such that the total LED area is at least about one-third of the LED-populated area. More specifically, the spacing and arrangement of the LEDs may be such that the total LED area is at least about two-thirds of the LED-populated area, or even as much as at least about 90% of the LED-populated area.

[0019] As used herein, the term "total LED area" means the sum of the submount areas immediately beneath each of the LEDs of the LED array.

[0020] In certain embodiments, the spacing between LEDs of the array is no more than about 1 millimeter (mm), or as little as no more than about 0.5 mm, or in some cases no more than about 0.1 mm. In some instances, the spacing is no more than about 0.075 mm, and even no more than about 0.05 mm.

[0021] Another embodiment shows a lighting apparatus comprising (1) a plurality of arrays of light-emitting diodes (LEDs) spaced along a circuit board, each array having first and second maximum cross-dimensions orthogonal to one another, the first maximum cross-dimension being greater than the second maximum cross-dimension, and each LED array defining a light-emission axis; (2) a plurality of first lenses each over a correspond-

ing array of LEDs, each first lens having an outer surface configured to refract light from its corresponding LED array; and (3) a plurality of second lenses each spaced over a corresponding one of the first lenses, each second lens having an inner surface and an outer surface which is configured to refract light from the inner surface.

[0022] As already noted, the plurality of LED arrays may be mounted to a submount, each to a common submount or, more particularly, each LED on its own submount, with each of the submounts being mounted on the circuit board. And, as noted, each first lens may be overmolded over each LED array. And, as also noted above, the plurality of second lenses may be portions of a one-piece lensing member.

[0023] In certain preferred embodiments, the first lens will have an outer surface configured to direct LED-emitted light toward the preferential side.

[0024] Still other embodiments show a lighting apparatus including (1) a plurality of arrays of LEDs spaced along a circuit board, each array having first and second maximum cross-dimensions orthogonal to one another, the first maximum cross-dimension being greater than the second maximum cross-dimension, and each LED array defining a light-emission axis; and (2) a plurality of lenses each over a corresponding array of LEDs, each lens having an outer surface configured to refract light from its corresponding LED array.

[0025] Yet another embodiment discloses a lighting apparatus including (1) an LED light source including a submount having an LED-populated area which has an aspect ratio greater than 1, the LED-populated area having an array of LEDs thereon, (2) a first lens on the submount over the LED array and having an outer surface configured to refract light from the LED array, and (3) a second lens spaced over the first lens, the second lens having an inner surface and an outer surface which is configured to refract light from the inner surface.

[0026] Another embodiment shows a lighting apparatus for preferential-side illumination, the apparatus including an LED light source with an axis and having an asymmetric primary lens over the LED light source and an asymmetric secondary lens spaced over the primary lens.

[0027] The term "asymmetric," as used herein with respect to lenses, when unmodified by any further limiting description, refers to a lens shape which is not rotationally symmetric about any axis perpendicular to its base plane. Types of asymmetric lenses include without limitation bilaterally symmetric lenses.

[0028] In descriptions of the invention, including in the claims below, the terms "comprising," "including" and "having" (each in their various forms) and the term "with" are each to be understood as being open-ended, rather than limiting, terms.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

FIGURE 1 is an enlarged cross-sectional perspective view of one embodiment of the inventive lighting apparatus.

FIGURE 2 is a perspective view of the lighting apparatus including a plurality of the optical systems of FIGURE 1.

FIGURE 3 is an enlarged perspective view of an embodiment of the LED package including an array of eight LEDs and an asymmetric primary lens overmolded over the LED array.

FIGURE 4 is a cross-sectional side view of the LED package of FIGURE 3.

FIGURE 5 is an enlarged plan view of the LED package of FIGURE 3.

FIGURE 6 is an enlarged plan view of the LED array of the LED package of FIGURE 3 and showing main dimensions of the LED array.

FIGURES 7 and 8 are enlarged plan views of alternative LED arrays according to the present invention and having asymmetric shapes.

FIGURES 9 and 10 are enlarged plan views of yet more alternative LED arrays each configured according to the present invention.

FIGURE 11 is a perspective view of a plurality of LED light sources of this invention on a common sub-mount.

FIGURE 12 is an enlarged perspective view of an embodiment of the LED package including an array of forty-eight LEDs and an asymmetric primary lens overmolded over the LED array.

FIGURE 13 is a transparent outer-surface perspective view of a single-piece lensing member.

FIGURE 14 is a transparent inner-surface perspective view of a single-piece lensing member of FIGURE 13.

FIGURE 15 is a non-transparent outer-surface perspective view of the single-piece lensing member of FIGURE 13.

FIGURE 16 is a non-transparent outer-surface plan view of the single-piece lensing member of FIGURE 13.

FIGURE 17 is a non-transparent back view of the single-piece lensing member of FIGURE 13.

FIGURE 18 is a non-transparent side view of the single-piece lensing member of FIGURE 13.

FIGURE 19 is an enlarged non-transparent cross-sectional side view of the optical system of FIGURE 1.

FIGURE 20 is an enlarged perspective view of another embodiment of the inventive lighting apparatus including an optical system with a hemispherical first optical surface and asymmetric second and third optical surfaces.

FIGURE 21 is an enlarged non-transparent cross-sectional side view of the optical system of FIGURE 19.

FIGURE 22 is an enlarged transparent plan view of the lighting apparatus of FIGURE 19.

FIGURE 23 is an enlarged transparent cross-sectional side view of the optical system of FIGURE 19. FIGURE 24 is an enlarged cross-sectional side view of the lighting apparatus of FIGURE 19 showing LED-light refraction toward the preferential side and the secondary lens as a separate piece.

FIGURE 25 is an enlarged cross-sectional perspective view of the lighting apparatus of FIGURE 25 showing second-lens direction of LED light which is emitted toward a non-preferential side.

FIGURE 26 is an enlarged fragmentary cross-sectional side view of the lighting apparatus of FIGURE 25.

FIGURE 27 is an enlarged plan view of still another alternative configuration of an LED array.

FIGURE 27A is an exemplary illustration of outer boundaries of an LED-populated area of the LED array of FIGURE 27.

FIGURE 27B is an exemplary illustration of location of an emitter axis of LED array of FIGURE 27, and is an exemplary illustration of two orthogonal maximum cross-dimensions for the purpose of determination of an aspect ratio of an LED-populated area of FIGURE 27A.

FIGURE 28 is a transparent outer-surface perspective view of an alternative embodiment of the secondary lens.

FIGURE 29 is a transparent inner-surface perspective view of the secondary lens of FIGURE 28.

FIGURE 30 is a non-transparent outer-surface plan view of the lens of FIGURE 28.

FIGURE 31 is a non-transparent inner-surface plan view of the secondary lens of FIGURE 28.

FIGURE 32 is a front-to-back sectional view of the lens of FIGURE 28 and illustrating forward and rearward light distributions.

FIGURE 33 is a side-to-side sectional view of the lens of FIGURE 28 and illustrating lateral light distribution.

FIGURE 34 is a two-dimensional ISO plot of illumination intensity distribution by the lens of FIGURE 28 on an illuminated surface substantially normal to the emitter axis.

FIGURE 35 is a polar intensity distribution in a plane which includes the emitter axis, illustrating light directed as shown in FIGURE 33.

FIGURE 36 is a polar intensity distribution in a plane which includes the emitter axis and is substantially orthogonal the plane of FIGURE 35, illustrating light directed as shown in FIGURE 32.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0030] FIGURES 1-26 illustrate a multi-lens LED-array optical system of an improved LED-based lighting apparatus.

[0031] FIGURE 1 shows lighting apparatus 10 for illu-

mination toward a preferential side 2 from an LED light emitter 20 having an axis 21. Lighting apparatus 10 has a first lens 30 over emitter 20 and a second lens 40 over first lens 30. The first lens is also sometimes referred to as a "primary" lens; and the second lens is also sometimes referred to as a "secondary" lens. Lighting apparatus 10 includes a first optical surface 31, a second optical surface 50 and a third optical surface 43. First optical surface 31 is an outer surface 32 of first lens 30 and is configured to refract light from emitter 20. Second optical surface 50 is an inner surface 41 of second lens 40. Second optical surface 50 is spaced from first optical surface 31 and has a refracting portion 51 and a reflecting portion 54, as best seen in FIGURES 1, 2, 13 and 14 and 19-25.

[0032] FIGURES 1, 2 and 19 best show refracting portion 51 surrounding first optical surface 31 and including front sector 52 and back sector 53 configured differently from one another. Reflecting portion 54 is around back sector 53 and is positioned to receive light refracted by the back sector 53 for total internal reflection (TIR) toward the preferential side 2. It is seen in FIGURES 1, 2 and 13-25 that third optical surface 43 is a second-lens outer surface 42 configured to refract light from second optical surface 50 toward the preferential side 2.

[0033] FIGURES 1-7 illustrate first lens 30 as configured such that first optical surface 31 refracts LED-emitted light toward preferential side 2. FIGURES 1-5 show first optical surface 31 shaped for refraction of LED-emitted light toward the preferential side 2. FIGURES 3-7 show first optical surface 31 having a centerline 33 offset from emitter axis 21 toward preferential side 2. FIGURES 1-5 show LED emitters 20 which have both first optical surface 31 having its centerline 33 offset from emitter axis 21 toward preferential side 2 and also being shaped for refraction of LED-emitted light toward preferential side 2.

[0034] FIGURES 1, 13, 14 and 19 best illustrate that front sector 52 of refracting portion 51 of second optical surface 50 has a substantially smooth surface configuration extending to juncture 55 of front and back sectors 52 and 53. It is also seen in these FIGURES that back sector 53 includes a pair of surface portions 53a and 53b transverse to each other.

[0035] FIGURES 3-12 show that emitter 20 includes an LED light source that includes a submount 22 having an array of LEDs 24 on an LED-populated area 23 which has an aspect ratio greater than 1. LED-populated area 23 also has a first maximum cross-dimension 15 and a second maximum cross-dimension 16 orthogonal to one another, first maximum cross-dimension 15 being greater than second maximum cross-dimension 16.

[0036] FIGURES 3 and 4 best show first lens 30 on submount 22 and overmolded over LED-populated area 23.

[0037] FIGURES 5-12 and 27 illustrate various configurations of LED-populated areas 23a-h with aspect ratios of at least about 1.25, at least about 1.5 and at least about 2. FIGURES 3-6 show LED emitter 20a including rectan-

gular LED-populated area 23a with eight LEDs 14 arranged in two rows of four LEDs 14 in each row. In FIGURE 6, dimensions are indicated in millimeters in brackets, the first maximum cross dimension being [2.08], *i.e.*, 2.08 millimeters, and are indicated in inches under the brackets. FIGURE 12 shows LED emitter 20g including forty-eight LEDs 14 arranged in four rows of twelve LEDs 14 in each row. The aspect ratios of LED-populated area 23a is about 2 and aspect ratio of LED-populated area 23g is about 3.

[0038] FIGURES 7 and 8 illustrate LED arrays 23b and 23c with LEDs 14 arranged in asymmetric configurations each having aspect ratio greater than 1.

[0039] FIGURE 27A illustrates an example of outer boundaries of LED-populated area 23h. FIGURE 27B is an exemplary illustration of two orthogonal maximum cross-dimensions for the purpose of determination of an aspect ratio of a particular LED-populated area 23. FIGURE 27B is also an exemplary illustration of a position of emitter axis 21 passing through geometric center 21a of minimum-area rectangle 21b bounding LED-populated area 23.

[0040] FIGURES 6-10 also show that the spacing and arrangement of the LEDs 14 on each LED-populated area 23 is such that the total LED area is at least about one-third of LED-populated area 23, as seen in FIGURES 8 and 27. In FIGURE 7, the spacing and arrangement of the LEDs 14 are such that the total LED area is at least about two-thirds of LED-populated area 23b. In FIGURES 6, 9 and 10, the spacing and arrangement of the LEDs 14 are such that the total LED area is at least about 90% of LED-populated areas 23a, 23d and 23e.

[0041] FIGURE 8 shows the spacing between LEDs 14 of array 24c is about 0.1 mm. In FIGURE 6, the spacing between LEDs 14 of array 24a is about 0.075 mm. And, in FIGURE 9 the spacing between LEDs 14 of array 24d is about 0.05 mm.

[0042] FIGURE 2 further illustrates another aspect of this invention which is lighting apparatus 100 which includes a plurality of LED arrays 24 spaced along a circuit board 11, a plurality of first lenses 30 each over a corresponding LED array 24, and a plurality of second lenses 40 each spaced over a corresponding one of first lenses 30.

[0043] FIGURE 2 also shows each first lens configured to refract LED-emitted light toward preferential side 2 with outer surface 32 of each first lens 30 being shaped for refraction of LED-emitted light toward preferential side 2, as best shown in FIGURES 3 and 4, and having centerline 33 offset from corresponding light-emission axis 21 toward preferential side 2, as shown in FIGURES 4-6. In FIGURE 2, each of LED emitters 20 is in the form of what is sometimes referred to as an LED package which includes LED array 24 on submount 22a and first lens 30 overmolded on submount 22a over its corresponding LED array 24. FIGURE 2 further shows each of submounts 22a mounted on circuit board 11.

[0044] FIGURE 11 illustrates a plurality of LED arrays

24 mounted on a common submount 22 and a plurality of first lenses 30 overmolded on submount 22 over a respective one of LED arrays 24.

[0045] FIGURES 2 and 13-18 show the plurality of second lenses as portions of a one-piece lensing member 44. One-piece lensing member 44 including a set of alignment protrusions 45 extending from a circuit-board-adjacent surface 46 of lensing member 44, best seen in FIGURES 2, 13 and 14. It is also seen in FIGURE 2 that circuit board 11 has a set of alignment holes formed in an LED-supporting surface 13 of circuit board 11 complementary to set alignment protrusions 45. Alignment protrusions 45 and alignment holes are engaged to accurately align secondary lenses 40 over their corresponding primary lenses 30.

[0046] It is also seen in FIGURES 2, 13 and 14 that protrusions 45 are first and second protrusions 451 and 452 extending from a circuit-board-adjacent surface 46 of lensing member 44, and that alignment holes defined by circuit board 11 are first and second holes 121 and 122. First hole 121 is complementary in shape to first protrusion 451 to fix the position of lensing member 44 along circuit board 11. Second hole 122 receives second protrusion 452 to prevent rotation of lensing member 44 about first protrusion 451. Second 122 hole is elongate along a line extending between first and second holes 121 and 122 which facilitates engagement of the alignment features 45 and 121.

[0047] FIGURES 20-26 illustrate an alternative embodiment of lighting apparatus 10b which includes a hemispheric primary lens 30b and a separate-piece secondary lens 410 configured for refracting light from primary lens 30 toward preferential side 2 and creating an asymmetric illumination pattern such as type III or type IV light distribution patterns used for roadway lighting, as established by The Illumination Engineering Society (IES). Lens 410 has an inner surface 41b spaced from first optical surface 31b and has a refracting portion 51b and a reflecting portion 54b. FIGURES 20 and 22 best show refracting portion 51b surrounding first optical surface 31b and including front sector 52b and back sector 53b configured differently from one another. Reflecting portion 54b is around back sector 53b.

[0048] FIGURES 24-26 illustrate that reflecting portion 54b is positioned to receive light refracted by the back sector 53b for total internal reflection (TIR) toward outer surface 42b. It is seen in FIGURES 20, 24-26 that outer surface 42b is configured to further direct light from inner surface 41b toward preferential side. Lens 410 is described in more detail in the parent Application Serial No. 12/475,194, filed May 29, 2009.

[0049] FIGURES 1 and 19 best illustrate lighting apparatus 10 for preferential-side illumination with first lens 30 configured to direct LED-emitted light toward preferential side 2 and second lens 40 configured to further direct the light toward preferential side 2. Both first (or primary) lens 30 and second (or secondary) lens 40 are shown as having asymmetric shapes with preferential

direction being a one side direction with respect to emitter axis 21.

[0050] FIGURES 28-36 illustrate yet another alternative embodiment of lighting apparatus 10c with a separate-piece secondary lens 411 configured for directing a majority of light from primary lens 30c into an elongate distribution 3 with some lateral light along the sides of elongate distribution 3, as illustrated in FIGURES 34-36, such that preferential side 2a are opposite sides along a longitudinal axial plane extending through emitter axis 21 and creating an non-rotationally symmetric elongate illumination pattern which is bilaterally symmetric in two main orthogonal directions. The illumination pattern produced by lens 411 is useful for tall elongate passageways such as warehouse aisles. Lens 411 has an inner surface 41c spaced from primary lens surface 30c and has a refracting surface portion 51c and a reflecting surface portion 54c.

[0051] FIGURES 28, 29 and 31 best show refracting portion 51c surrounding primary lens 30c and including front and back portions 52c and a pair of opposite lateral portions 53c, front and back portions 52c being substantially orthogonal to and extending between lateral portions 52c. Reflecting portion 54c substantially surrounds refracting surface portion 51c.

[0052] FIGURES 32 and 33 illustrate that reflecting portion 54c is positioned to receive substantially all forward and rearward light (best shown in FIGURE 32) and a portion of lateral light (best shown in FIGURE 33). Reflective surface portion 54c is configured for total internal reflection (TIR) of the received light toward outer surface 42c. It is also seen in FIGURES 32 and 33 that outer surface 42c receives light from refracting inner surface 51c and from reflecting surface 54c and forms elongate light distribution 3 (shown in FIGURES 34-36) by refracting such received light. Lens 411 is described in more detail in Application Serial No. 13/408,882, filed February 29, 2012.

Claims

1. Lighting apparatus (10) for preferential-side (2) illumination, the apparatus (10) including an LED light emitter (20) having an axis (21) which is a line orthogonal to a plane defined by the light emitter (20) and passing through the geometric center of an area of the emitter on the plane, the apparatus (10) comprising:

- a first lens (30) over the emitter (20) and configured to preferentially direct LED-emitted light toward the preferential side (2); and
- a second lens (40) spaced over the first lens (30) and configured to further preferentially direct the light toward the preferential side (2)

characterized in that

- the first lens (30) has a centerline (33) which is offset from the emitter axis (21) toward the preferential side (2).
2. The lighting apparatus (10) of claim 1 wherein the first lens (30) has an outer surface (32) configured to direct LED-emitted light toward the preferential side (2).
 3. The lighting apparatus (10) of claim 1 wherein the second lens (40) includes:
 - an inner surface (41) configured to preferentially direct light from the first-lens (30) outer surface (32); and
 - an outer surface (42) configured to direct light toward the preferential side (2) from the inner surface (41).
 4. The lighting apparatus (10) of claim 3 wherein the inner surface (41) of the second lens (40) includes:
 - a refracting portion (51; 51b) surrounding the first lens (30) and including front and back sectors (52, 53; 52b, 53b); and
 - a reflecting portion (54; 54b) around the back sector (53; 53b), the reflecting portion (54; 54b) positioned to receive light refracted by the back sector (53; 53b) for total internal reflection (TIR) toward the preferential side (2).
 5. The lighting apparatus (10) of claim 4 wherein the back sector (53; 53b) of the refracting portion (51; 51b) of the second lens (40) includes at least a pair of surface portions (53a, 53b) transverse to each other.
 6. The lighting apparatus (10) of claim 5 wherein the front sector (52; 52b) of the refracting portion (51; 51b) of the second lens (40) has a substantially smooth surface configuration extending to the juncture (55) of the front and back sectors (52, 53; 52b, 53b).
 7. The lighting apparatus (10) of claim 4 wherein the refracting portion (51; 51b) of the second-lens (40) inner surface (41) includes front and back sectors (52b, 53b) configured differently from one another.
 8. The lighting apparatus (10) of claim 1 wherein:
 - the emitter (20) includes an LED light source which includes a submount (22) having an LED-populated area (23) which has an aspect ratio greater than 1, and an array of LEDs (24) on the LED-populated area (23); and
 - the first lens (30) is on the submount (22) over the LED-populated area (23).
 9. The lighting apparatus (10) of claim 8 wherein the LED-populated area (23) is rectangular.
 10. The LED lighting apparatus (10) of claim 8 wherein the first lens (30) is overmolded on the submount (22).
 11. The lighting apparatus (10) of claim 1 further comprising:
 - a plurality of arrays of light-emitting diodes (LEDs) (24) spaced along a circuit board (11), each array (24) having first and second maximum cross-dimensions (15, 16) orthogonal to one another, the first maximum cross-dimension (15) being greater than the second maximum cross-dimension (16), and each LED array (24) defining a light-emission axis (21);
 - a plurality of first lenses (30) each over a corresponding array of LEDs (24), each first lens (30) having an outer surface (32) configured to refract light from its corresponding LED array (24); and
 - a plurality of second lenses (40) each spaced over a corresponding one of the first lenses (30), each second lens (40) having an inner surface (41) and an outer surface (42) which is configured to refract light from the inner surface (41).
 12. The lighting apparatus (10) of claim 11 wherein the plurality of LED arrays (24) are mounted on a common submount (22).
 13. The lighting apparatus (10) of claim 11 wherein each LED array (24) is on a submount (22) and each of the submounts (22) is mounted on the circuit board (11).
 14. The lighting apparatus (10) of claim 11 wherein each first lens (30) is overmolded over each LED array (24).
 15. The lighting apparatus (10) of claim 14 wherein each first lens (30) has an outer surface (32) configured to direct LED-emitted light toward the preferential side (2).

Patentansprüche

1. Beleuchtungseinrichtung (10) zum Ausleuchten einer bevorzugten Seite (2), wobei die Einrichtung (10) einen LED Lichtemitter (20) mit einer Achse (21) umfasst, die eine Linie senkrecht zu einer Ebene ist, die durch den Lichtemitter (20) definiert wird, und die durch den geometrischen Mittelpunkt eines Bereichs des Emitters auf der Ebene verläuft, wobei die Einrichtung (10) folgendes aufweist:

- eine erste Linse (30) über dem Emitter (20), die dazu eingerichtet ist, dass sie das von der LED emittierte Licht vorrangig in Richtung der bevorzugten Seite (2) lenkt; und
eine zweite Linse (40), die über der ersten Linse (30) beabstandet angeordnet und dazu eingerichtet ist, dass sie weiterhin das Licht vorrangig in Richtung der bevorzugten Seite (2) lenkt;
dadurch gekennzeichnet, dass
die erste Linse (30) eine Mittellinie (33) hat, die von der Emitter-Achse (21) in Richtung der bevorzugten Seite (2) versetzt ist.
2. Beleuchtungseinrichtung (10) nach Anspruch 1, wobei die erste Linse (30) eine Außenfläche (32) hat, die dazu eingerichtet ist, dass sie das von der LED emittierte Licht in Richtung der bevorzugten Seite (2) lenkt.
 3. Beleuchtungseinrichtung (10) nach Anspruch 1, wobei die zweite Linse (40) folgendes umfasst:

eine Innenfläche (41), die dazu eingerichtet ist, dass sie vorrangig Licht von der Außenfläche (32) der ersten Linse (30) lenkt; und
eine Außenfläche (42), die dazu eingerichtet ist, dass sie Licht von der Innenfläche (41) in Richtung der bevorzugten Seite (2) lenkt.
 4. Beleuchtungseinrichtung (10) nach Anspruch 3, wobei die Innenfläche (41) der zweiten Linse (40) folgendes umfasst:

einen lichtbrechenden Abschnitt (51; 51b), der die erste Linse (30) umgibt und vordere und hintere Sektoren (52, 53; 52b, 53b) umfasst; und
einen reflektierenden Abschnitt (54; 54b) um den hinteren Sektor (53; 53b), wobei der reflektierende Abschnitt (54; 54b) so angeordnet ist, dass er Licht empfängt, das von dem hinteren Sektor (53; 53b) zur Totalreflexion (TIR) in Richtung der bevorzugten Seite (2) gebrochen wird.
 5. Beleuchtungseinrichtung (10) nach Anspruch 4, wobei der hintere Sektor (53; 53b) des lichtbrechenden Abschnitts (51; 51b) der zweiten Linse (40) mindestens ein Paar quer zueinander verlaufender Oberflächenabschnitte (53a, 53b) aufweist.
 6. Beleuchtungseinrichtung (10) nach Anspruch 5, wobei der vordere Sektor (52; 52b) des lichtbrechenden Abschnitts (51; 51b) der zweiten Linse (40) eine im Wesentlichen glatte Oberflächenbeschaffenheit hat, die sich zum Verbindungsbereich (55) der vorderen und hinteren Sektoren (52, 53; 52b, 53b) erstreckt.
 7. Beleuchtungseinrichtung (10) nach Anspruch 4, wobei der lichtbrechende Abschnitt (51; 51 b) der Innenfläche (41) der zweiten Linse (40) vordere und hintere Sektoren (52b, 53b) umfasst, die unterschiedlich eingerichtet sind.
 8. Beleuchtungseinrichtung (10) nach Anspruch 1, wobei der Emitter (20) eine LED Lichtquelle umfasst, die einen Submount (22) mit einem mit LEDs bestückten Bereich (23), der ein Bildseitenverhältnis größer 1 hat, und ein Array aus LEDs (24) an dem mit LEDs bestückten Bereich (23) umfasst; und die erste Linse (30) an dem Submount (22) über dem mit LEDs bestückten Bereich (23) vorgesehen ist.
 9. Beleuchtungseinrichtung (10) nach Anspruch 8, wobei der mit LEDs bestückte Bereich (23) rechteckförmig ist.
 10. Beleuchtungseinrichtung (10) nach Anspruch 8, wobei die erste Linse (30) an dem Submount (22) mittels Spritzguss ausgebildet ist.
 11. Beleuchtungseinrichtung (10) nach Anspruch 1, weiterhin aufweisend
eine Vielzahl von Arrays aus lichtemittierenden Dioden (LEDs) (24), die entlang einer Platine (11) beabstandet sind, wobei jedes Array (24) erste und zweite maximale Querabmessungen (15, 16) senkrecht zueinander hat, wobei die erste maximale Querabmessung (15) größer als die zweite maximale Querabmessung (16) ist, und wobei jedes LED Array (24) eine Lichtemissionsachse (21) definiert; eine Vielzahl von ersten Linsen (30), von denen jede über einem entsprechenden Array aus LEDs (24) vorgesehen ist, wobei jede erste Linse (30) eine Außenfläche (32) hat, die dazu eingerichtet ist, dass sie Licht von dem ihr zugeordneten LED Array (24) bricht; und
eine Vielzahl von zweiten Linsen (40), von denen jede über einer entsprechenden der ersten Linsen (30) beabstandet angeordnet ist, wobei jede zweite Linse (40) eine Innenfläche (41) und eine Außenfläche (42) hat, die dazu eingerichtet ist, dass sie Licht von der Innenfläche (41) bricht.
 12. Beleuchtungseinrichtung (10) nach Anspruch 11, wobei die Vielzahl von LED Arrays (24) auf einem gemeinsamen Submount (22) angebracht ist.
 13. Beleuchtungseinrichtung (10) nach Anspruch 11, wobei jedes LED Array (24) auf einem Submount (22) vorgesehen ist und jeder Submount (22) auf der Platine (11) angebracht ist.
 14. Beleuchtungseinrichtung (10) nach Anspruch 11, wobei jede erste Linse (30) über jedem LED Array (24) mittels Spritzguss ausgebildet ist.

15. Beleuchtungseinrichtung (10) nach Anspruch 14, wobei jede erste Linse (30) eine Außenfläche (32) hat, die dazu eingerichtet ist, dass sie von der LED emittiertes Licht in Richtung der bevorzugten Seite (2) lenkt.

Revendications

1. Appareil d'éclairage (10) destiné à un éclairage d'un côté préférentiel (2), ledit appareil (10) comprenant un émetteur de lumière à DEL (20) ayant un axe (21) qui est une ligne orthogonale à un plan défini par l'émetteur de lumière à DEL (20) et qui passe par le centre géométrique d'une zone de l'émetteur dans le plan, ledit appareil (10) comprenant :
 - une première lentille (30) sur l'émetteur à DEL (20), conçue pour diriger, de préférence, une lumière émise par une DEL vers le côté préférentiel (2) ; et
 - une seconde lentille (40) espacée de et placée sur la première lentille (30), et conçue pour diriger en outre, de préférence, la lumière vers le côté préférentiel (2) ;

caractérisé en ce que la première lentille (30) présente une ligne centrale (33) qui est décalée par rapport à l'axe (21) de l'émetteur vers le côté préférentiel (2).
2. Appareil d'éclairage (10) selon la revendication 1, dans lequel la première lentille (30) présente une surface externe (32) conçue pour diriger une lumière émise par une DEL vers le côté préférentiel (2).
3. Appareil d'éclairage (10) selon la revendication 1, dans lequel la seconde lentille (40) comprend :
 - une surface interne (41) conçue pour diriger, de préférence, une lumière provenant de la surface externe (32) de la première lentille (30) ;
 - une surface externe (42) conçue pour diriger une lumière provenant de la surface interne (41) vers le côté préférentiel (2).
4. Appareil d'éclairage (10) selon la revendication 3, dans lequel la surface interne (41) de la seconde lentille (40) comprend :
 - une portion réfractrice (51 ; 51b) entourant la première lentille (30) et comprenant des secteurs avant et arrière (52, 53 ; 52b, 53b) ; et
 - une portion réfléchissante (54 ; 54b) autour du secteur arrière (53 ; 53b), la portion réfléchissante (54 ; 54b) étant positionnée de manière à recevoir la lumière réfractée par le secteur arrière (53 ; 53b) pour assurer une réflexion inter-

ne totale (TIR) vers le côté préférentiel (2).

5. Appareil d'éclairage (10) selon la revendication 4, dans lequel le secteur arrière (53 ; 53b) de la portion réfractrice (51 ; 51b) de la seconde lentille (40) comprend au moins une paire de portions de surface (53a, 53b) mutuellement transverses.
6. Appareil d'éclairage (10) selon la revendication 5, dans lequel le secteur avant (52 ; 53b) de la portion réfractrice (51 ; 51b) de la seconde lentille (40) présente une configuration de surface lisse qui s'étend jusqu'à la jonction (55) des secteurs avant et arrière (52, 53 ; 52b, 53b).
7. Appareil d'éclairage (10) selon la revendication 4, dans lequel la portion réfractrice (51 ; 51b) de la surface interne (41) de la seconde lentille (40) comprend des secteurs avant et arrière (52, 53b) configurés différemment l'un de l'autre.
8. Appareil d'éclairage (10) selon la revendication 1, dans lequel :
 - l'émetteur (20) comprend une source de lumière de DEL qui comprend une embase (22) qui présente une zone peuplée de DEL (23) qui possède un rapport de format supérieur à 1, et un réseau de DEL (24) sur la zone peuplée de DEL (23) ; et
 - la première lentille (30) se trouve sur l'embase (22) sur la zone peuplée de DEL (23).
9. Appareil d'éclairage (10) selon la revendication 8, dans lequel la zone peuplée de DEL (23) est rectangulaire.
10. Appareil d'éclairage (10) selon la revendication 8, dans lequel la première lentille (30) est surmoulée sur l'embase (22).
11. Appareil d'éclairage (10) selon la revendication 1, comprenant en outre :
 - une pluralité de diodes électroluminescentes (DEL) (24) espacées le long d'une carte de circuit imprimé (11), chaque réseau (24) ayant des première et seconde dimensions transversales maximum (15, 16) orthogonales l'une par rapport à l'autre, la première dimension transversale maximum (15) étant supérieure à la seconde dimension transversale maximum (16), et chaque réseau DEL (24) définissant un axe (21) d'émission de la lumière ;
 - une pluralité de premières lentilles (30) chacune sur un réseau correspondant de DEL (24), chaque première lentille (30) présentant une surface externe (32) conçue pour réfracter la lu-

mière provenant de son réseau de DEL (24)
correspondant ; et
- une pluralité de secondes lentilles (40) chacune
espacée de, et sur l'une, correspondante,
des premières lentilles (30), chaque seconde
lentille (40) présentant une surface interne (41)
et une surface externe (42) qui est conçue pour
réfracter la lumière provenant de la surface interne
(41).

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12. Appareil d'éclairage (10) selon la revendication 11,
dans lequel la pluralité de réseaux de DEL (24) sont
montés sur une embase (22) commune.

13. Appareil d'éclairage (10) selon la revendication 11, 15
dans lequel chaque réseau de DEL (24) se trouve
sur une embase (22) et chacune des embases (22)
est montée sur la carte de circuit imprimé (11).

14. Appareil d'éclairage (10) selon la revendication 11, 20
dans lequel chaque première lentille (30) est sur-
moulée sur chaque réseau de DEL (24).

15. Appareil d'éclairage (10) selon la revendication 14, 25
dans lequel chaque première lentille (30) présente
une surface externe (32) conçue pour diriger la lu-
mière émise par une DEL vers le côté préférentiel (2).

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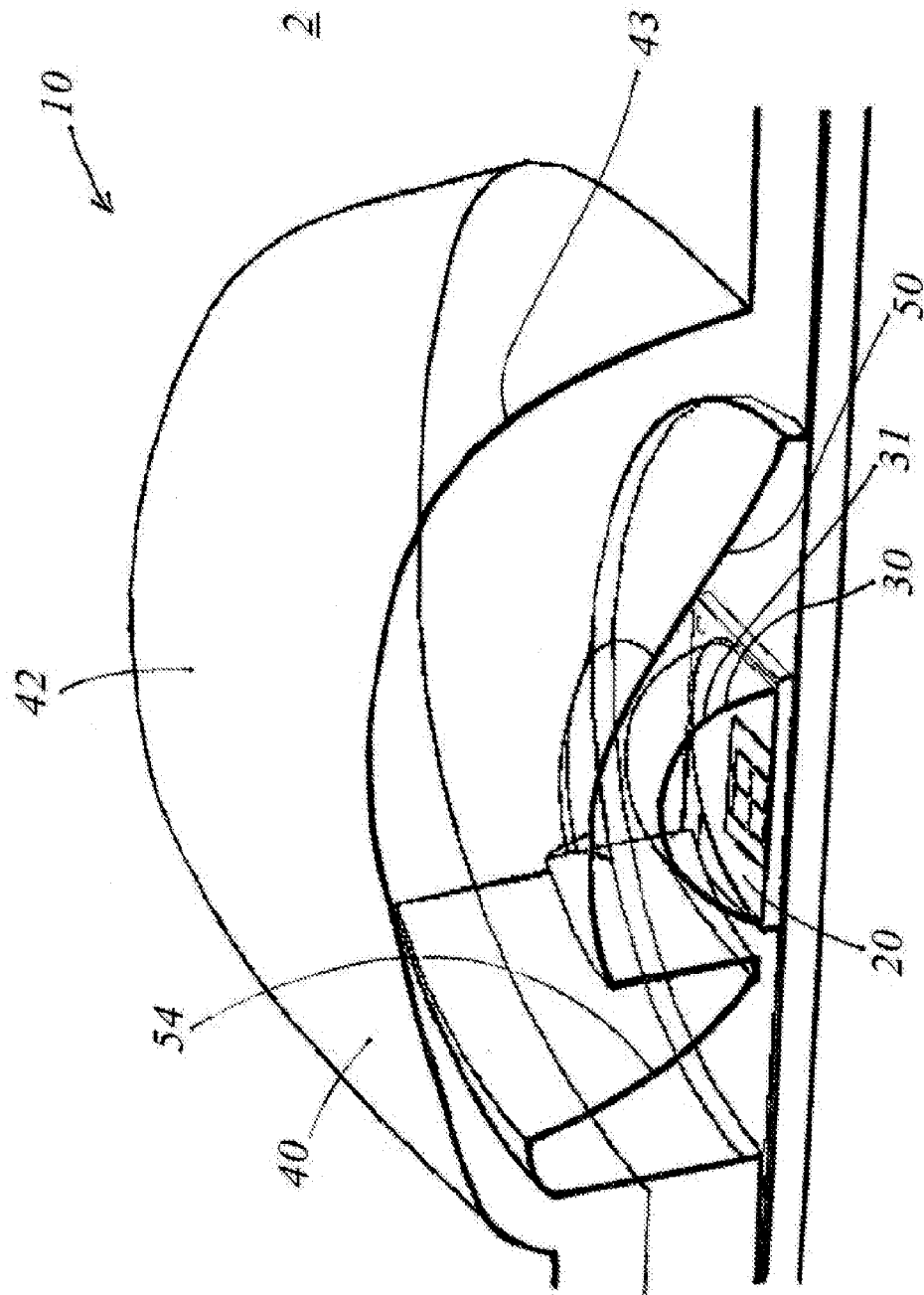
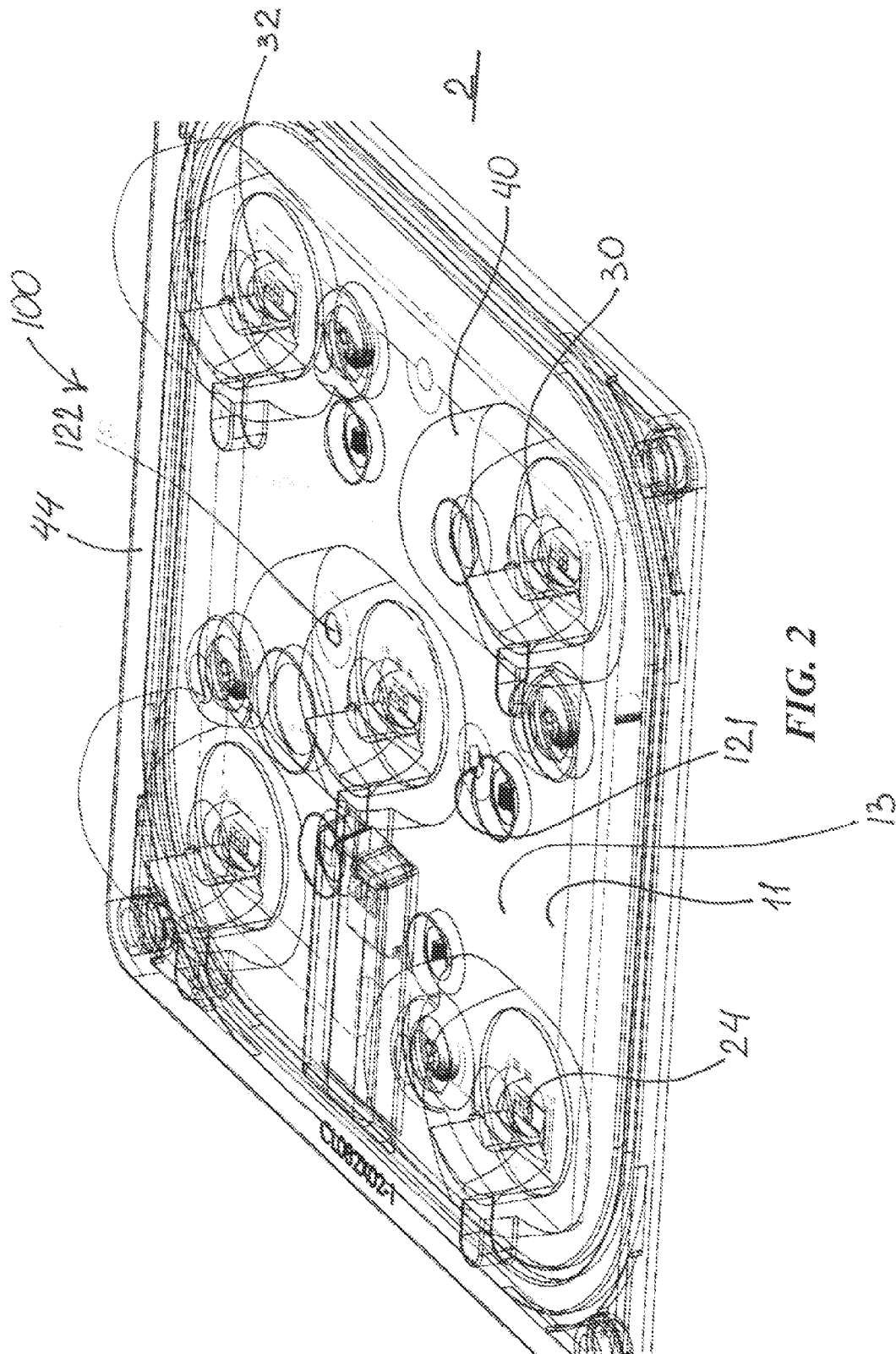


FIG. 1



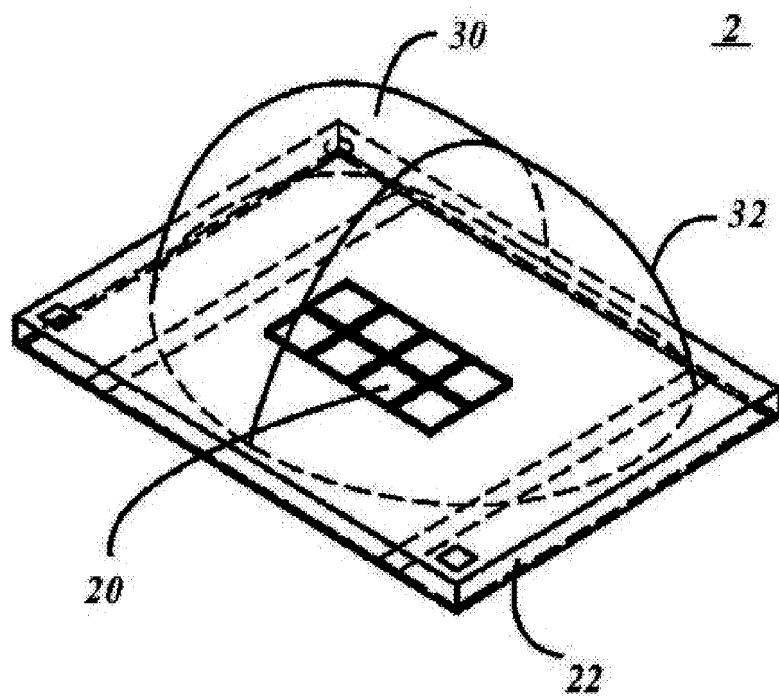


FIG. 3

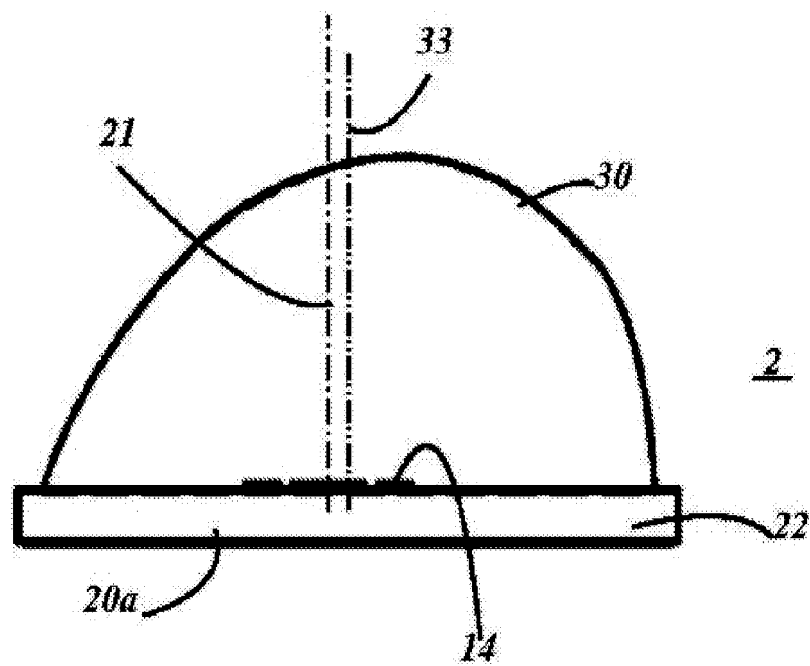


FIG. 4

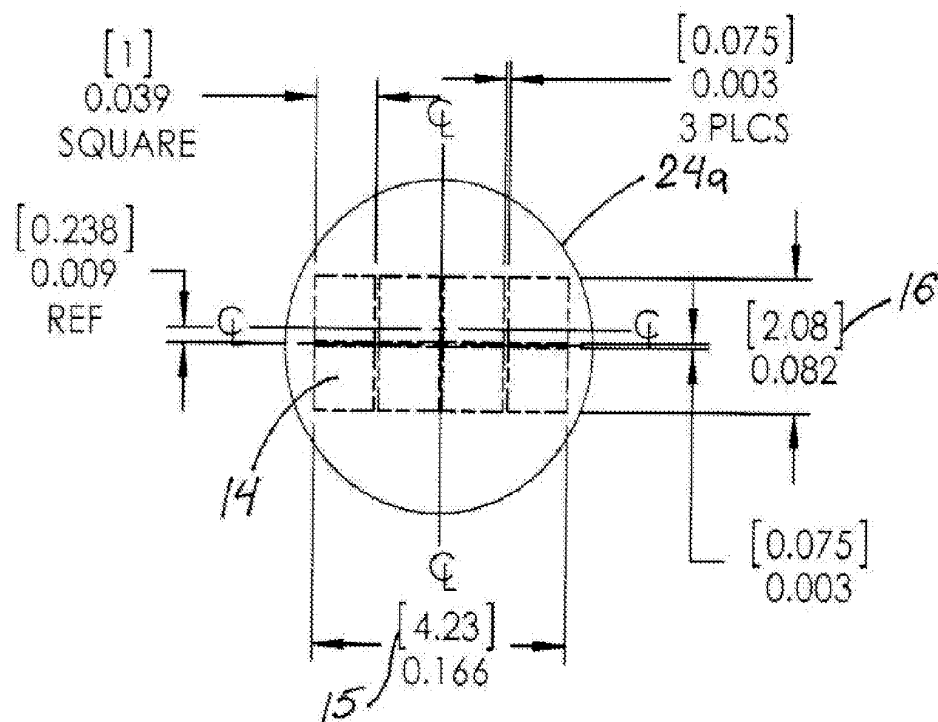
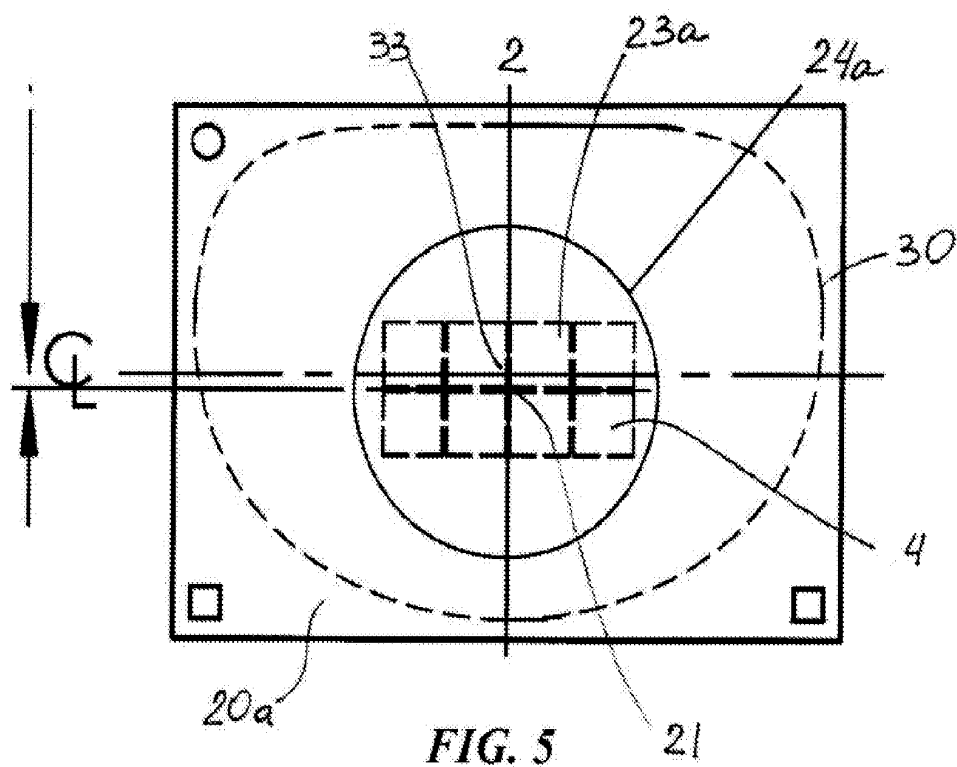


FIG. 6

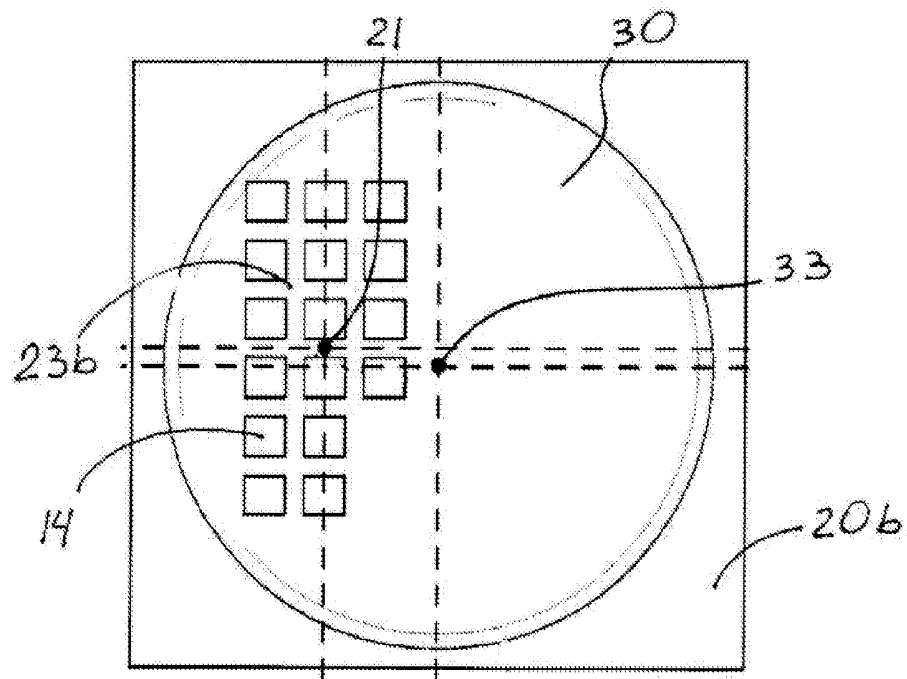


FIG. 7

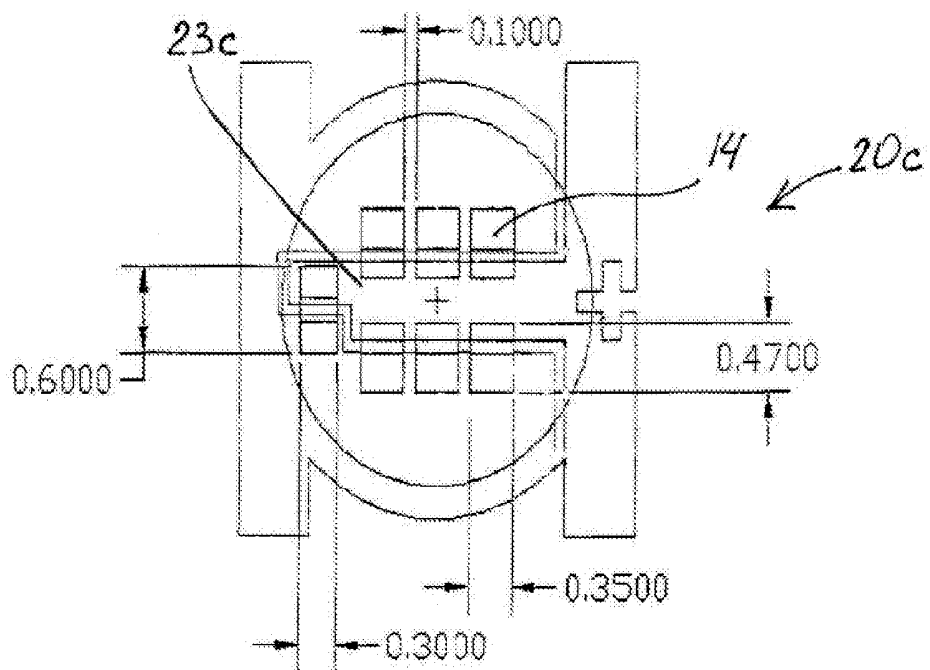


FIG. 8

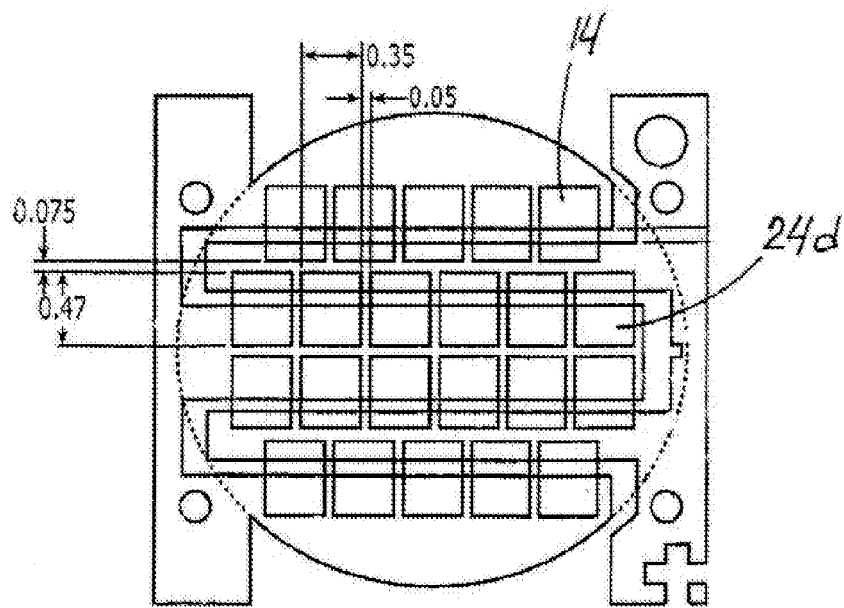


FIG. 9

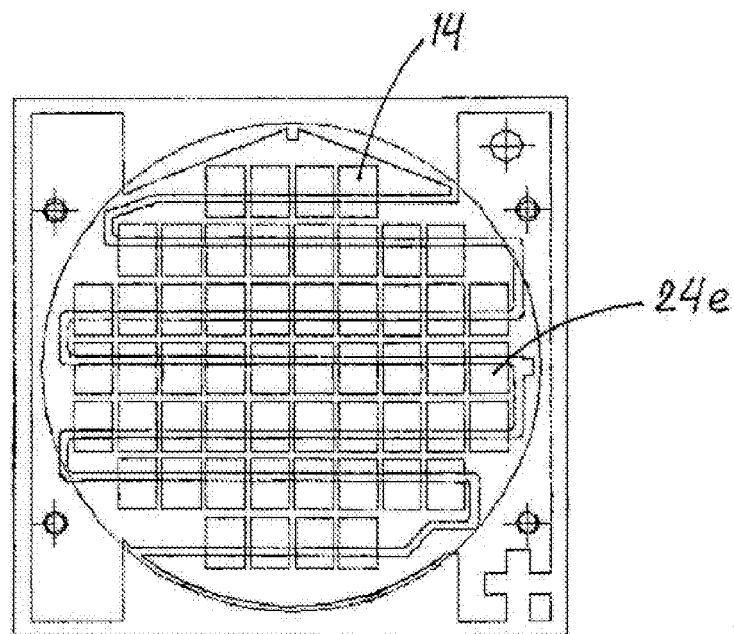


FIG. 10

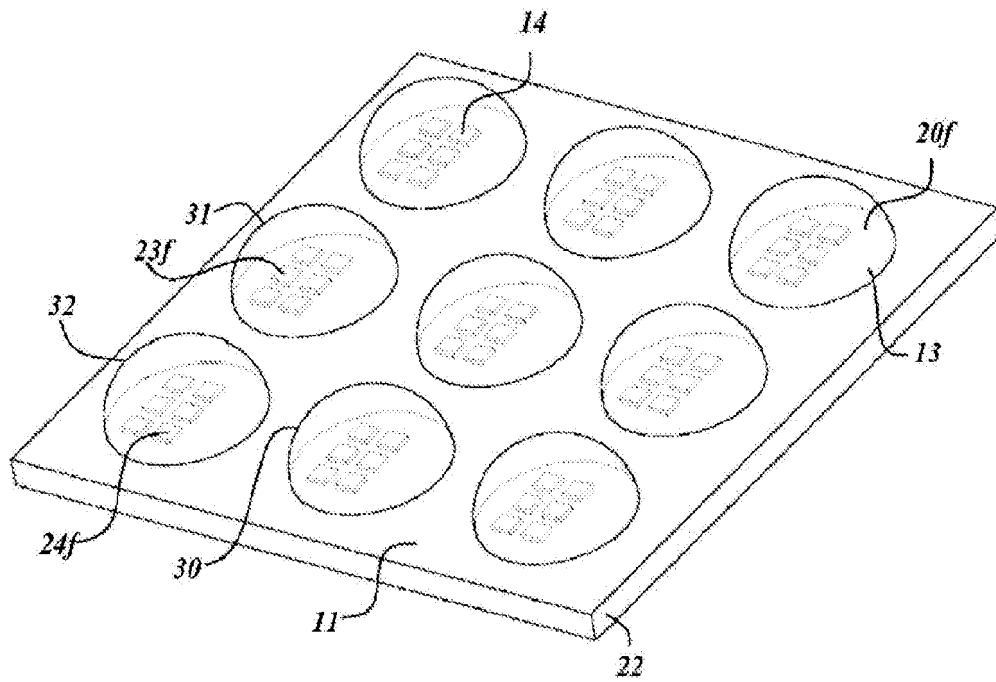


FIG. 11

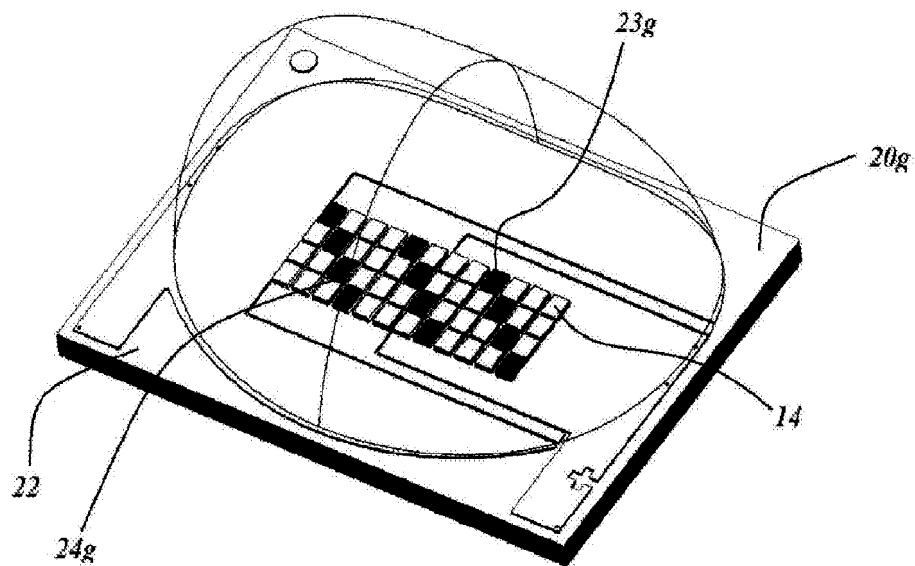


FIG. 12

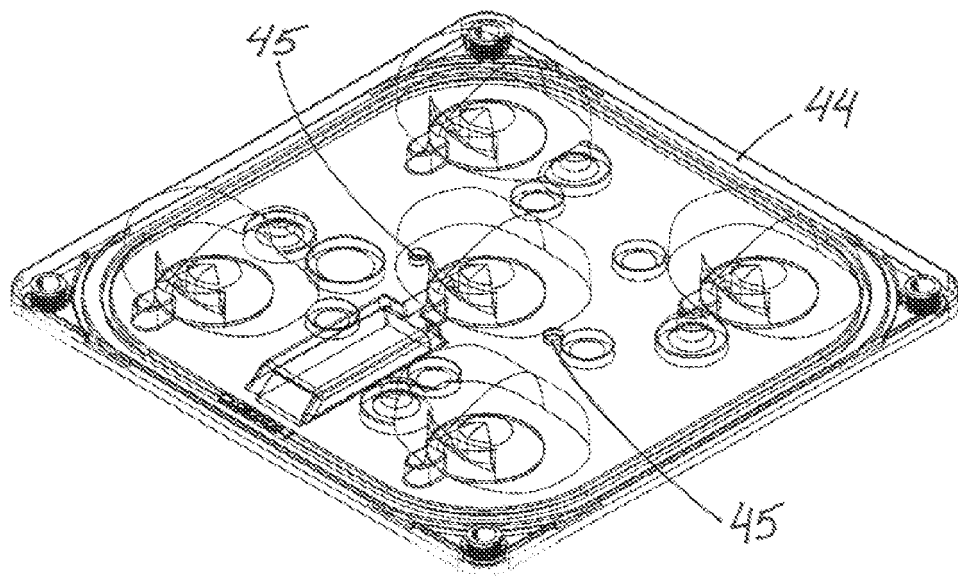


FIG. 13

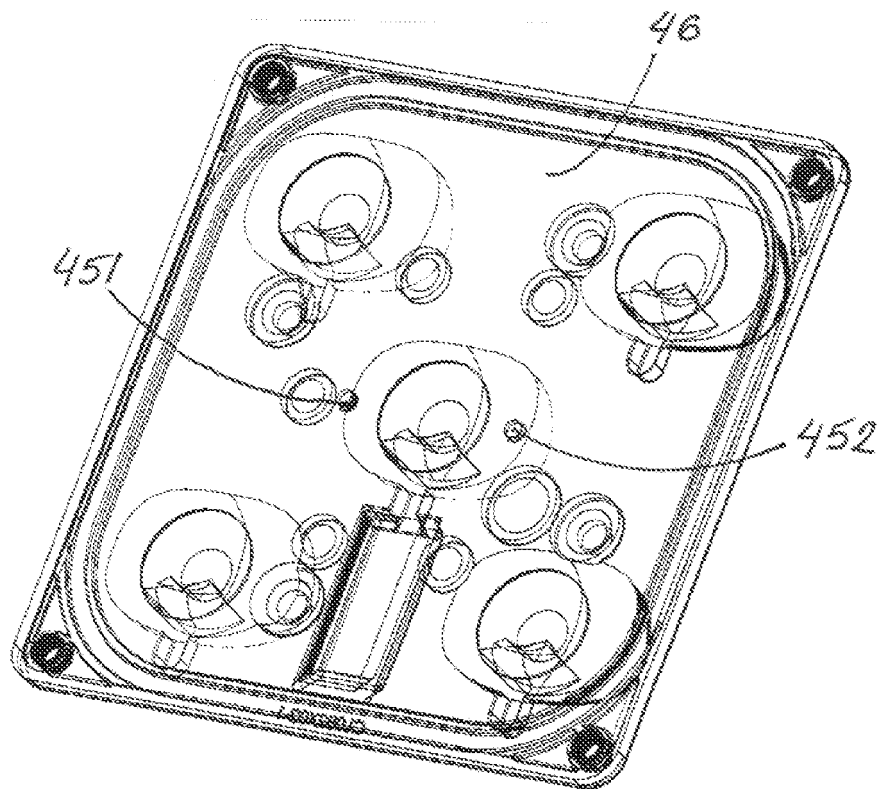


FIG. 14

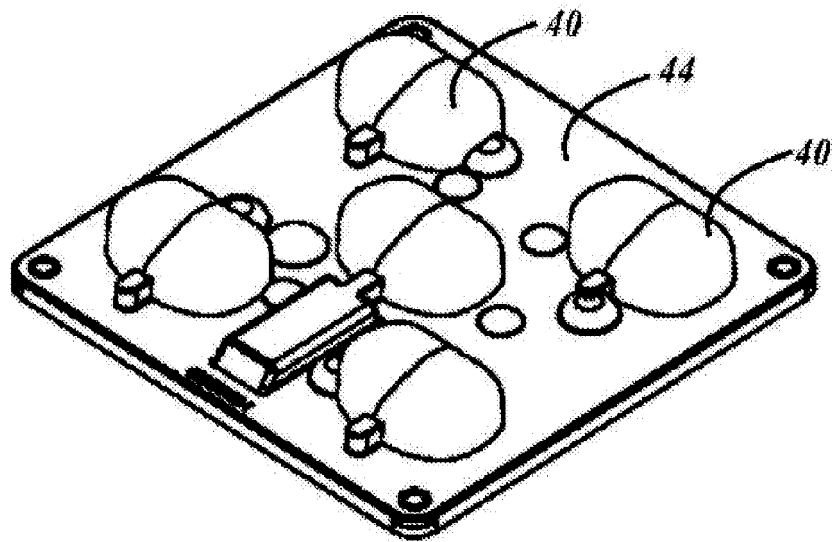


FIG. 15

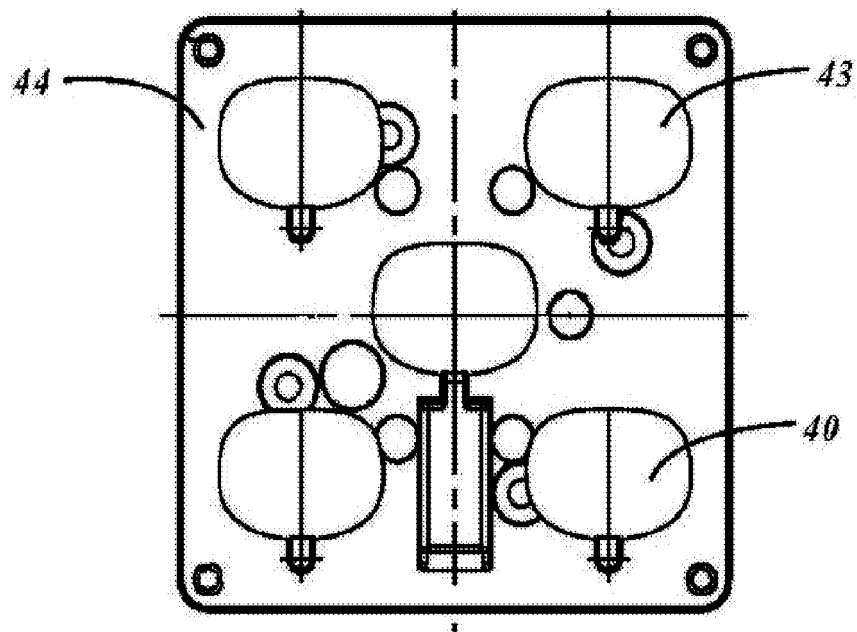
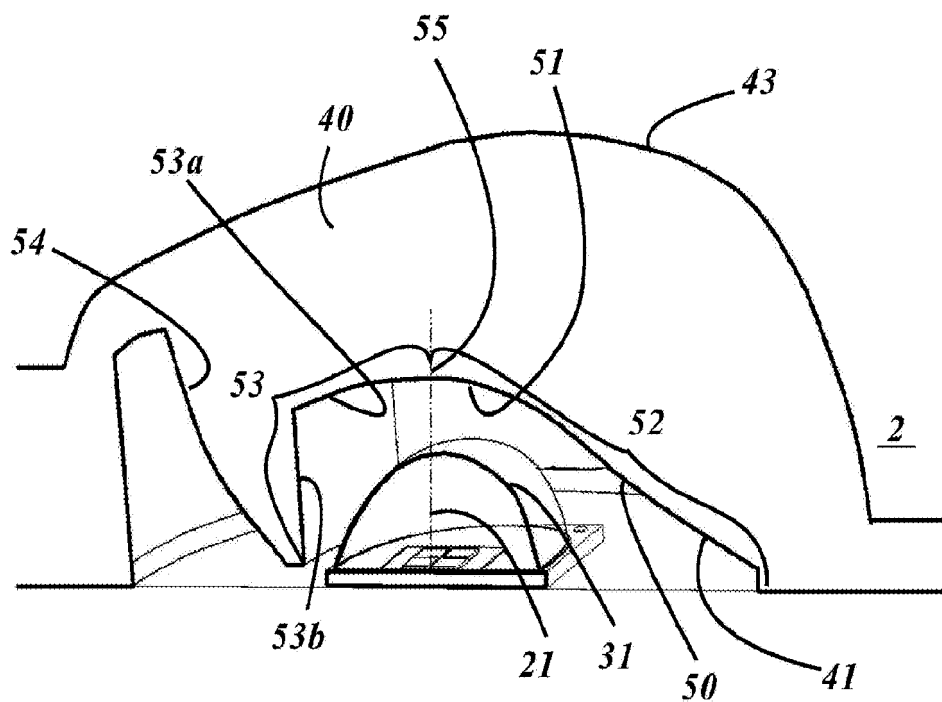
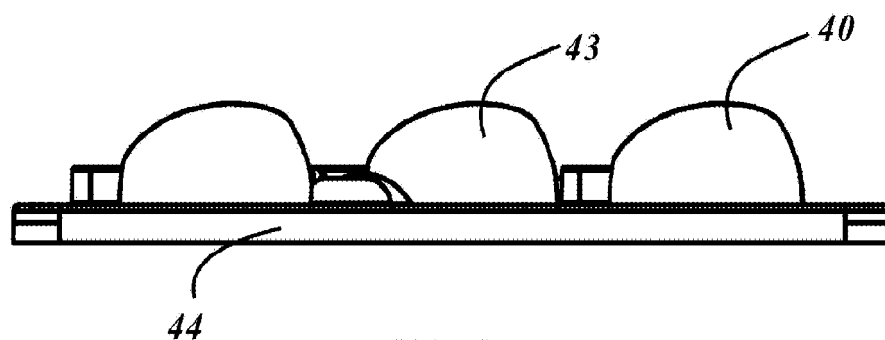
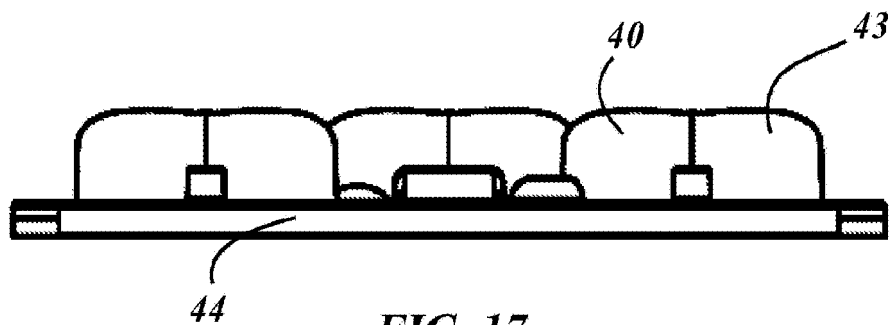


FIG. 16



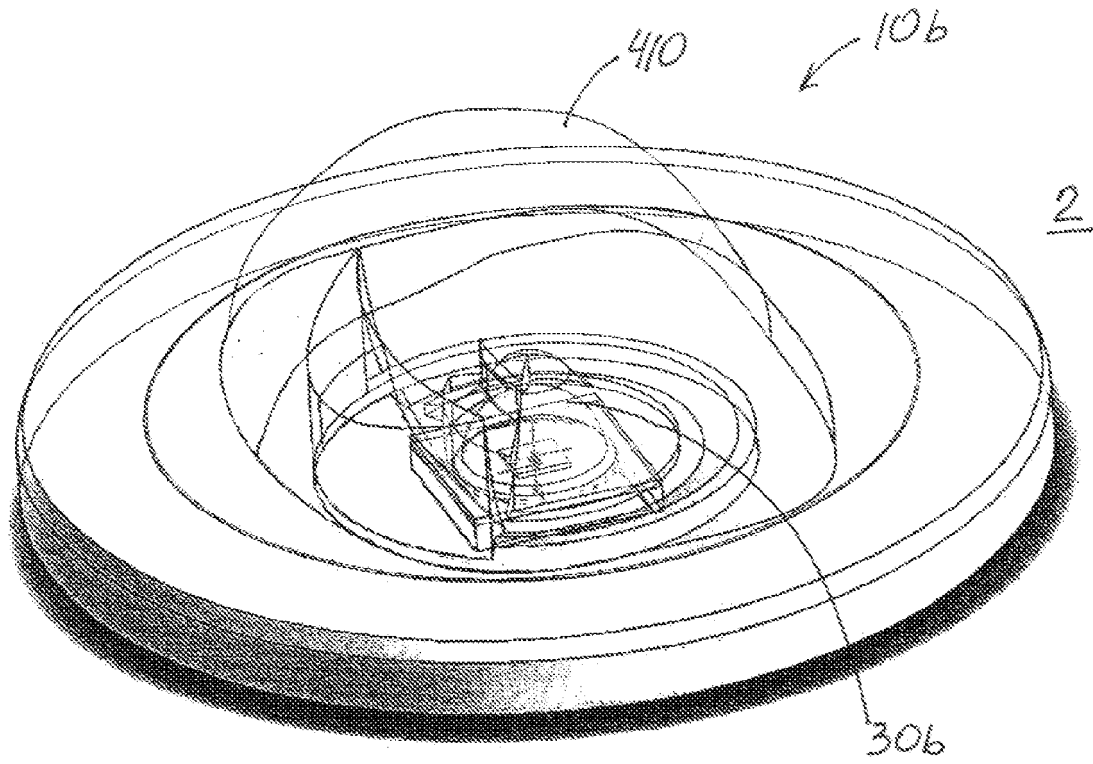


FIG. 20

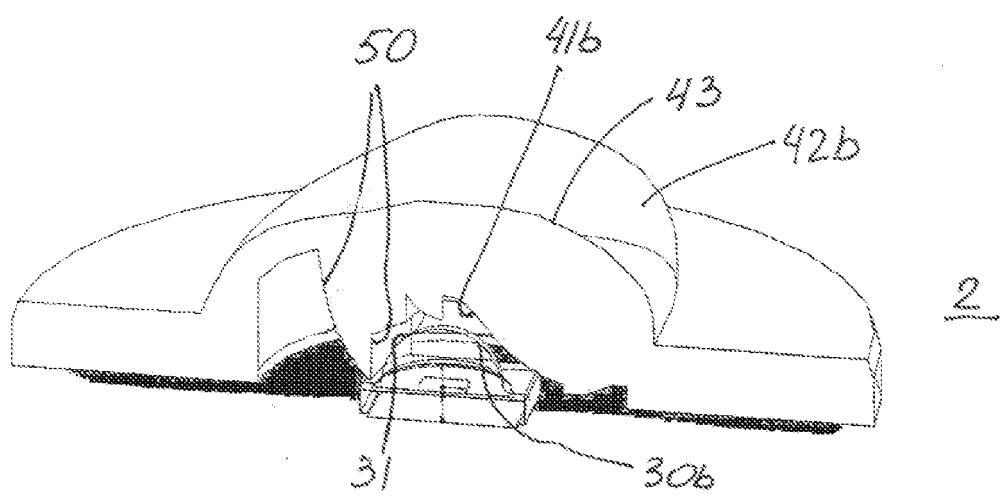


FIG. 21

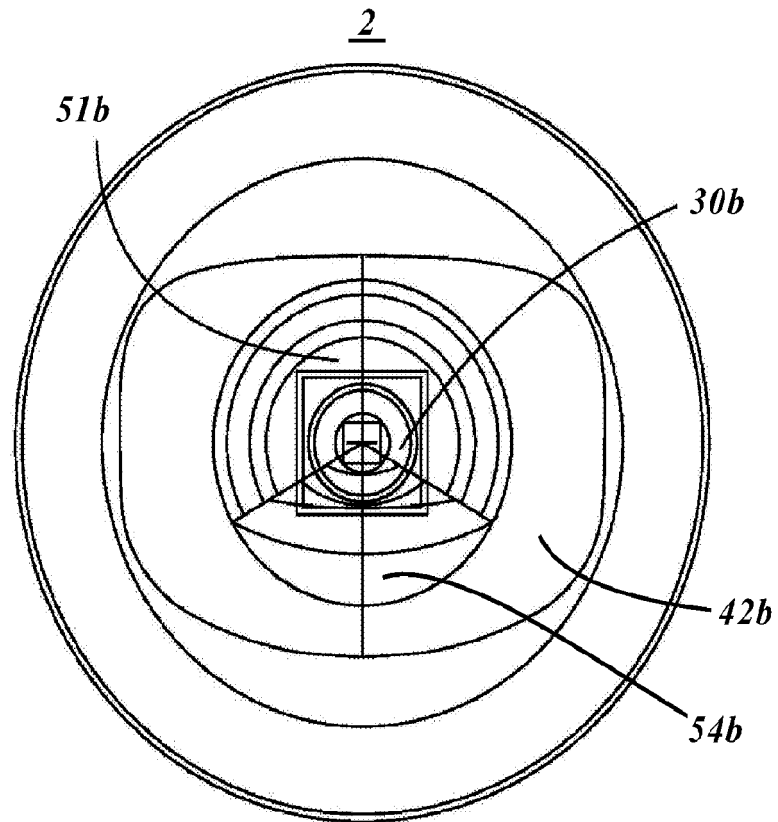


FIG. 22

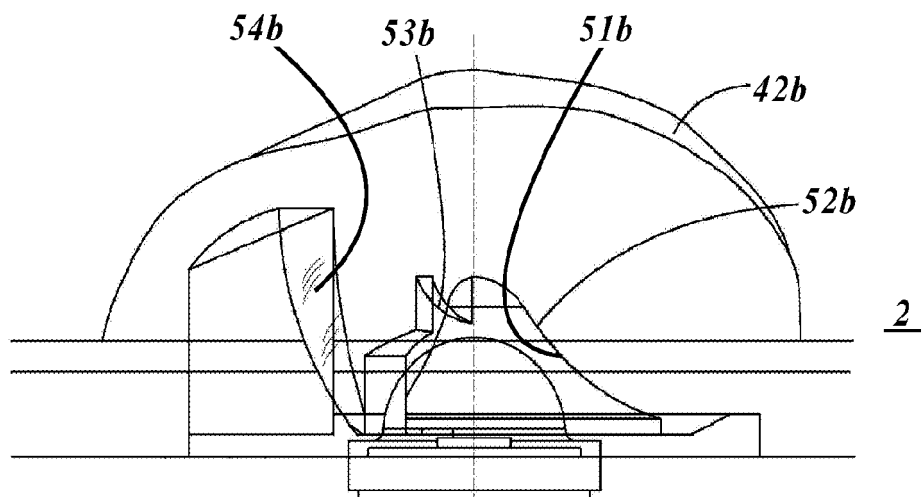


FIG. 23

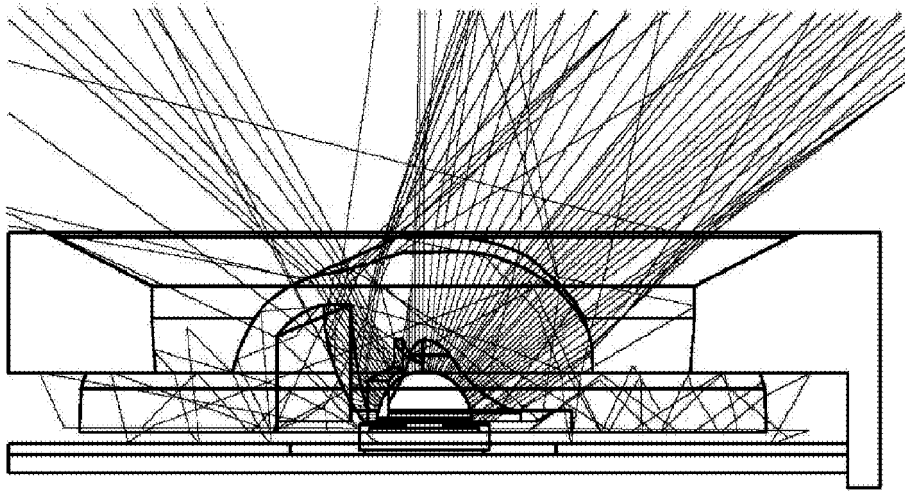


FIG. 24

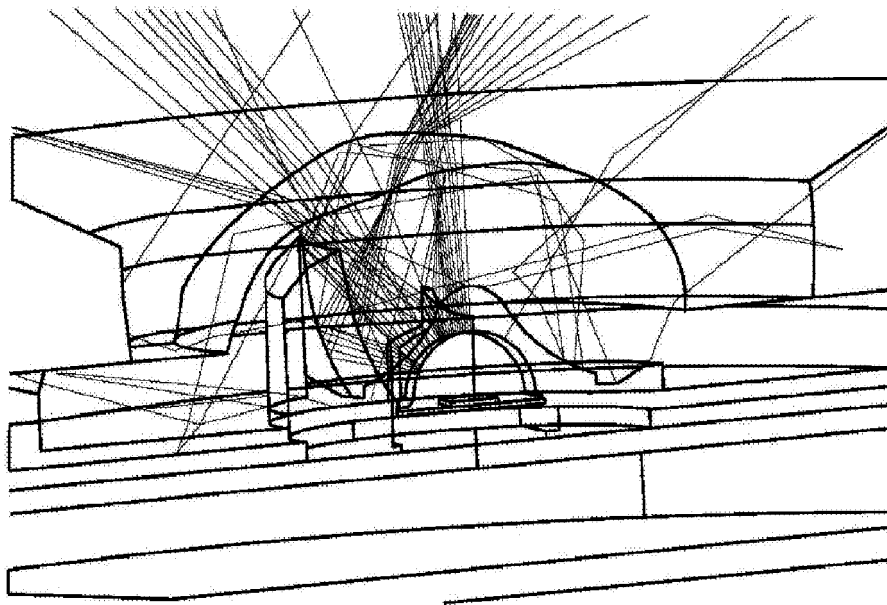


FIG. 25

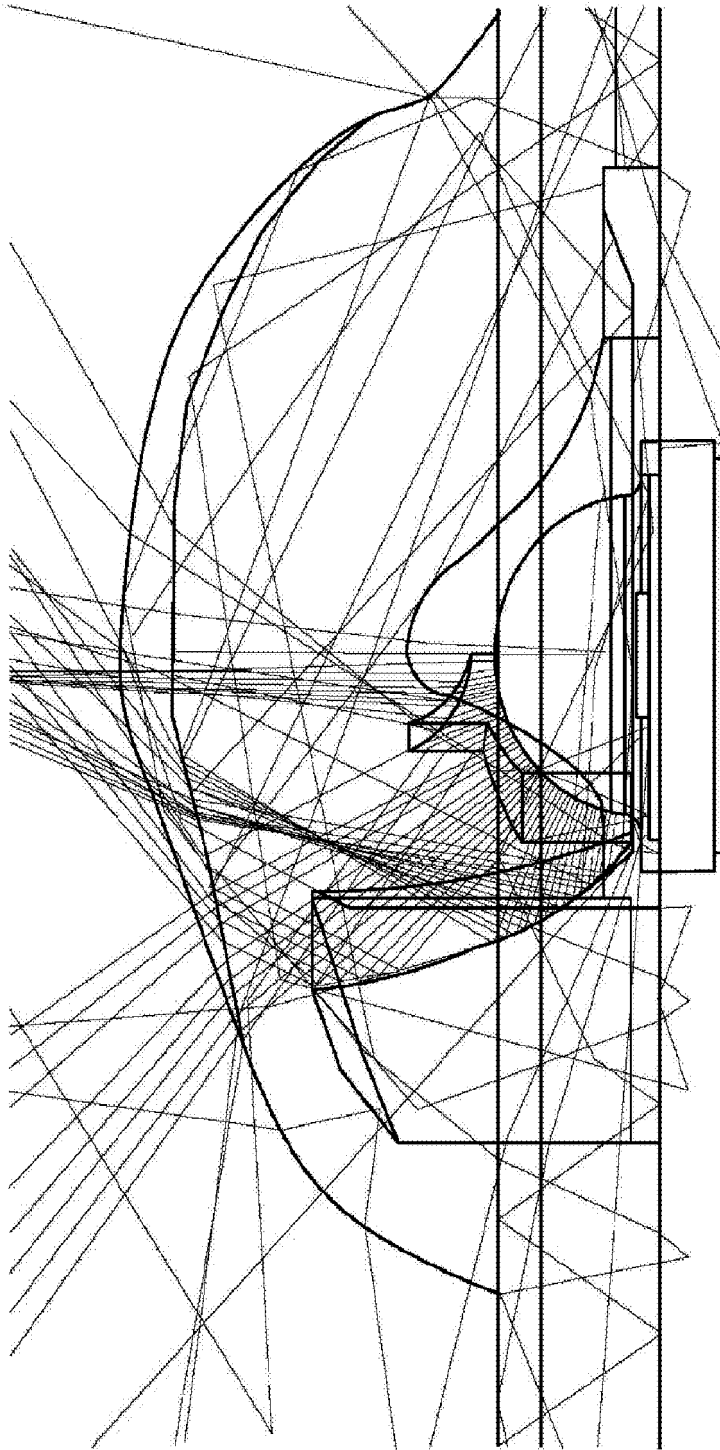


FIG. 26

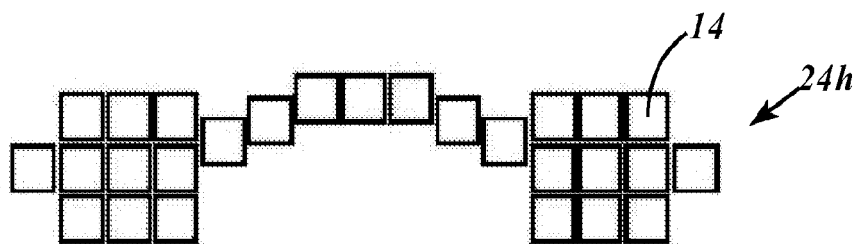


FIG. 27

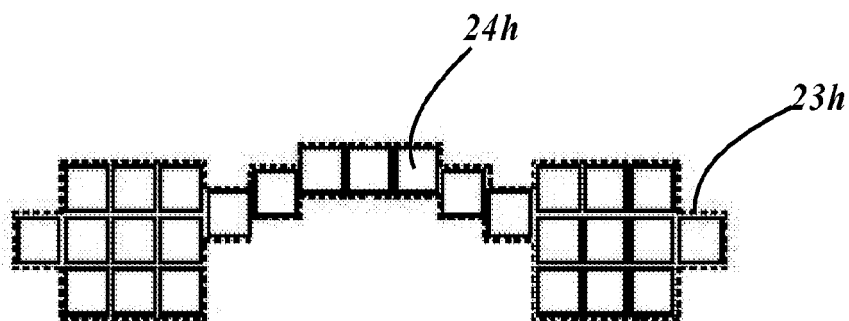


FIG. 27A

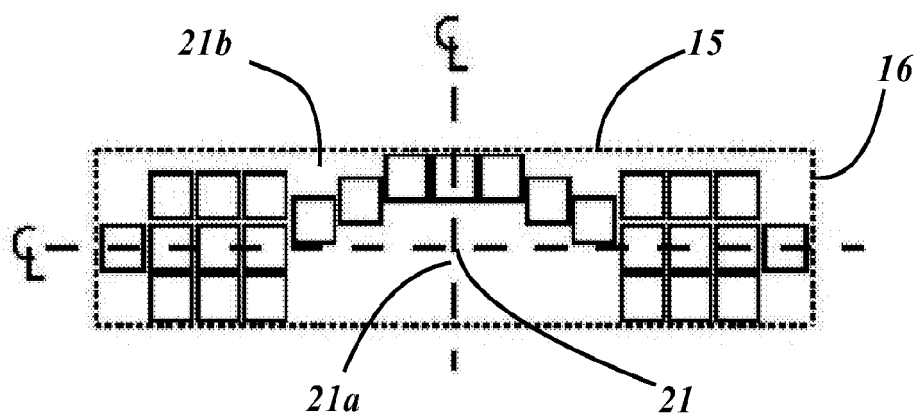


FIG. 27B

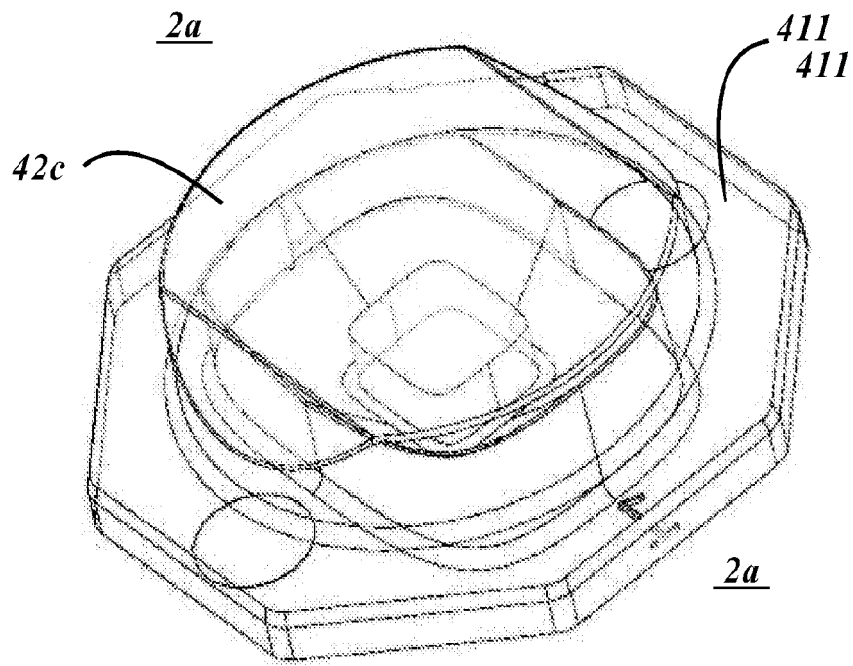


FIG. 28

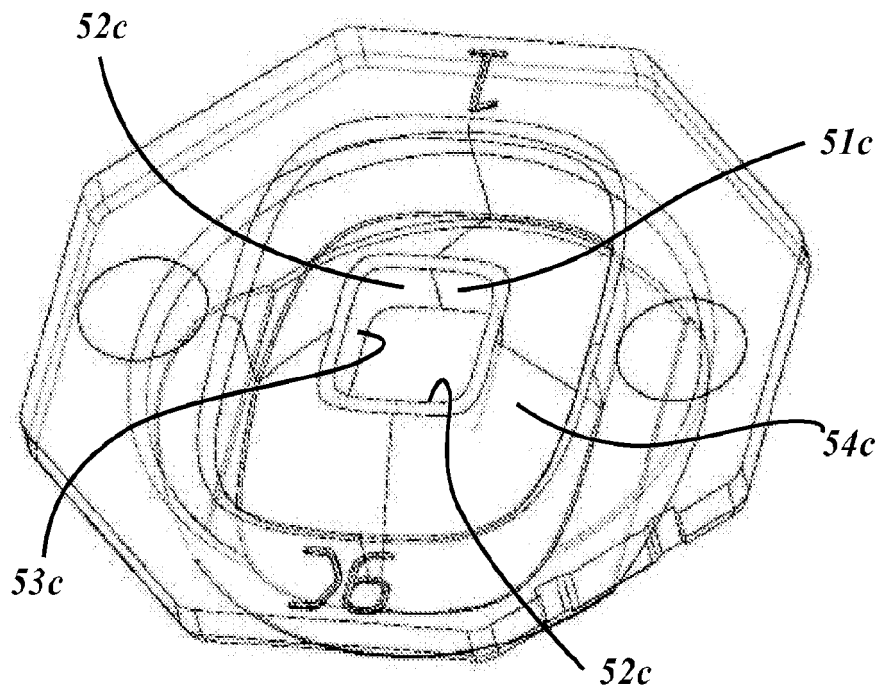


FIG. 29

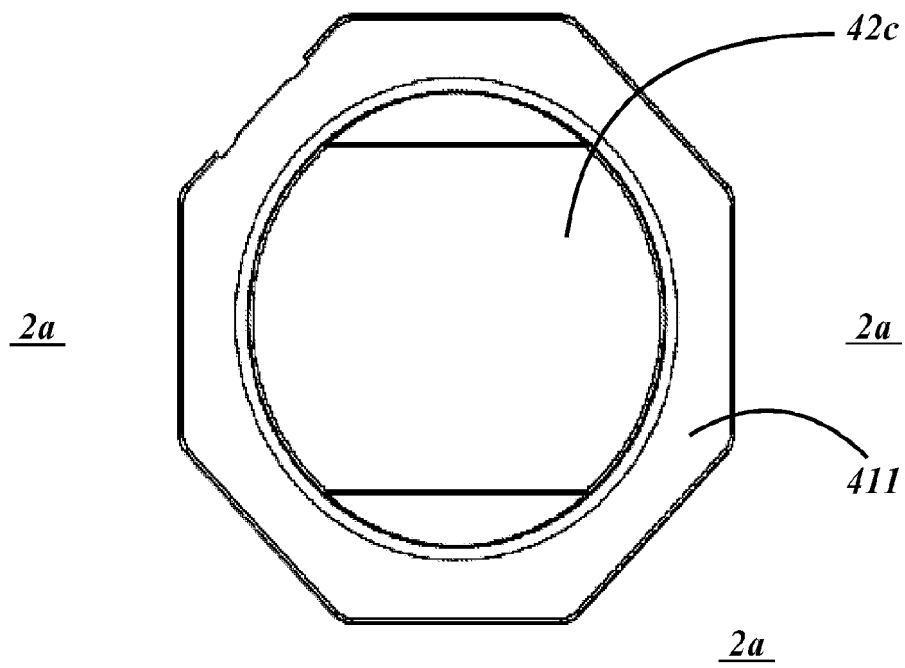


FIG. 30

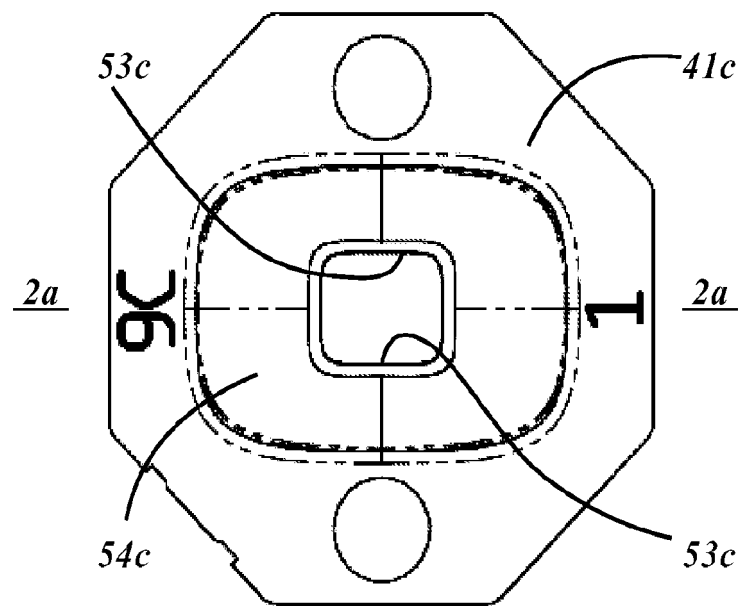


FIG. 31

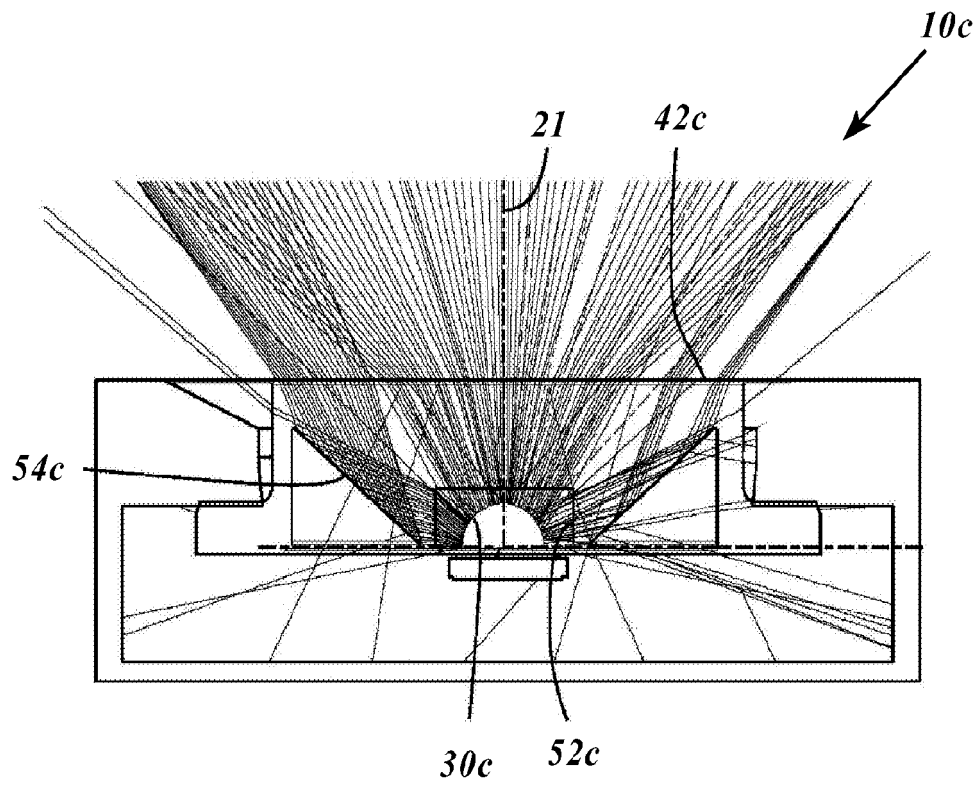


FIG. 32

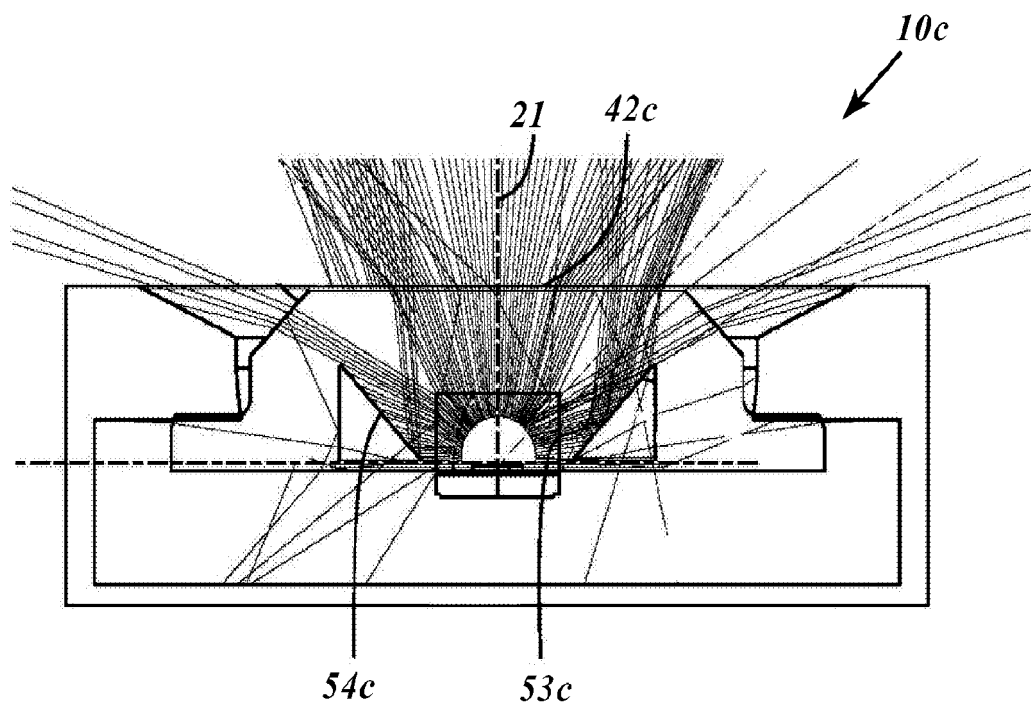


FIG. 33

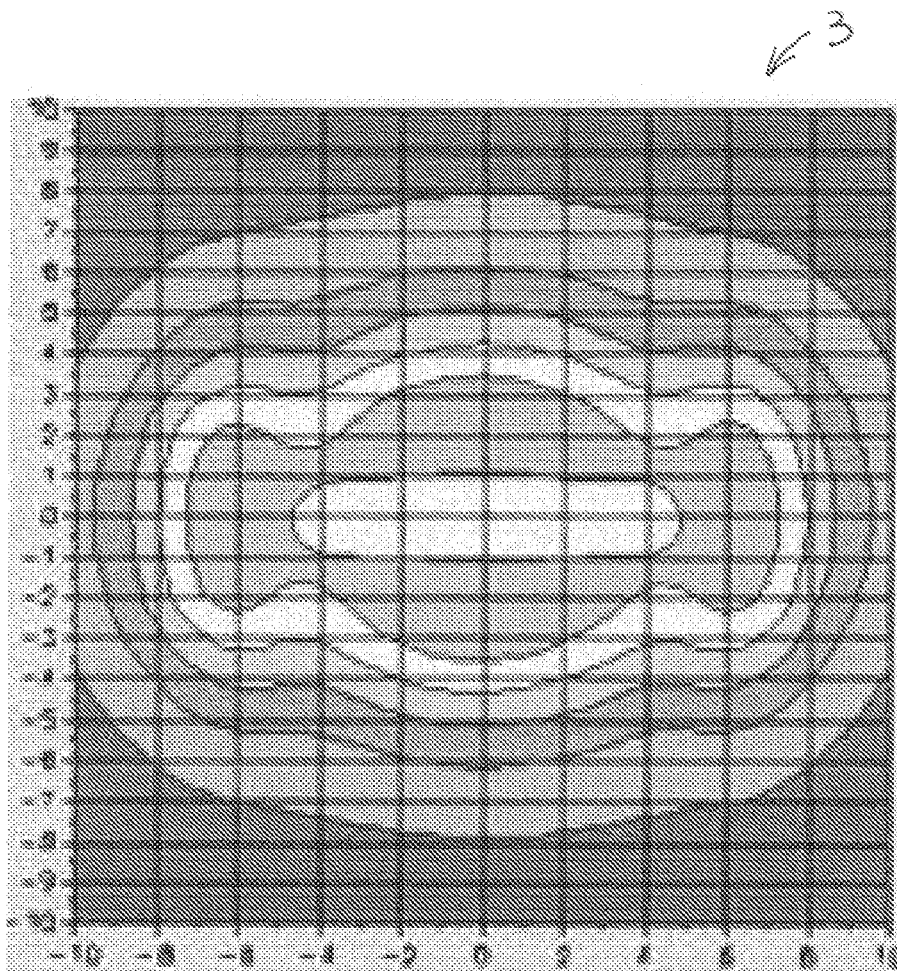


FIG. 34

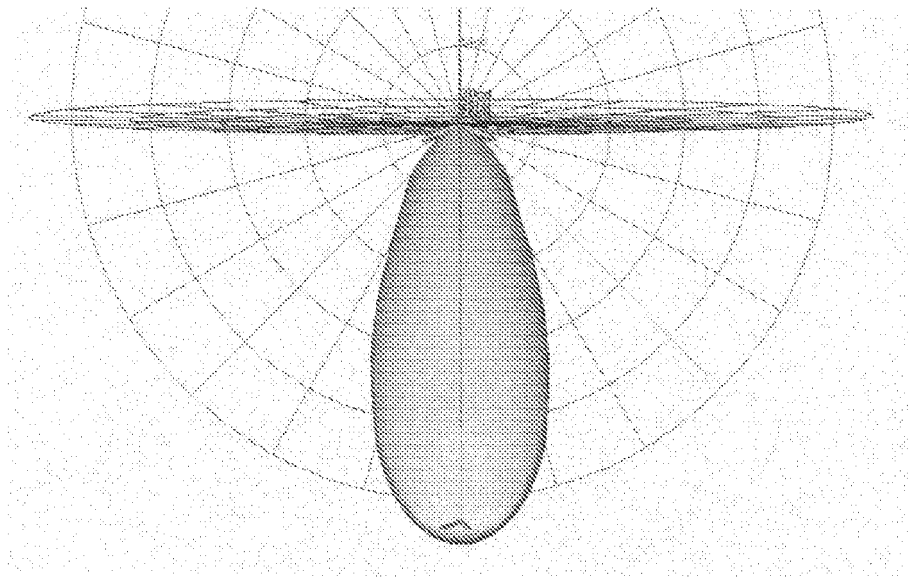


FIG. 35

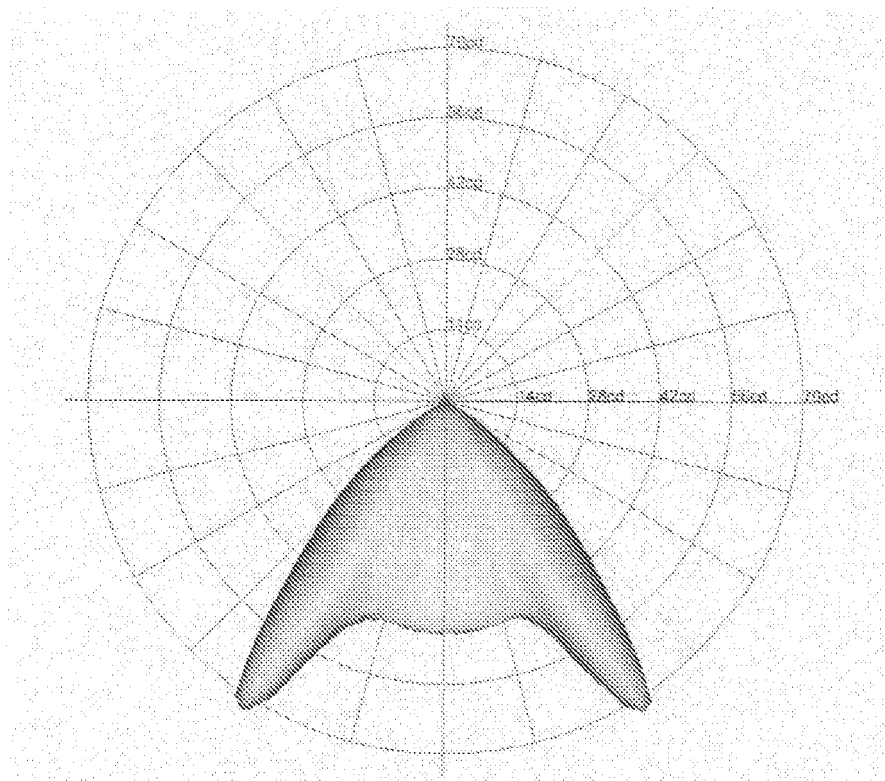


FIG. 36

REFERENCES CITED IN THE DESCRIPTION

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