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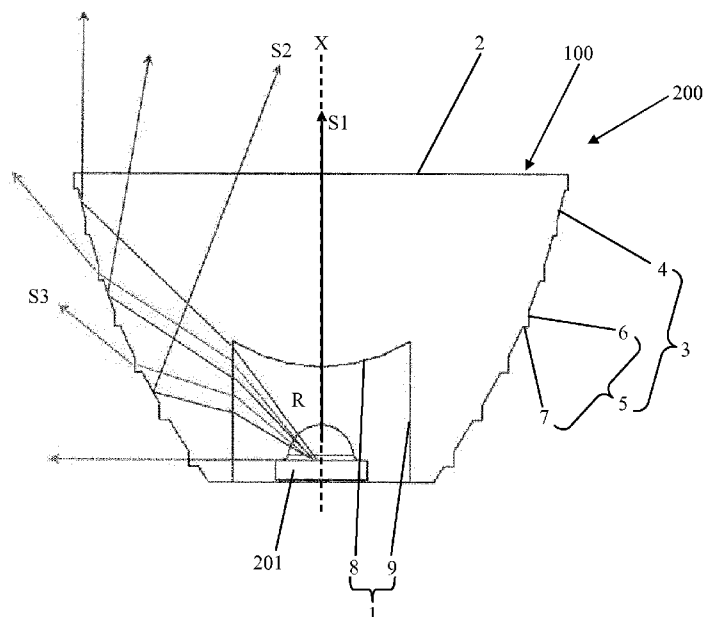
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[Continued on next page]

(54) Title: LENS FOR LED ILLUMINATION

Figure 2



(57) Abstract: Lens (100) comprising an incident surface (1), a first emergent surface (2) and a side surface (3) joining the incident surface (1) to the first emergent surface (2), wherein the incident surface (1) defines a cavity (R) for accommodating light sources (e.g. LED). The side surface (3) comprises a plurality of total-internal reflection surfaces (4) alternating with a plurality of refracting surfaces (5), light refracted by the incident surface (1) being either directly refracted by the emergent surface (2) or reflected by the total-internal reflection surfaces (4) towards the emergent surface (2) or directly refracted by the plurality of refracting surfaces (5).

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Description

LENS FOR LED ILLUMINATION

5 **Technical Field**

The present invention relates to a lens, an illuminating device comprising such lens and a light box.

Background Art

With the development of LED illumination technology, LED il-
10 luminating devices are used more and more in various environ-
ments. In order to improve the optical efficiency and to re-
alize predetermined light-distribution pattern, an LED illu-
minating device is usually equipped with a lens for light
sources. In a commonly used light box, a lens having a strip
15 profile covers light sources in a linear arrangement and is
mounted together with the light sources in a box-shaped
transparent housing, especially at the bottom of the housing.
Such lens preferably is a total-internal reflection lens
(TIR). Light emitted from the light sources can, for in-
20 stance, strike on the top of the housing from the bottom, and
part of light can strike on side walls of the housing. Such
light box is particularly suited for realizing decorative il-
lumination, for instance, used as advertisement light box.

However, since the lens installed at the bottom of the light
25 box is usually configured as a total-internal reflection
lens, light emitted from the light sources only can strike on
the top of the light box through a lens surface used as a
light emergent surface. For an area from the lens surface to
the top of the light box, such conventional total-internal
30 reflection lens leads to low luminance in the bottom region

of the light box, and a shadowed region at the bottom of the light box can be seen obviously as viewed from outside of the light box. Based on such illumination effect, aesthetics and applicability of the light box are affected to different degrees.

Summary of the Invention

In order to solve the above problems, the present invention provides a lens, through which incident light can be refracted to different directions to realize uniform illumination effect.

The first object the present invention is accomplished via a lens. The lens comprises a light incident surface, a first light emergent surface and side surfaces joining the light incident surface and the first light emergent surface,

wherein the light incident surface defines a space for accommodating light sources, characterized in that respective side surface comprises at least one total-internal reflection surface and at least one second light emergent surface, a first part of light passing through the light incident surface is refracted by the first light emergent surface and emerges to generate first emergent light, a second part of light passing through the light incident surface is reflected by the total-internal reflection surfaces to the first light emergent surface and is refracted by the first light emergent surface and emerges to generate second light emergent light, and a third part of light passing through the light incident surface is refracted by the second light emergent surfaces and emerges to generate third emergent light.

In solutions according to the present invention, the prior concept of using all side surfaces of a lens as total-

internal reflection surfaces is discarded, while some side surfaces preferably are retained as total-internal reflection surfaces and the other side surfaces are configured as light emergent surfaces that can refract light towards both sides of the lens. That is to say, the lens according to the present invention not only comprises a first emergent surface in the center but also comprises at least one second emergent surface at both sides of the first emergent surface. Incident light from the light sources can pass through the first and second emergent surfaces to strike towards different directions. Emergent light not only comprises a first part of emergent light through, e.g. the first light emergent surface as lens top surface, in the direction of the optical axis, but also comprises a second part of emergent light through the second light emergent surfaces on side surfaces of the lens at both sides of the optical axis. The first and second parts of emergent light extends in longitudinal and horizontal illumination areas of the lens, respectively, to enable outer surfaces of the lens to transmit light omnidirectionally, and then the second part of emergent light refracted from the side surfaces can be particularly used to illuminate the bottom region of the lens. Uniform light-distribution pattern can be obtained by using such lens.

According to one preferred solution of the present invention, the plurality of total-internal reflection surfaces are arranged to be spaced apart from each other, and adjacent total-internal reflection surfaces define the second light emergent surfaces therebetween. For the sake of uniform light-distribution effect, a plurality of (or as many as is possible) total-internal reflection surfaces and the second light emergent surfaces can be in a staggered arrangement according to practical situations to form side surfaces of the lens. Accordingly, while a part of incident light can be as-

sured to be reflected by the total-internal reflection surfaces to the first light emergent surface, the other part of incident light also can pass through the second light emergent surface to be refracted uniformly by side surfaces of the lens.

According to one preferred solution of the present invention, the plurality of total-internal reflection surfaces are spline-curve sections intercepted in sequence in cross section from a spline curve from the light incident surface to the first light emergent surface. The "cross section" in the present context refers to a plane simultaneously perpendicular to the first light emergent surface and a plane where the optical axis is located. A curve formed by connecting in sequence a plurality of lines, which are expressing the total-internal reflection surface, in cross section is a spline curve.

According to one preferred solution of the present invention, respective second light emergent surface in cross section is a groove recessed away from an optical axis in a direction perpendicular to the optical axis. It can be seen from the cross section that respective second light emergent surface has a curved profile protruding from inside to outside in a lateral direction of the lens, and the curved profile forms a groove with respect to the optical axis. According to requirements of practical application, height and width of the groove can be adjusted to obtain corresponding illumination effect.

According to one preferred solution of the present invention, respective second light emergent surface comprises a transmission portion parallel to the optical axis and a joining portion perpendicular to the optical axis. The transmission

portion and the joining portion are connected with each other and thus define a right angle. Herein the transmission portion is an optical surface of the second light emergent surface for refracting incident light, and the joining portion
5 is configured only in structure for joining the transmission portion with its adjacent total-internal reflection surface and does not change optical pathways of incident light.

According to one preferred solution of the present invention, the light incident surface has an arc-shaped first incident
10 surface and second incident surfaces joining the first incident surface and the side surfaces, and the first incident surface and the second incident surfaces define a cavity recessed towards the first light emergent surface in a direction of the optical axis. Linear light sources are arranged
15 in the recessed cavity defined by the light incident surface, and light emitted from the linear light sources can be collected as much as is possible using the cavity, and the light reaches the first incident surface in the center and the second incident surfaces at both sides of the first incident
20 surface. A part of light having a small angle with the optical axis strikes on the first incident surface configured to be circular arc and directly emerges through the first light emergent surface in convergence. The other part of light having a big angle with the optical axis strikes on the second
25 incident surfaces, and is reflected by and transmits through two opposite side surfaces of the lens, and then a part of reflected light converges towards the optical axis and emerges through the first light emergent surface. According to different application situations, the converging degree of
30 emergent light can be changed by adjusting a distance between the lens and an object to be illuminated and curve profiles of the light incident surface and side surfaces of the lens, and therefore, strip light-distribution patterns with differ-

ent widths and luminance are obtained.

According to one preferred solution of the present invention, the first incident surface in cross section is circular arc. Preferably, the first incident surface in cross section is a spline curve. Through the first incident surface having such profile, light striking on the lens can converge towards the optical axis and arrives at the first light emergent surface.

According to one preferred solution of the present invention, respective second incident surface defines a cylinder symmetrical with respect to the optical axis.

According to one preferred solution of the present invention, the lens is elongated and symmetrical with respect to a plane where the optical axis is located. As a result, symmetrical and uniform light-distribution patterns can be obtained through the symmetrical configuration of the lens.

Preferably, a joining surface parallel to the light emergent surface between the light incident surface and respective side surface is provided.

According to one preferred solution of the present invention, the first light emergent surface is a planar surface perpendicular to the optical axis. By configuring the first light emergent surface as a planar surface, light can highly effectively emerge, preventing occurrence of, e.g. reflection and refraction, on the uneven light emergent surface.

The present invention further relates to an illuminating device, comprising light sources, and the lens mentioned above, wherein the lens defines a space for accommodating the light sources. Preferably, the light sources of the illuminating

device are LED chips.

In addition, the present invention further relates to a light box comprising box-shape light-transmission housing, and further comprising the above illuminating device, wherein the lens is elongated and the light sources are light sources in linear arrangement. Such light box can realize uniform illumination, and particularly, shadowed region with low luminance will not appear at the bottom of the light box where the light sources are mounted.

10 **Brief Description of the Drawings**

The accompanying drawings constitute a part of the present Description and are used to provide further understanding of the present invention. Such accompanying drawings illustrate the embodiments of the present invention and are used to describe the principles of the present invention together with the Description. In the accompanying drawings the same components are represented by the same reference numbers. As shown in the drawings:

Fig. 1 is a cross-sectional view of a lens according to the present invention;

Fig. 2 is a cross-sectional view of an illuminating device according to the present invention;

Fig. 3 is a light-distribution diagram of the illuminating device according to the present invention; and

Fig. 4 is a 3D schematic diagram of a light box according to the present invention.

Detailed Description of the Embodiments

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in
5 which the invention may be practiced. In this regard, directional terminology, such as "top", "bottom", "inner", "outer", is used in reference to the orientation of the figures being described. Because components of embodiments of the present invention can be positioned in a number of different orientations, the directional terminology is used for
10 purposes of illustration and is in no way limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed
15 description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

It is to be understood that the features of the various exemplary embodiments described herein may be combined with each
20 other, unless specifically noted otherwise.

Fig. 1 is a cross-sectional view of a lens according to the present invention. It can be seen from Fig. 1 that a lens 100 has a light incident surface 1, a first light emergent surface 2 and two side surfaces 3 joining the light incident
25 surface 1 and the first light emergent surface 2, wherein the two side surfaces 3 opposite to each other substantially extend symmetrically in a form of spline curve. In accordance with the present invention, respective side surface 3 is configured to be formed by at least one (a plurality of, in the present embodiment) total-internal reflection surface 4 and
30 at least one (a plurality of, in the present embodiment) sec-

ond light emergent surface 5 joined therewith. And then light emergent surfaces in different directions, particularly perpendicular to a direction of an optical axis X, and emergent surfaces in two lateral directions for the incident light for obtaining uniform light-distribution patterns.

It can be seen further from the cross-sectional view of Fig. 1 that the circled curved line is the second light emergent surface 5 particularly configured according to the present invention. The two total-internal reflection surfaces 4 respectively joining two ends of the second light emergent surface 5 are spline-curve sections. Respective second light emergent surface 5 is formed by a transmission portion 6 parallel to the optical axis X and a joining portion 7 perpendicular to the optical axis X, and then a right-angle groove recessed away from the optical axis X is formed in the direction perpendicular to the optical X. The right-angle groove, with respect to the adjacent total-internal reflection surfaces 4, has a profile protruding outwardly from the lens 100.

The light incident surface 1 is configured as a curved surface for receiving incident light as much as is possible. The light incident surface 1 as shown in Fig. 1 comprises a first incident surface 8 in the center and second incident surfaces 9 extending downwardly parallel to the optical axis X at both sides thereof. The first incident surface 8 in cross section is configured to be circular-arc shape or spline-curve shape for directly converging the incident light. In addition, for preventing light loss, the second incident surfaces 9 surrounding the first incident surface 8 are configured as cylindrical curved surfaces, and they define, together with the first incident surface 8, a cavity R for accommodating light sources.

The first light emergent surface 2 is a planar surface perpendicular to a surface where the optical axis X is located, i.e. a top surface of the lens 10. Since there is no uneven structure on the first light emergent surface 2, reflection and refraction caused thereby can be avoided so that light emerges highly-effectively and uniformly through the first light emergent surface 2. A joining surface 10, i.e. a bottom surface of the lens 100, parallel to the first light emergent surface, is present between the light incident surface 1 and respective side surface 3.

Fig. 2 is a cross-sectional view of an illuminating device according to the present invention, wherein optical pathways of incident light from light sources 201 through the lens 100 are schematically shown. The light sources 201 arranged in the cavity R emit incident light towards the first incident surface 8 and the second incident surfaces 9. In a perpendicular direction, a first part of light entering the lens 100 through the first incident surface 8 is refracted by the first light emergent surface 2 along the optical axis X in a converging manner to form first emergent light S1. In a horizontal direction, light entering the lens 100 through the second incident surfaces 9 is refracted to different regions of the side surfaces 3: a part of light strikes on the total-internal reflection surfaces 4 and reflected to the first light emergent surface 2 to thus form second emergent light S2 substantially converging towards the optical axis X; and the other part of light strikes on the second light emergent surfaces 5 in staggered arrangement with the total-internal reflection surfaces 4 to form third emergent light S3. As respective second light emergent surface 5 comprises the transmission portion 6 parallel to the optical axis X, the transmission portion 6 can enable received light to emerge in a lateral direction of the lens 100. Based on the special

structure of the lens 100, the illuminating device 100 is allowed to have uniform and large-area illumination effect.

Of course, desired light-distribution patterns can be obtained by adjusting the profile of the lens according to requirements in practical situation. For instance, the profile of respective side surface 3, especially lengths in cross sections of the transmission portion 6 and the joining portion 7 that define the right-angle groove, can be changed to adjust emergent angle and optical density of light refracted by the side surfaces 3 of the lens 100. As a result, light-distribution patterns with adjustable width and luminance can be obtained.

The lens 100 as shown in Fig. 1 and Fig. 2 can have a strip profile. Such lens is particularly adaptive to the light sources 201 in a linear arrangement.

In combination with the light-distribution pattern of the illuminating device 200 as shown in Fig. 3, it can be seen that the illuminating device 200, starting from origin, i.e. starting from a point where the light sources are located, not only can realize longitudinal uniform light-distribution upwardly, but also can realize uniform light-distribution downwardly from the origin, i.e. in a bottom region of the illuminating device 200 as shown in Fig. 2. Accordingly, luminance in the bottom region of the illuminating device 200 can be improved.

Fig. 4 is a 3D schematic diagram of a light box according to the present invention. A light box 300 comprises a light-transmission housing 301 having a cubic profile and the illuminating device 200 installed at a bottom of the light-transmission housing 301. The lens 100 configured to be

strip-shaped covers the light sources 201 in a linear arrangement to constitute the illuminating device 200.

The light sources 201 can be LED chips within the scope of the present invention, and then the illuminating device 200
5 and the light box 300 have the advantages of high efficiency and energy-saving.

In addition, while a particular feature or aspect of an embodiment of the invention may have been disclosed with respect to only one of several implementations, such feature or
10 aspect may be combined with one or more other features or aspects of the other implementations as may be desired and advantageous for any given or particular application. Furthermore, to the extent that the terms "include", "have", "with", or other variants thereof are used in either the detailed description or the claims, such terms are intended to be inclusive
15 in a manner similar to the term "comprise".

The above is merely preferred embodiments of the present invention but not to limit the present invention. For the person skilled in the art, the present invention may have various
20 alterations and changes. Any alterations, equivalent substitutions, improvements, within the spirit and principle of the present invention, should be covered in the protection scope of the present invention.

List of reference signs

	1	light incident surface
	2	first light emergent surface
	3	side surface
5	4	total-internal reflection surface
	5	second light emergent surface
	6	transmission portion
	7	joining portion
	8	first incident surface
10	9	second incident surface
	10	joining surface
	100	lens
	200	illuminating device
	201	light source
15	300	light box
	301	light-transmission housing
	R	cavity
	X	optical axis

S1	first emergent light
S2	second emergent light
S3	third emergent light

Claims

1. A lens (100), comprising a light incident surface (1), a first light emergent surface (2) and side surfaces (3) joining the light incident surface (1) and the first light emergent surface (2), wherein the light incident surface (1) defines a space for accommodating light sources, characterized in that respective side surface (3) comprises at least one total-internal reflection surface (4) and at least one second light emergent surface (5), a first part of light passing through the light incident surface (1) is refracted by the first light emergent surface (2) and emerges to generate first emergent light (S1), a second part of light passing through the light incident surface (1) is reflected by the total-internal reflection surfaces (4) to the first light emergent surface (2) and is refracted by the first light emergent surface (2) and emerges to generate second light emergent light (S2), and a third part of light passing through the light incident surface (1) is refracted by the second light emergent surfaces (5) and emerges to generate third emergent light (S3).

2. The lens (100) according to Claim 1, characterized in that the plurality of total-internal reflection surfaces (4) are arranged to be spaced apart from each other, and adjacent total-internal reflection surfaces (4) define the second light emergent surfaces (5) therebetween.

3. The lens (100) according to Claim 2, characterized in that the plurality of total-internal reflection surfaces (4) are spline-curve sections intercepted in sequence in cross section from a spline curve from the light incident surface (1) to the first light emergent surface (2).

4. The lens (100) according to Claim 2, characterized in that respective second light emergent surface (5) in cross section is a groove recessed away from an optical axis (X) in a direction perpendicular to the optical axis (X).

5 5. The lens (100) according to Claim 4, characterized in that respective second light emergent surface (5) comprises a transmission portion (6) parallel to the optical axis (X) and a joining portion (7) perpendicular to the optical axis (X).

6. The lens (100) according to any one of Claims 1-5, characterized in that the light incident surface (1) has an arc-shaped first incident surface (8) and second incident surfaces (9) joining the first incident surface (8) and the side surfaces (3), and the first incident surface (8) and the second incident surfaces (9) define a cavity (R) recessed towards the first light emergent surface (2) in a direction of the optical axis (X).

7. The lens (100) according to Claim 6, characterized in that the first incident surface (8) in cross section is circular arc.

20 8. The lens (100) according to Claim 6, characterized in that the first incident surface (8) in cross section is a spline curve.

9. The lens (100) according to Claim 6, characterized in that respective second incident surface (9) defines a cylinder symmetrical with respect to the optical axis (X).

10. The lens (100) according to any one of Claims 1-5, characterized in that the lens is elongated and symmetrical with respect to a plane where the optical axis (X) is located.

11. The lens (100) according to any one of Claims 1-5, characterized in that a joining surface (10) parallel to the light emergent surface (2) between the light incident surface (1) and respective side surface (3) is provided.

5 12. The lens (100) according to any one of Claims 1-5, characterized in that the first light emergent surface (2) is a planar surface perpendicular to the optical axis (X).

13. An illuminating device (200), comprising light sources (201), characterized by further comprising the lens (100) according to any one of Claims 1-12, wherein the lens (100) defines a space for accommodating the light sources (201).
10

14. The illuminating device (200) according to Claim 13, characterized in that the light sources (201) are LED chips.

15. A light box (300) comprising a box-shape light-transmission housing (301), characterized by further comprising the illuminating device (200) according to Claim 13 or 14, wherein the lens (100) is elongated and the light sources (201) are light sources in linear arrangement.

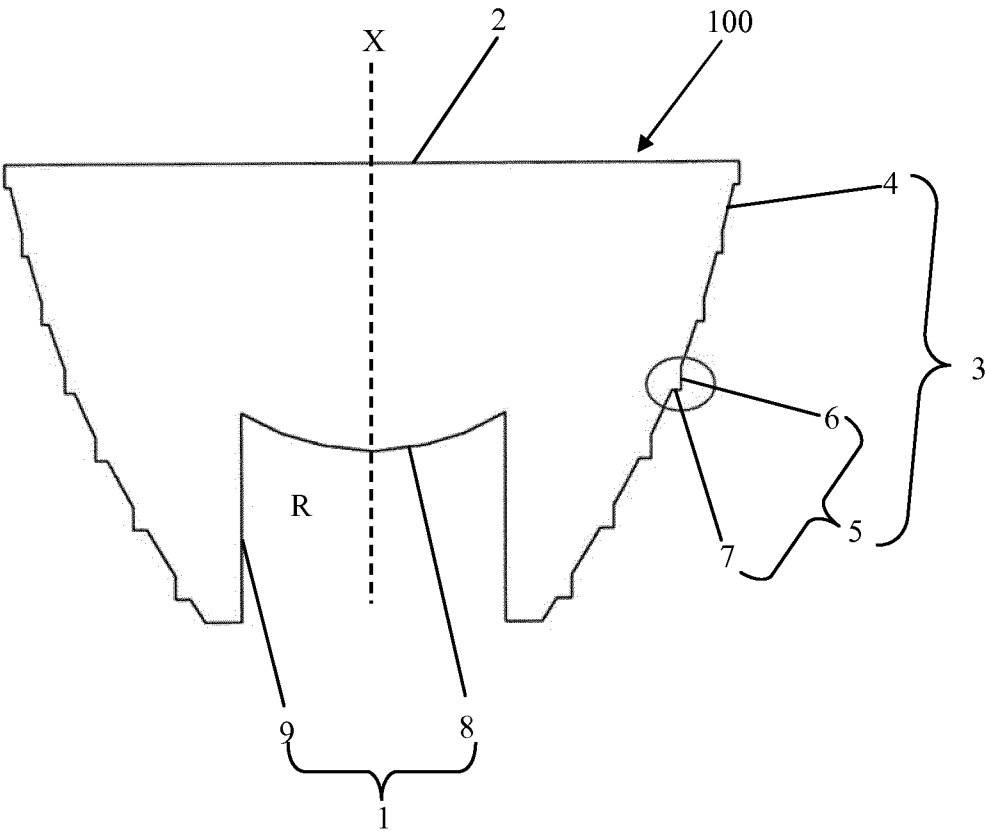


Figure 1

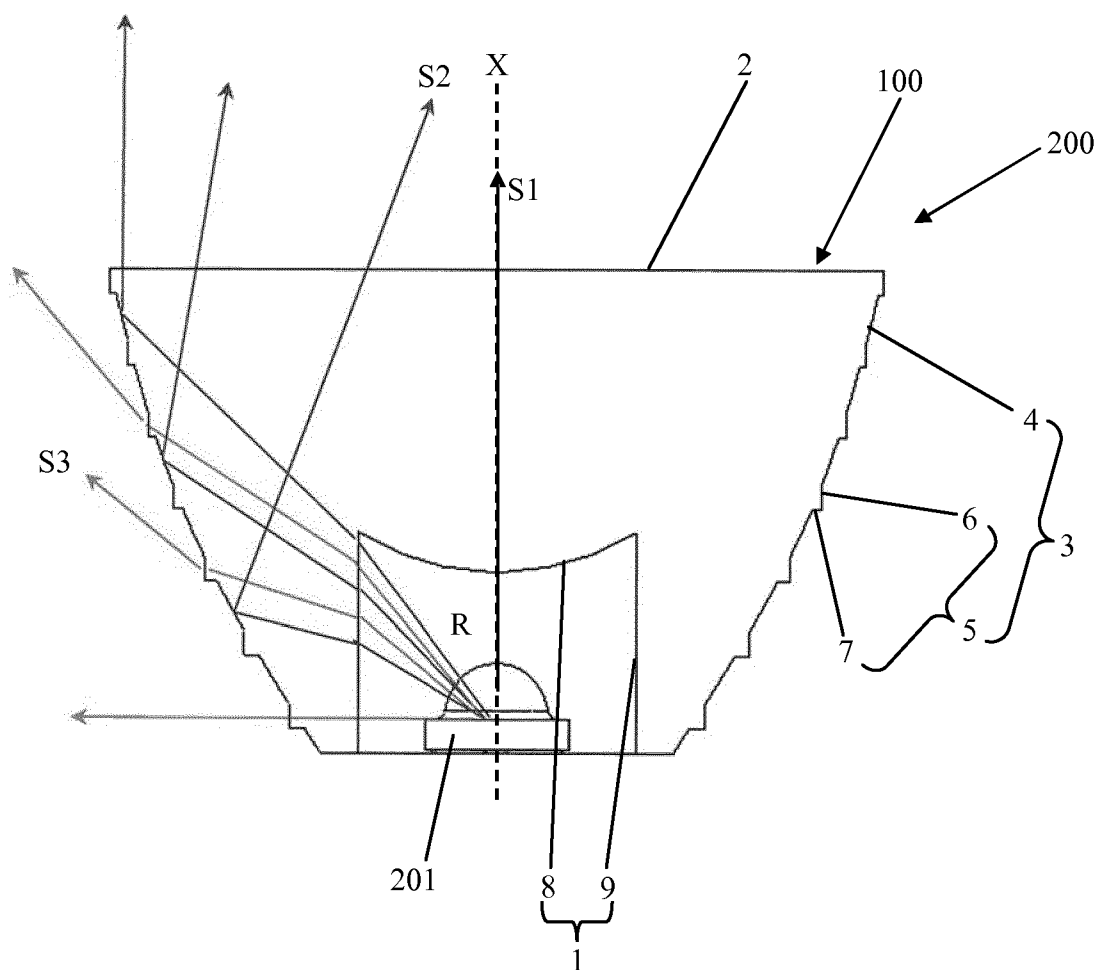


Figure 2

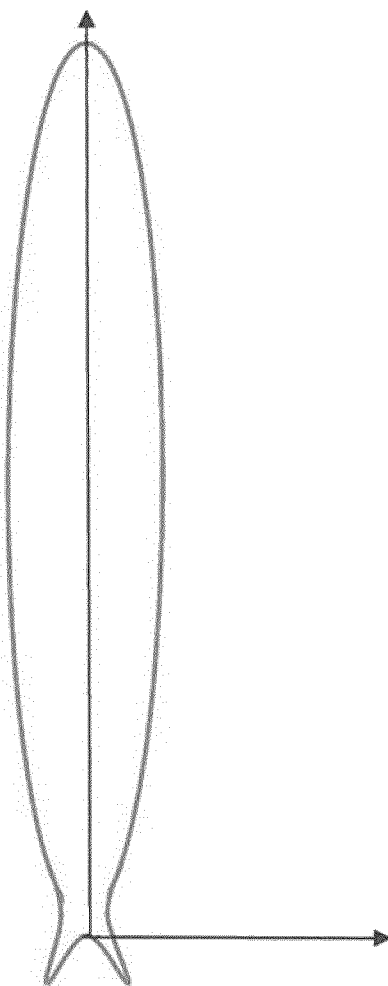


Figure 3

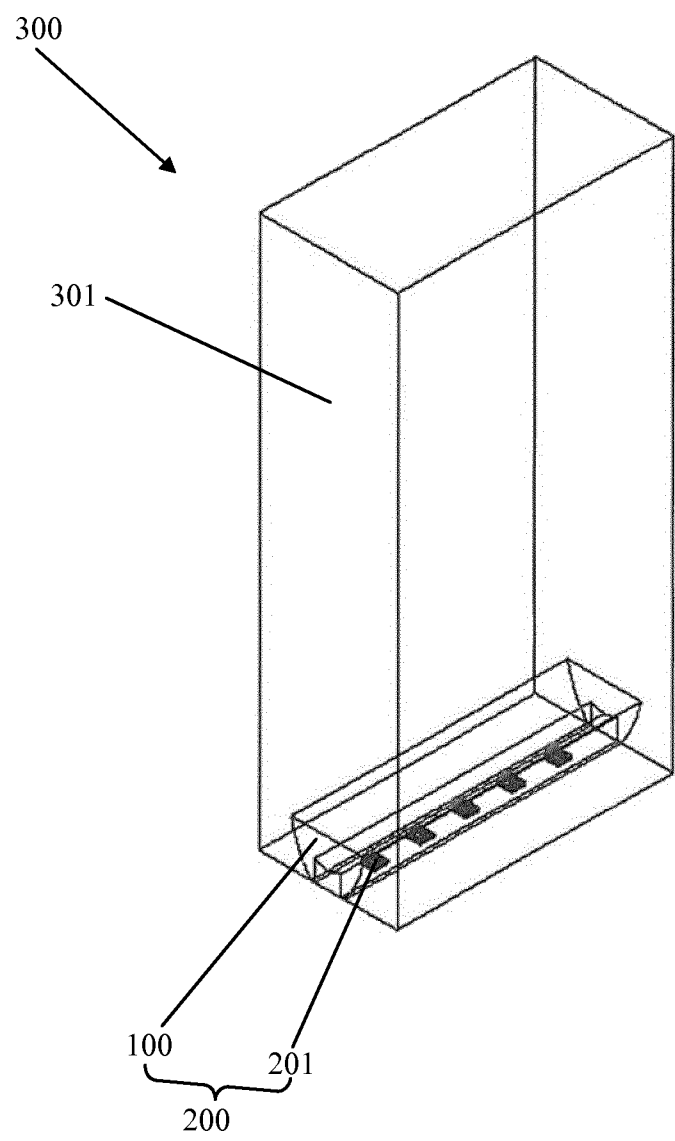


Figure 4

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2013/063589

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B19/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G02B F21V H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/327302 A1 (WANG ZHONG-QING [CN] ET AL) 30 December 2010 (2010-12-30)	1,6,7,9-14
Y	figure 4	8,15
Y	WO 2011/076214 A1 (MARTIN PROFESSIONAL AS [DK]; AALBORG UNIVERSITY [DK]; JOERGENSEN DENNI) 30 June 2011 (2011-06-30)	8
Y	US 2011/026247 A1 (ZHANG HAI-WEI [CN] ET AL) 3 February 2011 (2011-02-03)	15
	figures 2-3	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

23 September 2013

Date of mailing of the international search report

30/09/2013

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2013/063589

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