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(54) **Lighting unit**

(57) The invention relates to a wide-radiating lighting unit, comprising a lens for adjustment of light exiting from a light source. The lens defines a specific light distribution, whereby the light intensity above the 65° radiation angle is less than 10% of the light intensity directly under the fixture and wherein the light intensity at 35° is greater than 90% of the light intensity directly under the fixture. The side of the lens remote from the light source is provided with a microstructure, such as, for example, a roughening, which enlarges the luminance image of the light source.

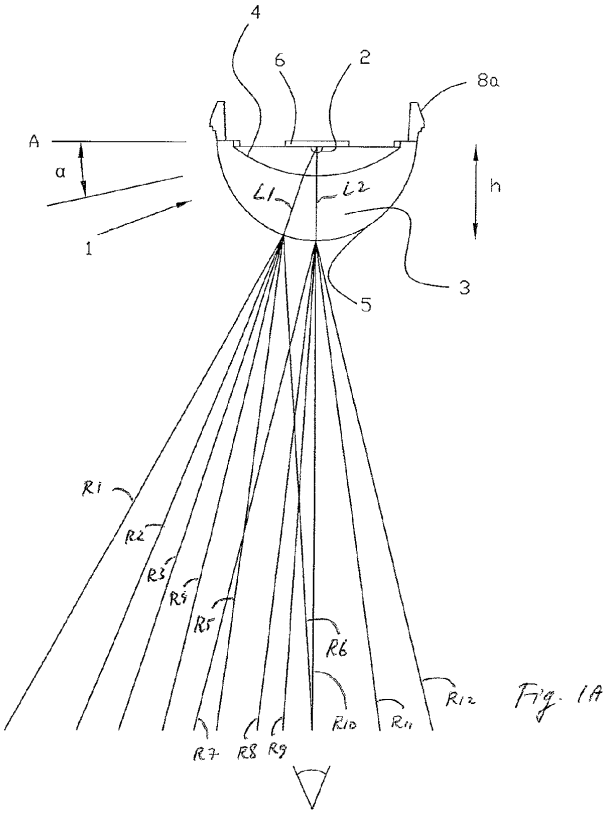


Fig. 1A

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Description

[0001] The invention relates to a lighting unit, comprising a lens for adjustment of light exiting from a light source implemented as LED, wherein the lens has a side proximate to the light source and a side remote from the light source, and wherein the lens defines a specific light distribution.

[0002] Such lighting units are known and are used in various applications, for example, in office spaces or industrial halls.

[0003] Lighting units provided with LEDs have a use as, for instance, diffuser product or spot lighting. In combination with a lens, normally a light beam is obtained with a specific aperture angle, while the light exiting with exit angles lying outside the aperture angle is screened. Diffuser fixtures have a large surface with a height well over 20 millimeters. Lighting units for spot lighting can have a smaller height. In spot lighting, the lens provides for a small aperture angle, for example, of less than thirty degrees.

[0004] A distinction can be made between spot lighting and wide-radiating lighting. The lens in a spot lighting unit is obviously not intended to illuminate large surfaces uniformly. Lighting a surface, by means of multiple spot lighting units, with a uniformity of better than 0.7 would require using a mutual distance between the spot lighting units of from 0.1 to 1 time the distance to the surface to be lighted. With wide-radiating lighting units within the meaning as intended here, the uniformity of 0.7 is attained with a mutual distance to a minimum of 1.1 times the distance to the surface to be lighted. A wide-radiating lighting unit is therefore not a spot lighting unit.

[0005] The invention envisages a lighting unit of the kind indicated in the opening paragraph hereof which is suitable for functional interior lighting.

[0006] According to the invention, there is provided a lighting unit according to the opening paragraph, wherein the light intensity above the 65° radiation angle is less than 10% of the light intensity directly under the fixture and wherein the light intensity at 35° is greater than 90% of the light intensity directly under the fixture, wherein the side of the lens remote from the light source is provided with a microstructure which scatters the light exiting from the lens.

[0007] By the use of a scattering microstructure the light exiting from the lens is spread, as a result of which the apparent surface of the bright LED itself is enlarged, for example by more than 50%, in any direction, and the brightness of a partial surface of the lens having the size of the apparent surface of the LED is reduced at least by the same factor, so, for example, is at least halved.

[0008] Thus, according to an aspect of the invention, the side of the lens remote from the light source may be provided with a microstructure such that the lens provides for locally varying deviations of an angle of refraction with respect to the angle of refraction of a nominal smooth lens, wherein the spread of the deviation in the microstructure is at least so large that an area enlargement of the image of the light source, for which the luminance is greater than 10% of the peak luminance, is at least 50% higher than the image of the light source that would be obtained with the nominal smooth lens.

[0009] It is noted that according to the invention one or a plurality of LEDs may be used, each having an identical and approximately lambertian light distribution. The light exiting from the LED or LEDs undergoes via the transparent lens a so-called lower hemispheric secondary light treatment.

[0010] Depending on the inclination of inner and outer wall, in the different lower hemispheric angles, the lens can realize a continuously variable light refraction, so that diverse lower hemispheric light distributions can be realized, for example, wide-radiating or deep-radiating, possibly with diverse screens, that is, reduced amount of light in greater angles with respect to the vertical. By realizing a light distribution whereby the light intensity above the 65° radiation angle is less than 10% of the light intensity directly below the fixture and whereby the light intensity at 35° is greater than 90% of the light intensity directly under the fixture, a practically applicable functional interior lighting is obtained.

[0011] With a wide-radiating lens a relatively large surface can be illuminated, so that efficient use is made of the amount of light generated. Lighting units according to the invention can thus be placed at a large distance from each other while yet a relatively large surface is illuminated sufficiently uniformly. By furthermore providing the surface through which the light leaves the lens with a microstructure, a lighting unit has been obtained whereby peak luminances are averaged out, so that a relatively uniform light distribution as a function of the exiting angle is obtained. Owing to the balanced light distribution and the large aperture angle of the exiting light, the lighting unit is eminently suitable for use as functional interior lighting. For that matter, the specific light distribution of the lens does not have to be wide-radiating. Also another specific light distribution may be used, for example, a deep-radiating light distribution.

[0012] It is noted that the height of the lens is understood to mean the dimension of the lens in a direction from the light source to the surface to be illuminated.

[0013] Furthermore, it is noted that in the context of this application, the term 'microstructure' denotes that the respective lens surface is provided at a micro level with a relief, so that the exiting light undergoes a scattering effect.

[0014] The microstructure on the outer side of the lens may be realized, for instance, by roughening that side mechanically or with the help of a laser process.

[0015] Preferably, the lighting unit comprises a plurality of lenses, so that maximum luminance limits can be observed.

[0016] By designing the lens as a Fresnel lens the lens height can be reduced considerably, for instance, by a factor of two, or even more.

[0017] Further advantageous embodiments of the invention are represented in the subclaims.

[0018] The invention will be further elucidated on the basis of exemplary embodiments which are represented in the drawing. In the drawing:

Fig. 1A shows a schematic cross section of an embodiment of a lighting module 1 according to the invention;

Fig. 1B shows a schematic cross section of the lighting module 1 of Figure 1A in which the side of the lens remote from the light source is not provided with a microstructure;

Fig. 2 shows a schematic cross section of an embodiment of a lighting unit 7 according to the invention; and

Fig. 3 shows a schematic perspective view of an embodiment of a lighting unit 7 according to the invention.

[0019] The figures are only schematic representations of preferred embodiments of the invention. In the figures, the same or corresponding parts are indicated with the same reference numerals.

[0020] Fig. 1A shows a schematic section of an embodiment of a lighting module 1 according to the invention. The lighting module 1 comprises at least one light source 2 and a lens 3 for adjustment of light exiting from the light source 2. In principle, the module 1 may also have a plurality of, identical or non-identical, light sources, for example, two, three, four, ten or fifty. The plurality of light sources 2 together with a lens 3 then constitute a lighting module 1. The lens is preferably manufactured from a plastic. It is also possible that the lens is manufactured from another material, for example, glass, a mineral, or other material that is at least partly light-transmissive. The lens 3 has a side 4 proximate to the light source 2 during use and a side 5 remote from the light source 2 during use.

[0021] The side 5 remote from the light source 2 is provided with a microstructure, i.e., having at a micro level a locally varying deviation of the angle of refraction of the surface of an ideal imaging lens having a smooth surface. The locally varying deviation of the angle of refraction can be obtained, for instance, with locally varying deviations of the orientation of the surface of the ideal lens. Micro level is understood to mean that no limited number of clearly distinguishable images are formed. The microstructure may be manufactured by roughening the side 5 remote from the light source 2. Also, it is possible to provide this side 5 with a microstructure in a different manner, for instance, by applying a resin to the surface. By realizing the lens side concerned with a pattern or structure that is not smooth but at a micro level has a locally varying orientation, the exiting light is scattered to some extent, so that the image of the light source is enlarged and the peak luminances are reduced. In Figure 1A the scattering is symbolically represented in that two light rays L1, L2 propagating through the lens 3, when emerging from the lens, scatter in different directions R1-R6 and directions R7-R12, respectively. The extent of enlargement increases with increasing roughness and increasing statistical spread of the deviations between the orientation of the microstructure and the ideal smooth lens shape (for example, with the standard deviation).

[0022] In illustration, Figure 1B shows a schematic cross section of the lighting module 1 of Figure 1A in which the side of the lens 3 remote from the light source is not provided with a microstructure. Here, the light rays L1, L2 exit only in one direction R1, R2, without scattering.

[0023] A measure for the enlargement is the ratio between the size of an image of the light source through the lens with microstructure and the size of an image of the light source through a corresponding lens without microstructure (a lens having a level surface, such as a smooth surface). As a size of the image, one can take the diameter of an area in which the luminance in the image is more than ten percent of the peak luminance in the image. With increasing roughness and orientation spread of the microstructures, enlargements are possible for which this measure is 1.65 or higher.

[0024] In principle, the lens 3 may be so designed that light coming from a plurality of light sources 2 is adjusted in a predefined manner.

[0025] Independently of the manner in which the microstructure is provided, the structure may be provided regularly or irregularly over the side 5 of the lens 3 remote from the light source 2.

[0026] The lens 3 is preferably provided with microstructure such that the image of the light source for which the luminance is more than 10% of the peak luminance is minimally 50% larger than with a lens having a surface without microstructure applied. A total maximum luminance in all viewing directions is preferably limited, preferably at 50,000 cd/m^2 to prevent blinding when looking into the light. The limit may also be set higher or lower, for example, at 10,000 cd/m^2. Furthermore, the peak luminances are averaged out. Peak lighting intensities on the working surface to be illuminated will also be averaged out by the microstructure.

[0027] By the use of a plurality of lighting modules a high total lighting intensity can be obtained, while yet the luminance of a singular lighting module is limited.

[0028] The lens is wide-radiating and has a screening angle that is smaller than 50° with luminance limits below 1000 cd/m^2. The screening angle is the angle beyond which the observed light intensity of the lighting unit is below a minimum. The screening angle is determined by the properties of the lens. The screening angle is defined with respect to a plane A in which the light source is situated, parallel to the surface B to be lighted.

[0029] To illuminate surface B uniformly, a multiplicity of light sources may be used in plane A. A norm for such lighting is that the uniformity should be 0.7 at a minimum, uniformity being the ratio between the minimum lighting intensity on the surface B and the average lighting inten-

sity.

[0030] Based on this norm for uniformity, another measure for wide-radiating and for the screening angle is the maximum intermediate distance between the lighting units mutually, in proportion to the distance of the lighting units to a lighted surface B, that is possible without the uniformity of the lighting on the lighted surface falling below 0.7.

[0031] By realizing a light distribution whereby the light intensity above the 65° radiation angle is less than 10% of the light intensity directly under the fixture and whereby the light intensity at 35° is greater than 90% of the light intensity directly under the fixture, a practically applicable functional interior lighting is obtained.

[0032] Alternatively, within the angular range parallel to the plane A in which the light source is situated, and the screening angle, the light may be screened. Preferably, the screening angle α is less than 50°, for example, 40°. It is also possible, however, to realize a still smaller screening angle, for example, 30° or 25°. Outside the wide-radiating area the luminance, upon reaching the screening angle, decreases significantly. Thus, a wide-radiating lighting unit may be obtained, with the mutual distance between lighting units attached to the ceiling being 1.1 times greater than the distance between lighting unit and the working surface to be lighted. When the units are attached, for example, about 3 meters above the working surface, the mutual distance between the units can be about 3.3 meters. At the same time, the ratio of the minimum lighting intensity with respect to the average lighting intensity on the working surface to be lighted can remain above 0.7. Thus, with a small number of fixtures, still a good uniformity of the surface to be lighted can be obtained.

[0033] The light source 2 is an LED and more preferably an LED having a high power.

[0034] The lens 3 shown is, in bottom view, disk-shaped, round. In principle, also a different geometry is applicable, for example, a lens that is square in bottom view.

[0035] The control of peak luminances is of importance especially when using LED light sources because the light emitting surfaces of the LEDs are relatively small, resulting in relatively high luminances.

[0036] Preferably, the lens has relatively large dimensions with respect to the dimensions of an LED light source. The light-emitting surface is thereby artificially enlarged. Furthermore, the side proximate to the light source, also called inner contour, and the side remote from the light source, also called outer contour, are so adapted that the texturing has no, or practically no, adverse influence on the desired light distribution.

[0037] In the embodiment shown, a light source 2 is mounted on a substrate 6, and the light source 2 and the lens together constitute a lighting module 1 which optionally forms an integrated product.

[0038] Figure 2 shows a schematic section of an embodiment of a lighting unit 7 according to the invention. The lighting unit is suitable for mounting to, for example, a ceiling 12. The lighting unit 7 comprises at least one lens 3 such as described with reference to Figure 1. In the lighting unit 7 according to the preferred embodiment shown in Figure 2, one lens 3 and one or more light sources 2 together constitute a lighting module 1. The lighting module 1 is preferably detachably attachable, so that the module can easily be replaced, for instance, at the end of the life of the light source or upon occurrence of a defect in the light source of the module. In a preferred embodiment, the lighting unit 7 comprises a carrier 9 for carrying at least one lighting module 1. Similarly, the carrier 9 may be suitable for carrying a plurality of, for example, 2, 3, 5, 18 or 50 lighting modules 1. Furthermore, the lighting module 1 is preferably provided with fastening means 8, these means 8 being preferably implemented as snap fingers 8a reaching through openings 8b in the carrier 9. However, alternative fastening means are also possible, for example, a thread connection or a bayonet closure.

[0039] Further, Figure 2 shows that the lighting unit 7 according to a preferred embodiment comprises a cooling body 10. The cooling body 10 is preferably directly or indirectly in thermal contact with the light source 2. Thus, heat can be efficiently transferred from the light source 2, for example, via the substrate 6 and/or the lens 3 to the cooling body 10.

[0040] Figure 3 shows a schematic view of an embodiment of a lighting unit according to the invention. In this embodiment, the lighting modules 1 are arranged in the form of a disk or ring. Alternative arrangements are also possible, as, for example, in the form of a polygon, a heart, or as a straight or curved line. The lighting unit 7 shown has a central part, while the carrier 9 has a recess 13, free from lighting modules 1. Owing to the specific geometry of the cooling body, an air circulation between the lighting unit 7 and the ceiling 12 can be forced.

[0041] The lighting unit has utility as functional interior lighting, for instance, as a circular downlight product or as a light fixture for office environment. As the lens can be realized with a relatively small thickness, the lighting unit can advantageously be used in relatively low rooms as well.

[0042] The dimension of the lens, seen in a direction from the light source to the surface to be lighted, also called the height or thickness of the lens, is less than about 40 mm, preferably less than about 20 or about 14 mm, but may in principle be still smaller, for example, about 12 mm or about 10 mm.

[0043] The invention is not limited to the exemplary embodiments described here. Many variants are possible.

[0044] Thus, the lighting unit may be mounted, for instance, in a floor or a wall of a building or be used in a vehicle, trailer home or tent.

[0045] Similarly possible are embodiments of a lighting unit according to the invention where the light source 2 and the lens 3 do not together constitute a detachably

attachable module, but are separately attached to the carrier.

[0046] In addition, the lens may be provided with a trim in order to realize a mechanical screening. Such variants will be clear to those skilled in the art and are understood to be within the scope of the invention, as set forth in the following claims.

Claims

1. A lighting unit, comprising a lens for adjustment of light exiting from a light source implemented as LED, wherein the lens has a side proximate to the light source and a side remote from the light source, wherein the lens defines a specific light distribution, whereby the light intensity above the 65° radiation angle is less than 10% of the light intensity directly under the fixture and whereby the light intensity at 35° is greater than 90% of the light intensity directly under the fixture, and wherein the side of the lens remote from the light source is provided with a microstructure which scatters the light exiting from the lens.

2. A lighting unit according to claim 1, wherein the lens is designed for adjustment of light exiting from a plurality of light sources.

3. A lighting unit according to claim 1 or 2, wherein the specific light distribution of the lens is wide-radiating or deep-radiating.

4. A lighting unit according to any one of the preceding claims, wherein the microstructure provides for locally varying deviations of an angle of refraction with respect to the angle of refraction of a nominal smooth lens with a spread of the deviation that is at least so great that a surface enlargement of the image of the light source, for which the luminance is greater than 10% of the peak luminance is at least 50% higher than the image of the light source that would be obtained with the nominal smooth lens.

5. A lighting unit according to any one of the preceding claims, wherein the lens is of the Fresnel type.

6. A lighting unit according to any one of the preceding claims, wherein the peak lighting intensity on the surface to be lighted is lower than in a similar design with a level lens.

7. A lighting unit according to any one of the preceding claims, wherein the lens has a height that is less than about 40 mm.

8. A lighting unit according to any one of the preceding claims, wherein the side of the lens remote from the light source is roughened.

9. A lighting unit according to any one of the preceding claims, furthermore comprising the light source or the plurality of light sources which together with the lens constitute a lighting module.

10. A lighting unit according to claim 9, furthermore comprising a plurality of lighting modules.

11. A lighting unit according to claim 9 or 10, furthermore comprising a carrier for carrying the lighting module or the plurality of lighting modules.

12. A lighting unit according to claim 10 or 11, wherein the plurality of lighting units are arranged in the form of a disk or polygon.

13. A lighting unit according to any one of the preceding claims, wherein the lens is manufactured from a plastic.

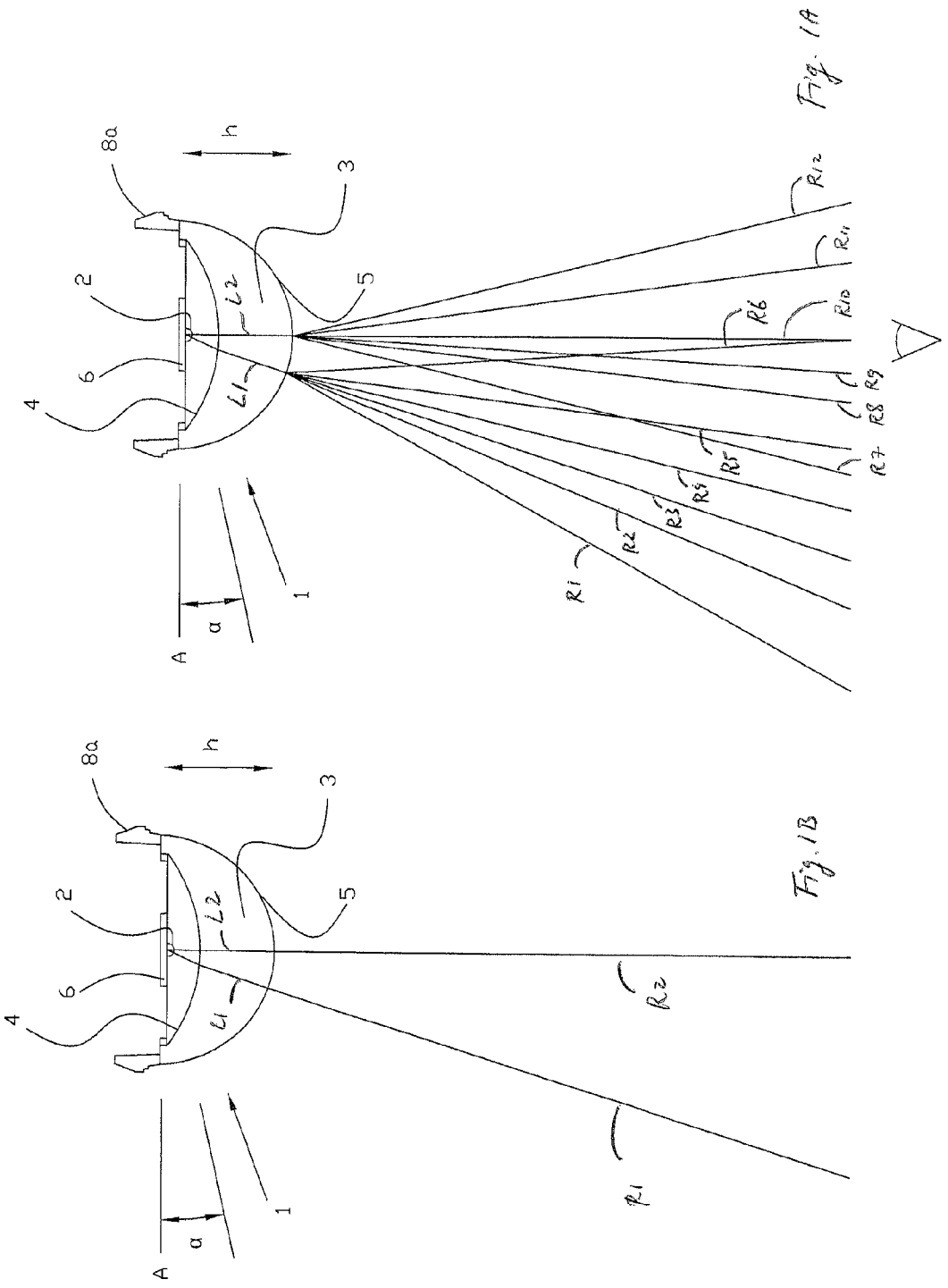

8a
h
3
2
5
L2
6
L1
4
A
a
1
R12
R11
R6
R10
R9
R8
R7
R5
R4
R3
R2
R1

Fig. 1A

8a
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3
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5
L2
6
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4
A
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Fig. 1B

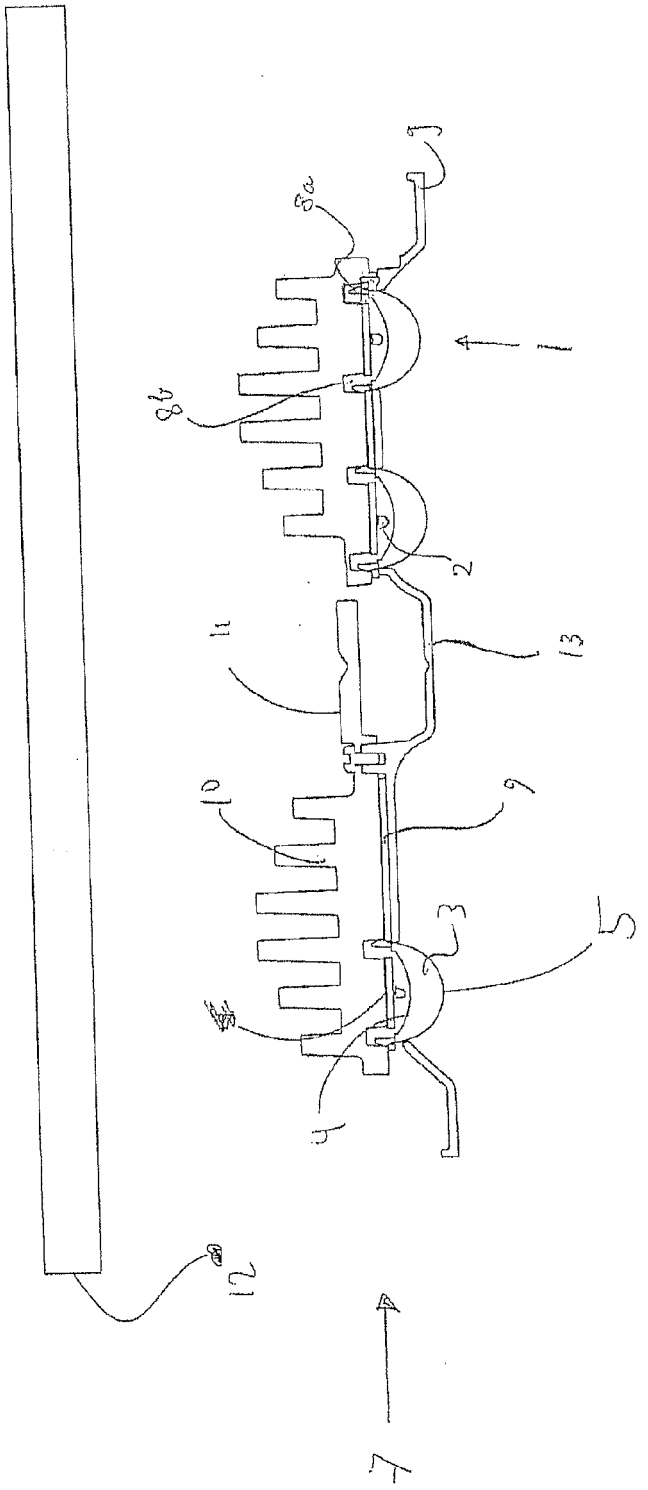


Fig. 2

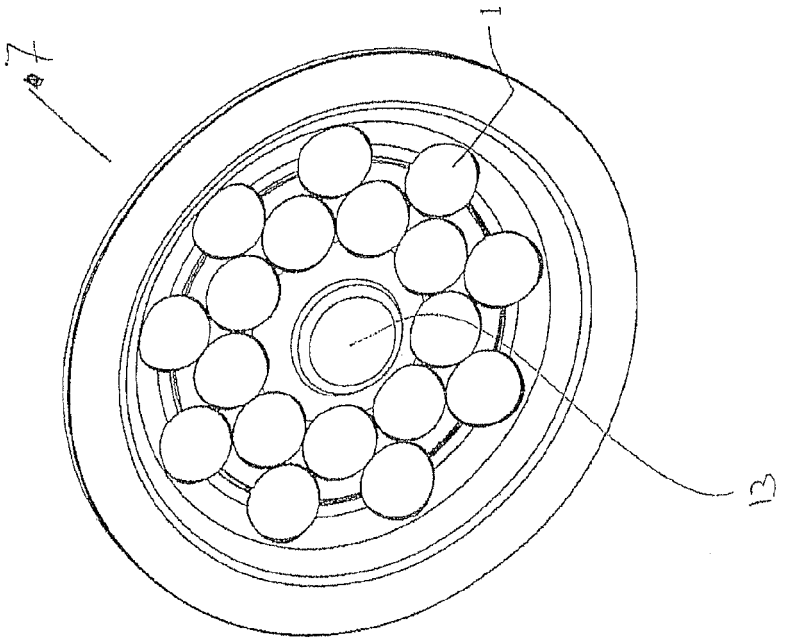


Fig 3