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(71) Applicant: **OSRAM GMBH** [DE/DE]; Marcel-Breuer-Straße 6, 80807 München (DE).

(72) Inventors: **MING, Yusheng**; 5F, Hantang Building, OCT (Overseas Chinese Town), Shenzhen, Guangdong 518053 (CN). **LIU, Tingming**; 5F, Hantang Building, OCT (Overseas Chinese Town), Shenzhen, Guangdong 518053 (CN). **YANG, Jianghui**; 5F, Hantang Building, OCT (Overseas Chinese Town), Shenzhen, Guangdong 518053 (CN). **LU, Huanghui**; 5F, Hantang Building, OCT (Overseas Chinese Town), Shenzhen, Guangdong 518053 (CN).

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(54) Title: ILLUMINATION DEVICE

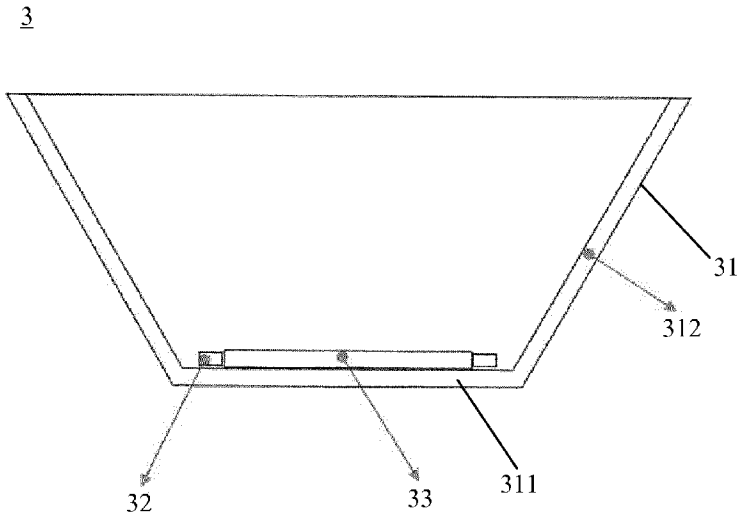


Figure 3A

(57) Abstract: An illumination device according to an embodiment of the present technique comprises: a housing comprising a bottom portion and a side wall portion; a light guide plate provided on the bottom portion of the housing and comprising a side surface, a first surface, and a second surface facing the first surface, the second surface being closer to the bottom portion of the housing than the first surface; and a plurality of light sources provided on the side surface of the light guide plate and emitting light to the side surface, the light emerging from the first surface of the light guide plate to the outside, after travelling in the light guide plate. By providing the light guide plate, the illumination device according to an embodiment of the present technique can mix the light from the plurality of light sources with a very small light loss. Thus, the illumination device can maintain high luminous efficiency, and obtain a smooth emergent light intensity distribution, without producing multiple shadows.

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Description

Illumination Device

Technical Field

The present disclosure relates to an illumination device, and specifically, to an illumination device capable of obtaining a smooth emergent light intensity distribution.

Background Art

Recently, point light sources such as an LED are more and more frequently applied to illumination devices. Fig. 1A and Fig. 1B show a downlight 1 as one example of the illumination devices using a point light source, wherein Fig. 1A is a sectional view of the downlight 1, and Fig. 1B is a top view of the downlight 1. Referring to Fig. 1A and Fig. 1B, the downlight 1 comprises a housing 11 comprising a bottom portion and a side wall portion, and a plurality of LEDs 12 arranged on the bottom portion of the housing 11 and emitting light of different colors, wherein the plurality of LEDs 12 are arranged on the bottom portion of the housing 11 in such a manner that they form a circle.

In the example shown in Fig. 1A and Fig. 1B, the plurality of LEDs 12 are separately disposed at different positions on the bottom portion of the housing 11. Each LED 12 forms light spots at different positions on an illuminated surface, in accordance with its location and the luminous intensity distribution. These light spots partially overlap, and as a result, the light intensity distribution curve on the illuminated surface S is not smooth, and the user may observe glare, chromatic aberration or bright-dark change on the il-

luminated surface S.

Moreover, when a barrier B exists between the downlight 1 and the illuminated surface S, the plurality of LEDs 12 emitting light of different color illuminate the barrier B, and produce shadows on the illuminated surface S. Since the plurality of LEDs 12 are separately disposed at different positions on the bottom portion of the housing 11, the different LEDs 12 will produce shadows at different positions on the illuminated surface S. These shadows partially overlap, and as a result, as shown in Fig. 1A, multiple shadows are formed on the illuminated surface S, which deteriorates the illumination effects of the downlight 1.

As a solution for solving this problem, an illumination device using a diffuser has been proposed. Fig. 2 shows a downlight 2 as one example of illumination devices comprising a point light source and a diffuser. Referring to Fig. 2, the downlight 2 comprises a housing 21 comprising a bottom portion and a side wall portion, and a plurality of LEDs 22 disposed on the bottom portion of the housing 21 and emitting light of different colors, wherein the plurality of LEDs 22 are arranged on a PCB board 23 on the bottom portion of the housing 21 in such a manner that they form a circle. The downlight 2 further comprises a diffuser 24 located on the light emergent side. By providing the diffuser 24, the light emitted from the plurality of LEDs 22 are mixed, which enhances the smoothness of light intensity distribution curve of the light emerging from the downlight 2.

However, in the case of using the diffuser 24, a portion of the light emitted from the plurality of LEDs 22 is lost due to the diffuser 24. Moreover, since the diffuser 24 has a small thickness, the light mixing effect thereof is limited.

Further, it is also difficult for the downlight 2 to obtain a narrow beam angle.

Therefore, it is desirable to provide an illumination device having high luminous efficiency and capable of obtaining a smooth emergent light intensity distribution (without producing multiple shadows).

Summary of the invention

An illumination device according to an embodiment of the present technique comprises: a housing comprising a bottom portion and a side wall portion; a light guide plate provided on the bottom portion of the housing and comprising a side surface, a first surface, and a second surface facing the first surface, the second surface being closer to the bottom portion of the housing than the first surface; and a plurality of light sources provided on the side surface of the light guide plate and emitting light to the side surface, the light emerging from the first surface of the light guide plate to the outside, after travelling in the light guide plate.

By providing the light guide plate, the illumination device according to an embodiment of the present technique can mix the light from the plurality of light sources with a very small light loss. Thus, the illumination device can maintain high luminous efficiency, and obtain a smooth emergent light intensity distribution, without producing multiple shadows.

Preferably, a plurality of convex-concave structures are formed on the second surface of the light guide plate.

In the case where a plurality of convex-concave structures are formed on the second surface of the light guide plate,

the light mixing effect of the light guide plate can be adjusted by setting the size, density, arrangement, etc. of the plurality of convex-concave structures, so as to obtain the desired emergent light intensity distribution.

For example, preferably, the plurality of convex-concave structures can be designed such that the first surface of the light guide plate has a Gaussian emergent light intensity distribution.

In such case, the illumination device has a smooth emergent light intensity distribution (Gaussian emergent light intensity distribution), and thereby, the occurrence of multiple shadows can be avoided despite the use of the plurality of light sources for illumination. Thus, excellent illumination effects are achieved.

Preferably, the size of the convex-concave structure decreases as a distance between the convex-concave structure and the center of the light guide plate increases, or the density of the plurality of convex-concave structures decreases as the distance between the convex-concave structures and the center of the light guide plate increases.

Thus, the desired emergent light intensity distribution can be obtained by adjusting the size and density of the convex-concave structures.

Preferably, the convex-concave structure can be a dot-like convex structure or a dot-like concave structure.

In such case, it is possible to form the convex-concave structure in a simple manner, for example, the convex-concave structure can be formed on the second surface of the light

guide plate by an inkjet printing method or a mechanical engraving method, or the convex-concave structure can be formed integrally with the light guide plate by an injection molding method or a press molding method.

Similarly, the convex-concave structures can be designed such that the first surface of the light guide plate has a smooth curved emergent light intensity distribution in which the center is higher than the circumference or the center is lower than the circumference.

Further, according to the needs of design, the convex-concave structure can be designed such that the first surface of the light guide plate has an emergent light intensity distribution of other type.

According to the needs of design, the light guide plate can have, in a top view, a circular shape, an elliptical shape, a rectangular shape, or a regular hexagonal shape.

Preferably, the plurality of light sources are uniformly distributed around the light guide plate. Preferably, the plurality of light sources include red light sources, blue light sources and green light sources. Preferably, the plurality of light sources are point light sources such as LEDs and laser diodes.

Preferably, the bottom portion and/or the side wall portion of the housing have a function of specular reflection or diffuse reflection.

In such case, the luminous efficiency of the illumination device can be further enhanced.

Brief Description of the Drawings

Fig. 1A and Fig. 1B are respectively a sectional view and a top view of an example of the illumination devices according to relevant techniques;

Fig. 2 is a diagram showing another example of the illumination devices according to relevant techniques;

Fig. 3A and Fig. 3B are respectively a sectional view and an oblique view of an example of the illumination device according to the implementation of the present technique;

Fig. 4A and Fig. 4B are respectively an oblique view and a top view of an example of the light guide plate according to the implementation of the present technique;

Fig. 5A is a schematic diagram of an optical path example of the illumination device according to the implementation of the present technique; and Fig. 5B is a schematic diagram of an optical path of the illumination device according to relevant techniques;

Fig. 6 is an optical simulation diagram of the optical path example of the illumination device according to the implementation of the present technique;

Fig. 7 is an optical simulation diagram of an illumination distribution example of the illumination device according to the implementation of the present technique; and

Fig. 8 is a diagram of examples of emergent light intensity distribution of the illumination device according to the implementation of the present technique.

Detailed Description of the Embodiments

In the following detailed description, some exemplary embodiments of the present technique are described with reference to the accompanying drawings which form a part hereof. It is to be understood that other embodiments may be utilized and various changes may be made without departing from the scope of the present technique. The following detailed description, therefore, is not to be taken in a limiting sense, and the present technique is defined by the appended claims.

Fig. 3A and Fig. 3B schematically illustrate an illumination device 3 according to the implementation of the present technique, wherein Fig. 3A is a sectional view of the illumination device 3, and Fig. 3B is an oblique view of the illumination device 3. Referring to Fig. 3A and Fig. 3B, the illumination device 3 comprises a housing 31, a plurality of LEDs 32 and a light guide plate 33.

The housing 31 comprises a bottom portion 311 and a side wall portion 312 extending from the circumference of the bottom portion 311 towards the outside. Preferably, the surface of the bottom portion 311 and/or the surface of the side wall portion 312 have a function of specular reflection or diffuse reflection, so as to enhance light extraction efficiency.

The plurality of LEDs 32 are disposed on the bottom portion 311 of the housing 31. The plurality of LEDs 32 can be either supported by a single support member such as a PCB board, or supported by respective support members. The plurality of LEDs 32 include LEDs emitting light having different colors, e.g., including LEDs emitting red light, green light and blue light.

The light guide plate 33 is disposed on the bottom portion 311 of the housing 31. In the present embodiment, the light guide plate 33 has a circular shape in the top view, and the plurality of LEDs 32 are uniformly disposed around the light guide plate 33. In the case where the plurality of LEDs 32 include LEDs emitting light having different colors, the LEDs emitting light having different colors can be arranged around the light guide plate 33 in a predetermined sequence, for example, in a sequence of red LED, green LED, blue LED, red LED ….

Referring to Fig. 4A and Fig. 4B, a plurality of dot-like convex structures 331 are provided on the lower surface (the surface of the light guide plate 33 on the side of the bottom portion 311 of the housing 31) of the light guide plate 33. The plurality of dot-like convex structures 331 are arranged on the lower surface of the light guide plate 33 in a manner of central symmetry, and the symmetry center is the center of the lower surface of the light guide plate 33. In the present embodiment, the size and density of the plurality of dot-like convex structures 331 decrease as the distance between the dot-like convex structures 331 and the center of the lower surface of the light guide plate 33 increases.

The plurality of dot-like convex structures 331 can be formed on the lower surface of the light guide plate 33 by an inkjet printing method or a mechanical engraving method, or the plurality of dot-like convex structures 331 can be formed integrally with the light guide plate 33 by an injection molding method or a press molding method.

Fig. 5A shows an optical path example of the illumination device 3 according to the implementation of the present technique, and as a contrast, Fig. 5B shows an optical path of

the illumination device 1 according to relevant techniques as shown in Fig. 1.

Referring to Fig. 5A, in the illumination device 3 according to the present embodiment, the light emitted by the plurality of LEDs 32 is incident upon the light guide plate 33 via the side surface of the light guide plate 33, and emerges from the upper surface of the light guide plate 33 after being totally reflected for many times via the upper surface and the lower surface of the light guide plate 33 and sufficiently mixed. A portion of the emergent light directly emerges to the outside of the illumination device 3, and the other portion of the emergent light emerges to the outside after being reflected by the inner surface of the side wall portion 312 of the housing 31.

Since the plurality of dot-like convex structures 331 are provided on the lower surface of the light guide plate 33, the light inside the light guide plate 33 is totally reflected at the plurality of dot-like convex structures 331. Further, since the plurality of dot-like convex structures 331 are arranged in a predetermined manner, the light inside the light guide plate 33 undergoes different total reflections at different positions on the lower surface of the light guide plate 33, and thereby, the desired light intensity distribution is obtained on the upper surface of the light guide plate 33.

In the present embodiment, since the size and density of the plurality of dot-like convex structures 331 decrease as the distance between the dot-like convex structures 331 and the center of the lower surface of the light guide plate 33 increases, the maximum light intensity is obtained at the center of the upper surface of the light guide plate 33, and the

minimum light intensity is obtained in the vicinity of the edge of the upper surface of the light guide plate 33. Further, since the size and density of the plurality of dot-like convex structures 331 gradually decrease, a light intensity distribution curve with smooth transition is obtained between the center and the vicinity of the edge of the upper surface of the light guide plate 33.

However, in the illumination device 1 of relevant techniques, referring to Fig. 5B, a plurality of LEDs 12 separately emit light to the outside of the illumination device 1, each LED 12 form light spots at different positions on an illuminated surface, and these light spots partially overlap each other. As a result, the light intensity distribution on the illuminated surface does not have a curve with smooth transition.

Fig. 6 is an optical simulation diagram of the optical path example of the illumination device according to the implementation of the present technique. Fig. 7 is an optical simulation diagram of an illumination distribution example of the illumination device according to the implementation of the present technique.

Referring to Fig. 6 and Fig. 7, in the present embodiment, Gaussian emergent light intensity distribution is obtained on the upper surface of the light guide plate 33. Specifically, as shown in Fig. 7, the maximum illumination of about 2000 Lux is obtained at the center of the upper surface of the light guide plate 33, as the distance from the center increases, the illumination gradually (smoothly) decreases, and the minimum illumination of about 200 Lux is obtained in the vicinity of the edge of the upper surface of the light guide plate 33.

Thus, the illumination device 3 according to the present embodiment can obtain smooth emergent light intensity distribution while maintaining high luminous efficiency, which avoids the occurrence of multiple shadows. Moreover, due to the light mixing effect of the light guide plate 33, the occurrence of glare is reduced.

In the illumination device 3 according to the present embodiment, when the plurality of LEDs 32 include LEDs emitting light having different colors, by means of the light mixing effect of the light guide plate 33, superior color mixing effect can be achieved.

The example in which a plurality of LEDs 32 are used as the light source is described as above. However, the present technique is not limited to this. The illumination device according to the present technique can include light sources in other forms, for example, point light sources, linear light sources or area light sources such as laser diodes, as long as the light emitted therefrom can be effectively guided into the side surface of the light guide plate 33.

The plurality of LEDs 32 are side-emission type LEDs. However, the present technique is not limited to this. In the illumination device according to the present technique, a light source of top-emission type can also be used, as long as light guide means such as a mirror or a prism is provided on its light emitting surface to effectively guide the light emitted therefrom into the light guide plate.

The example in which a plurality of dot-like convex structures 331 are used as the plurality of convex-concave structures on the lower surface of the light guide plate 33 is described as above. However, the present technique is not lim-

ited to this. In the illumination device according to the present technique, a plurality of dot-like concave structures can be provided on the lower surface of the light guide plate, and the same effect can be achieved. The plurality of convex-concave structures do not necessarily have a circular bottom surface as the dot-like convex structures 331 shown in Fig. 4B, and optionally, they can have an elliptical bottom surface, a triangular bottom surface, or a rhombic bottom surface. In addition, in the illumination device according to the present technique, the plurality of convex-concave structures are not necessarily formed as dot-like structures as shown in Fig. 4B, and they can have a shape such as a stelliform or helical linear shape, and a concentric wave shape.

In the above embodiment, the size, density, and arrangement of the plurality of dot-like convex structures 331 on the lower surface of the light guide plate 33 are designed such that the first surface of the light guide plate 33 has a Gaussian emergent light intensity distribution. However, the present technique is not limited to this. For example, in the illumination device according to the present technique, the plurality of convex-concave structures on the lower surface of the light guide plate can be designed such that the upper surface of the light guide plate has a smooth curved emergent light intensity distribution in which the center is higher than the circumference or the center is lower than the circumference, or has other desired emergent light intensity distribution.

Fig. 8 shows three examples of emergent light intensity distribution of the illumination device according to the implementation of the present technique. As shown in Fig. 8, in Fig. (a), the emergent light intensity distribution in which

the center is higher than the circumference is obtained; and in Fig. (b), the emergent light intensity distribution in which the center is lower than the circumference is obtained. Moreover, in Fig. (a) and Fig. (b), the emergent light intensity distribution is in a smooth transition from the center to the circumference. In Fig. (c), the emergent light intensity distribution which is completely uniform is obtained. In addition, according to the needs of design, various parameters of the plurality of convex-concave structures such as size, density, and arrangement can be appropriately set, in order to obtain the desired emergent light intensity distribution.

Description is made as above by taking the case in which the light guide plate 33 has a circular shape in the top view as an example. However, the present technique is not limited to this. For example, the light guide plate can also has, in the top view, an elliptical shape, a rectangular shape, or a regular hexagonal shape, which can be appropriately set in accordance with the needs of design.

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

In addition, while a particular feature or aspect of an embodiment of the present invention may have been disclosed with respect to only one of several implementations, such feature or 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.

Although specific embodiments have been illustrated and de-

scribed herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this invention be limited only by the claims and the equivalents thereof.

List of reference signs

1, 2, 3	illumination device
11, 21, 31	housing
12, 22, 32	LED
311	bottom portion
312	side wall portion
33	light guide plate
331	dot-like convex structure

Claims

1. An illumination device (3), comprising:
a housing (31) comprising a bottom portion (311) and a side wall portion (312);
a light guide plate (33) provided on the bottom portion (311) of the housing (31) and comprising a side surface, a first surface, and a second surface facing the first surface, the second surface being closer to the bottom portion of the housing than the first surface; and
a plurality of light sources (32) provided at the side surface of the light guide plate (33) and emitting light to the side surface, the light emerging from the first surface of the light guide plate (33) to the outside after travelling in the light guide plate (33).

2. The illumination device (3) according to Claim 1, wherein,
a plurality of convex-concave structures are formed on the second surface of the light guide plate (33).

3. The illumination device (3) according to Claim 2, wherein,
the plurality of convex-concave structures are designed such that the first surface of the light guide plate (33) has a Gaussian emergent light intensity distribution.

4. The illumination device (3) according to Claim 2 or 3, wherein,
the size of the convex-concave structure decreases as a distance between the convex-concave structure and the center of the second surface of the light guide plate (33) increases.

5. The illumination device (3) according to Claim 2 or 3, wherein,
the density of the plurality of convex-concave structures decreases as the distance between the convex-concave structures and the center of the second surface of the light guide plate (33) increases.

6. The illumination device (3) according to Claim 2 or 3, wherein,
the convex-concave structure is a dot-like convex structure (331) or a dot-like concave structure.

7. The illumination device (3) according to Claim 2, wherein,
the plurality of convex-concave structures are designed such that the first surface of the light guide plate (33) has a smooth curved emergent light intensity distribution in which the center is higher than the circumference or the center is lower than the circumference.

8. The illumination device (3) according to any of Claims 1-3, wherein,
the light guide plate (33) has, in a top view, a circular shape, an elliptical shape, a rectangular shape, or a regular hexagonal shape.

9. The illumination device (3) according to any of Claims 1-3, wherein,
the plurality of light sources (32) are uniformly arranged around the light guide plate.

10. The illumination device (3) according to any of Claims 1-3, wherein,

the plurality of light sources (32) include red light sources, blue light sources and green light sources.

11. The illumination device (3) according to any of Claims 1-3, wherein,
the plurality of light sources (32) are LEDs or laser diodes.

12. The illumination device (3) according to any of Claims 1-3, wherein,
the bottom portion (311) and/or the side wall portion (312) of the housing (31) have a function of specular reflection or diffusive reflection.

13. A downlight comprising an illumination device (3) according to any of Claims 1-12.

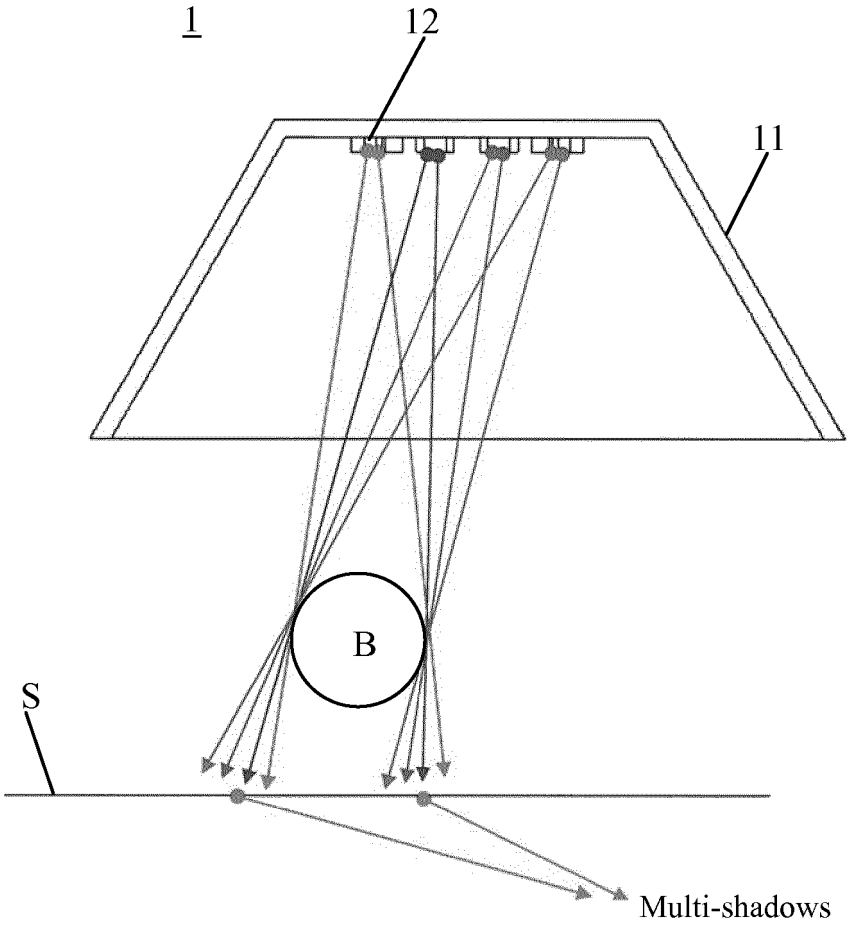


Figure 1A

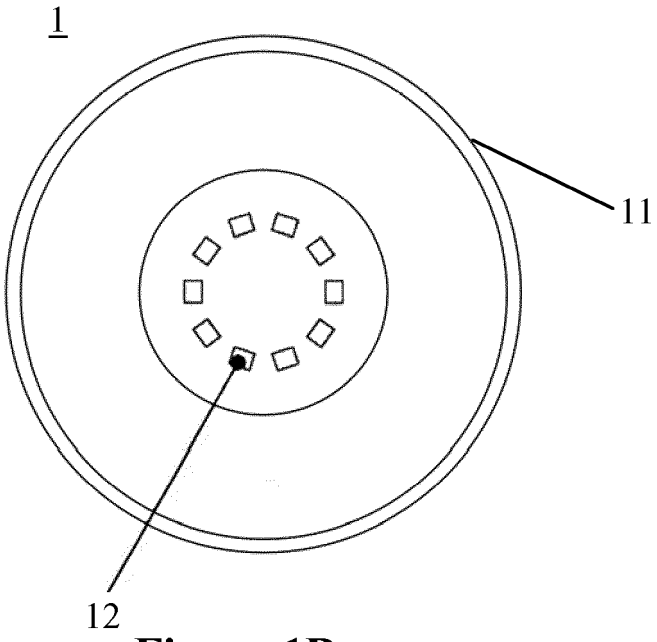


Figure 1B

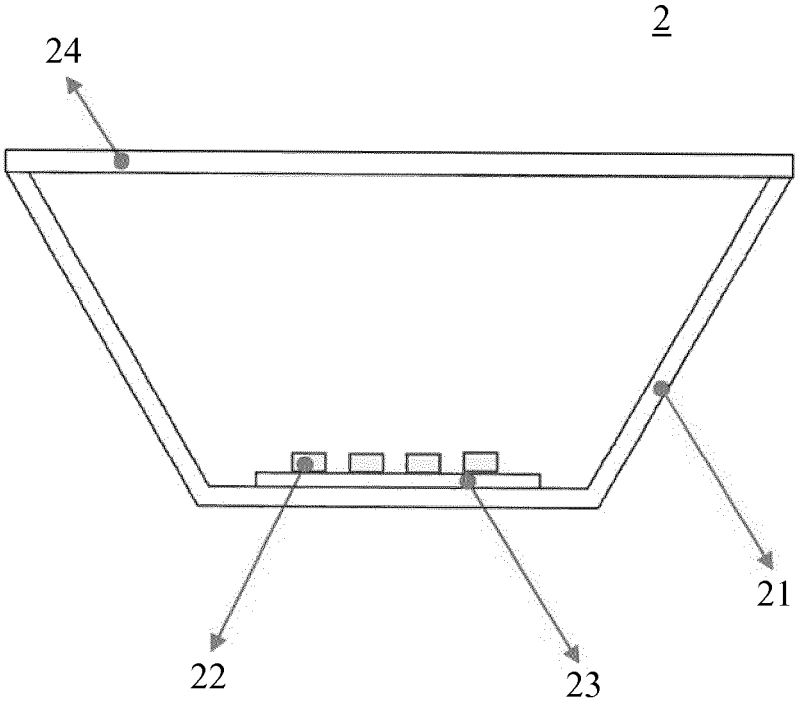


Figure 2

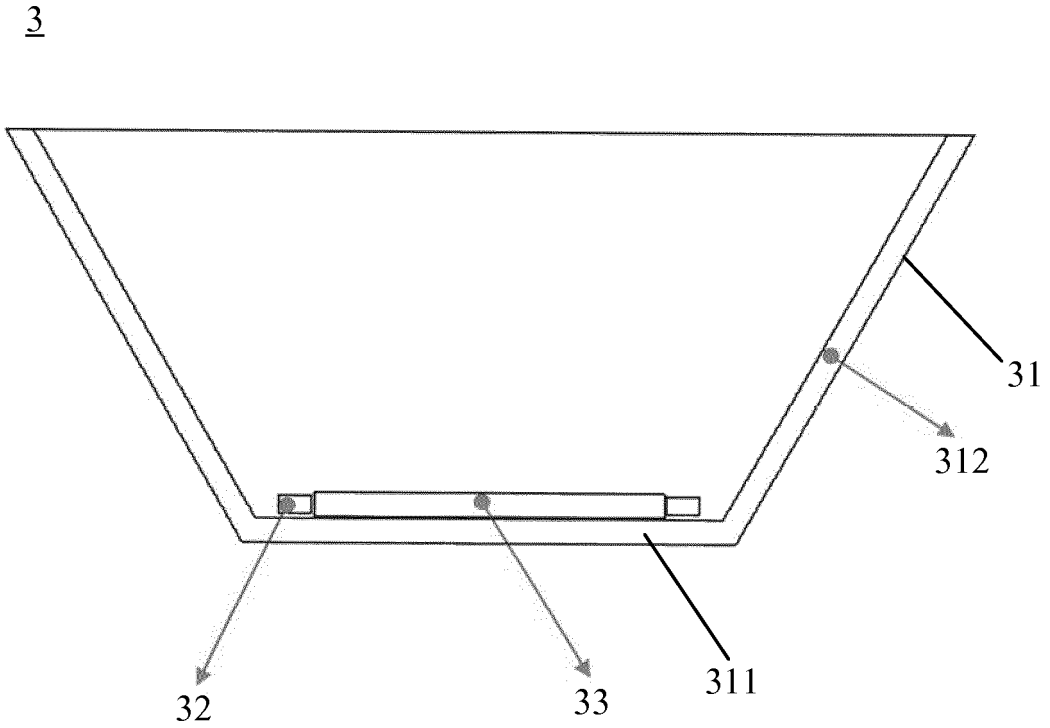


Figure 3A

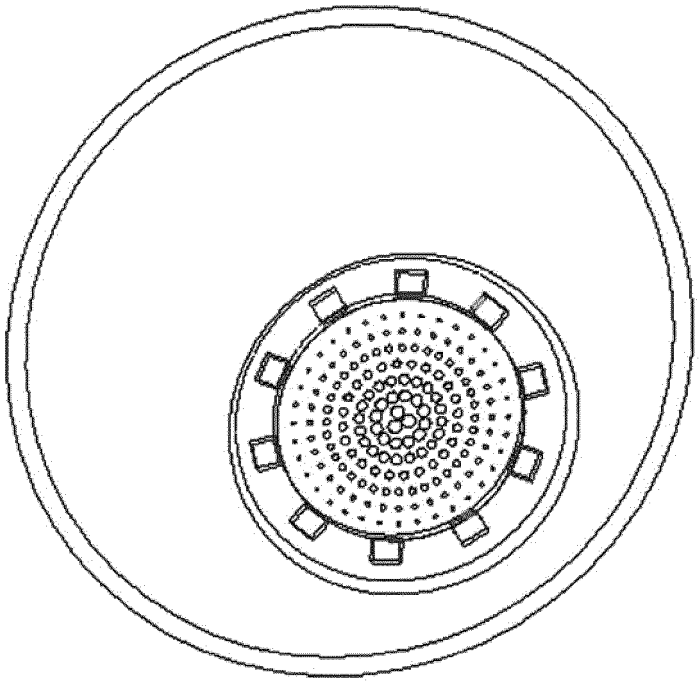


Figure 3B

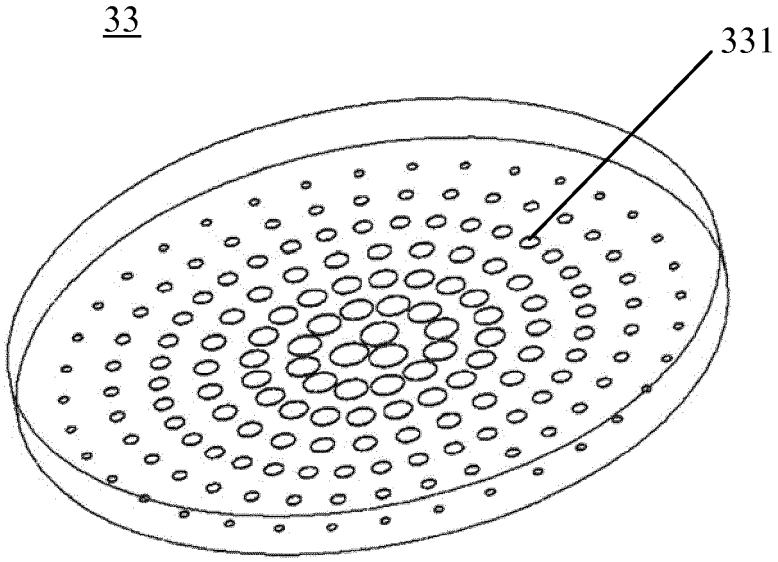


Figure 4A

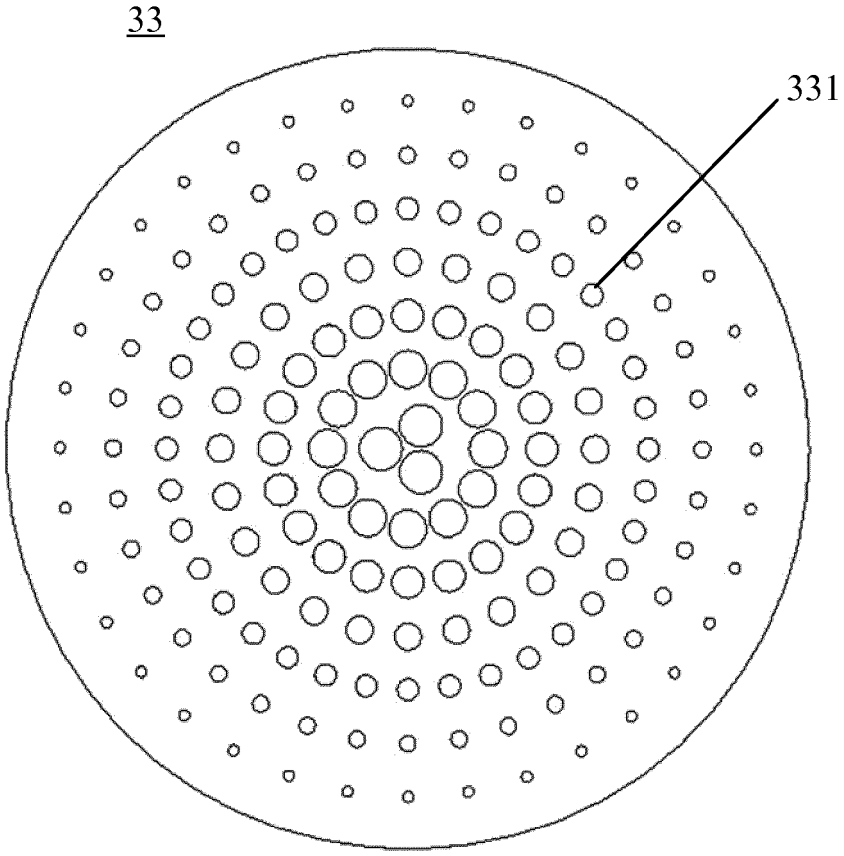


Figure 4B

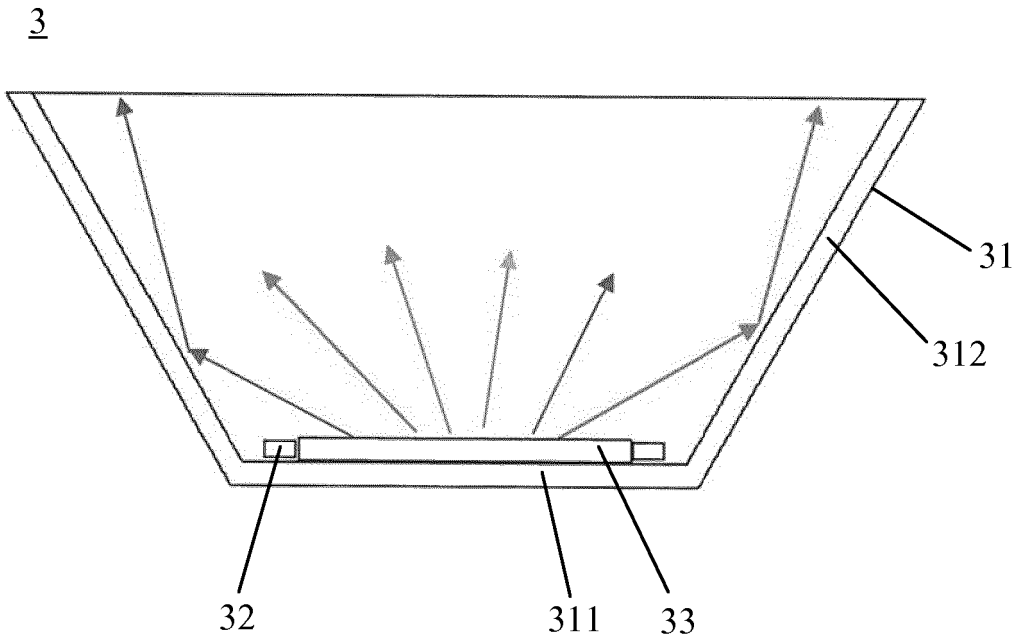


Figure 5A

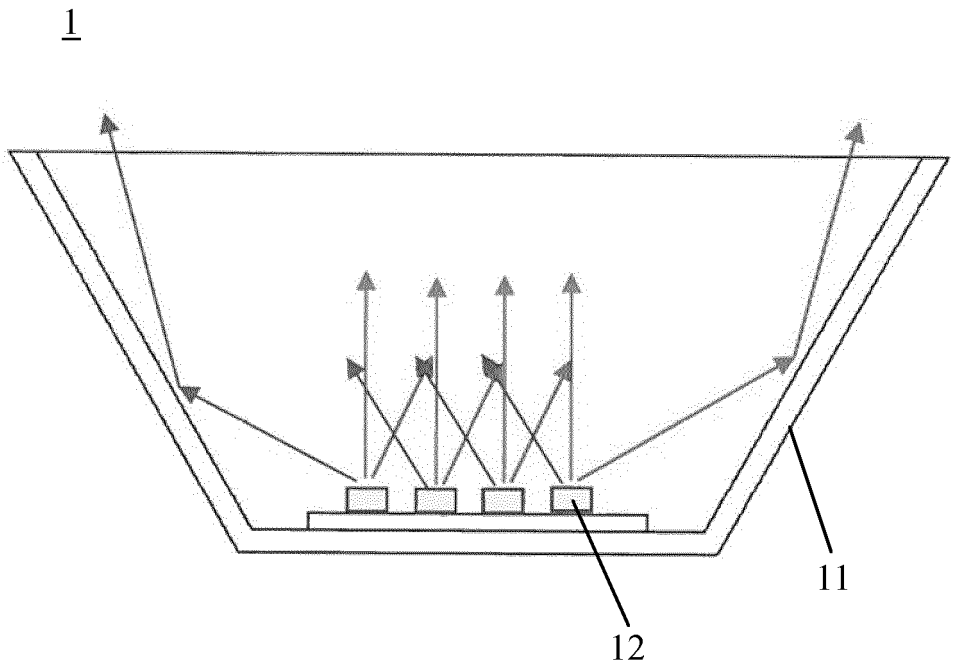


Figure 5B

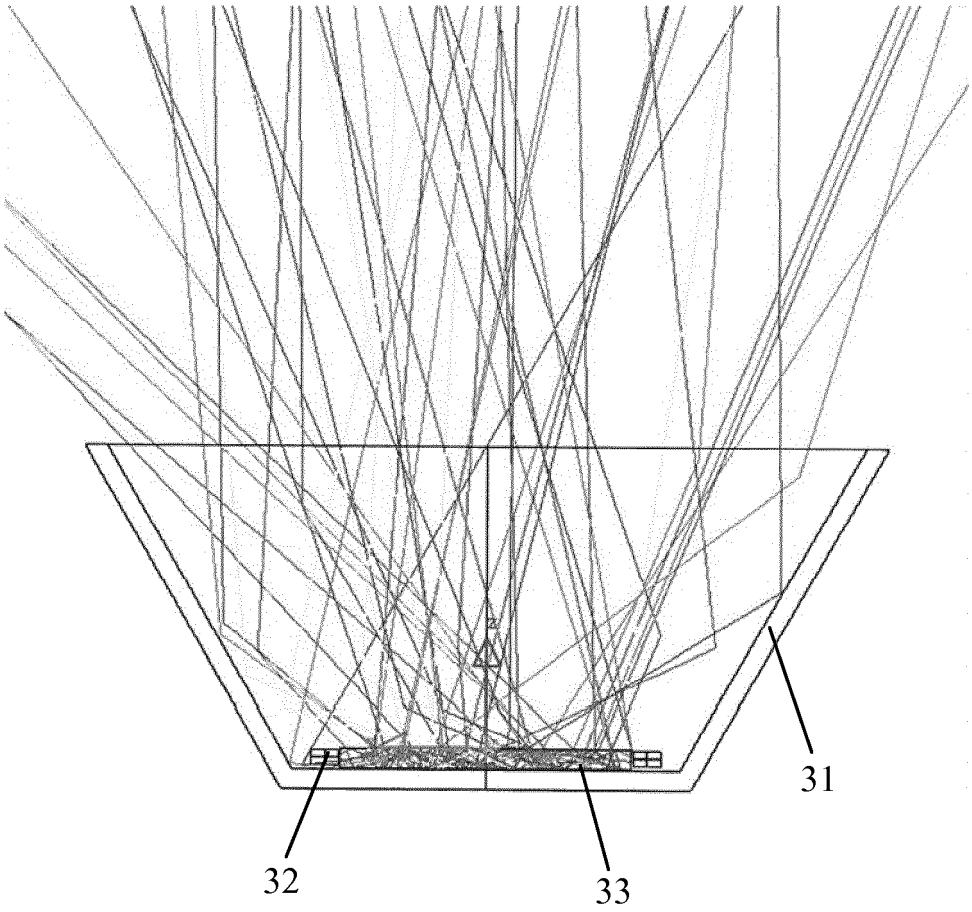


Figure 6

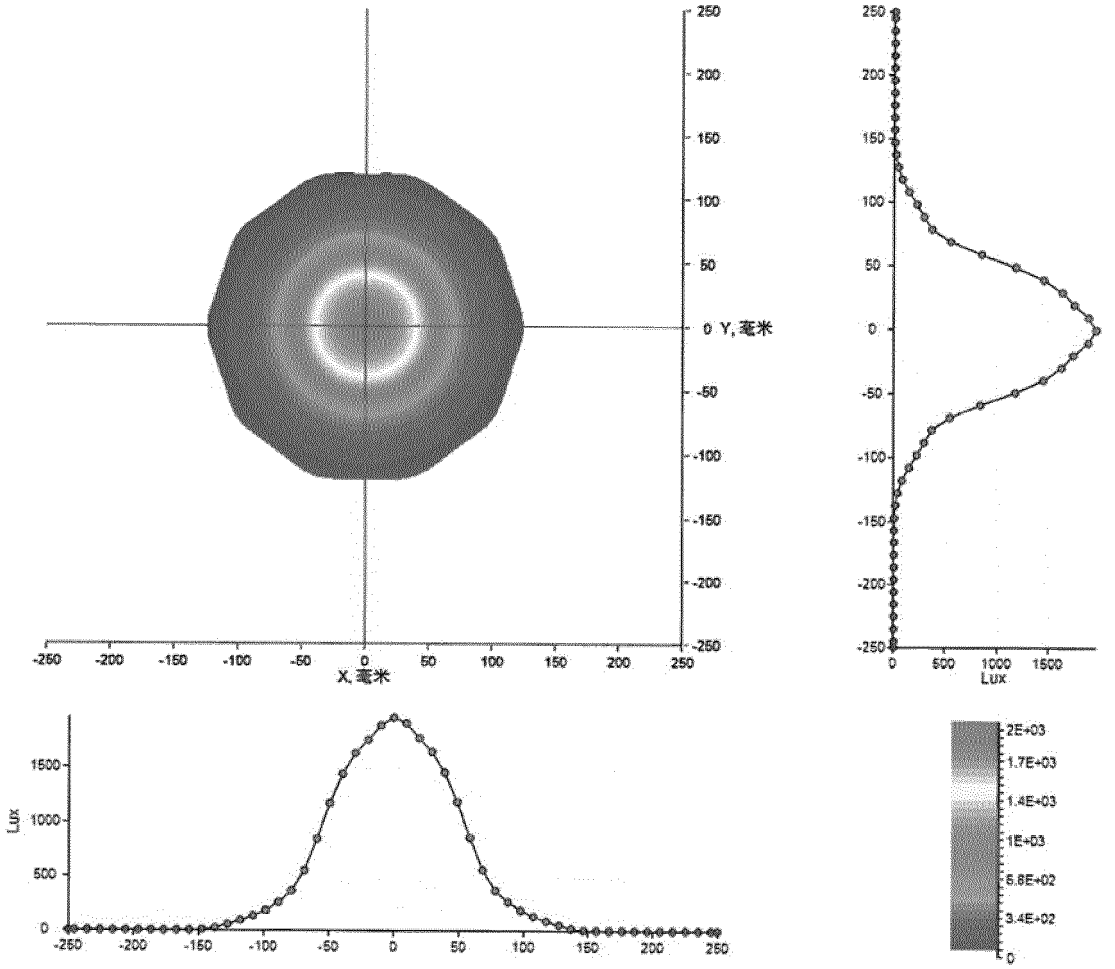
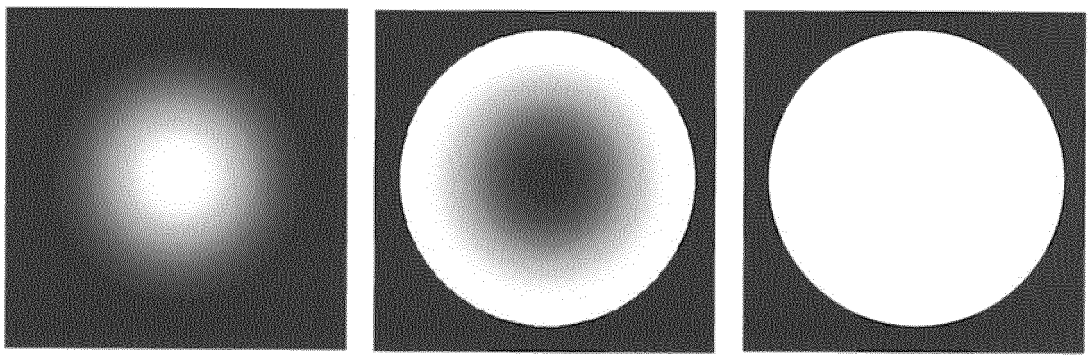


Figure 7



(a) (b) (c)

Figure 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/067331

A. CLASSIFICATION OF SUBJECT MATTER
INV. F21V8/00 F21S8/02
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)
F21V F21S

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	TW M 434 165 U (ENLIGHT CORP [TW]) 21 July 2012 (2012-07-21) figures & US 2013/128608 A1 (LIAO CHIH-MING [TW] ET AL) 23 May 2013 (2013-05-23) paragraphs [0020], [0026] figures	1,8,9, 11-13 2-7,10
Y	US 2010/254121 A1 (ZHOU JIAN-LIN [CN]) 7 October 2010 (2010-10-07) abstract; figures	2-7
Y	US 6 540 373 B2 (BAILEY BENDRIX L [US]) 1 April 2003 (2003-04-01) column 6, lines 27-39	10

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
5 November 2013	13/11/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kloppenburg, Martin

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/067331

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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