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(71) Applicants:
- **OSRAM GmbH**
  80807 München (DE)
- **OSRAM S.P.A. - SOCIETA' RIUNITE OSRAM EDISON CLERICI**
  20126 Milano (IT)
  Designated Contracting States:
  IT

(72) Inventors:
- **ZANOTTO, Alberto**
  I-35127 Padova (IT)
- **BOBBO, Simon**
  I-35128 Padova (IT)
- **BALDO, Lorenzo**
  I-31040 Giavera del Montello (Treviso) (IT)
- **DIDONE', Roberto**
  I-36027 Rosà (Vicenza) (IT)
- **MICHIELAN, Valerio**
  I-31021 Mogliano Veneto (Treviso) (IT)
- **CALDON, Matteo**
  I-30030 Fossò (Venezia) (IT)

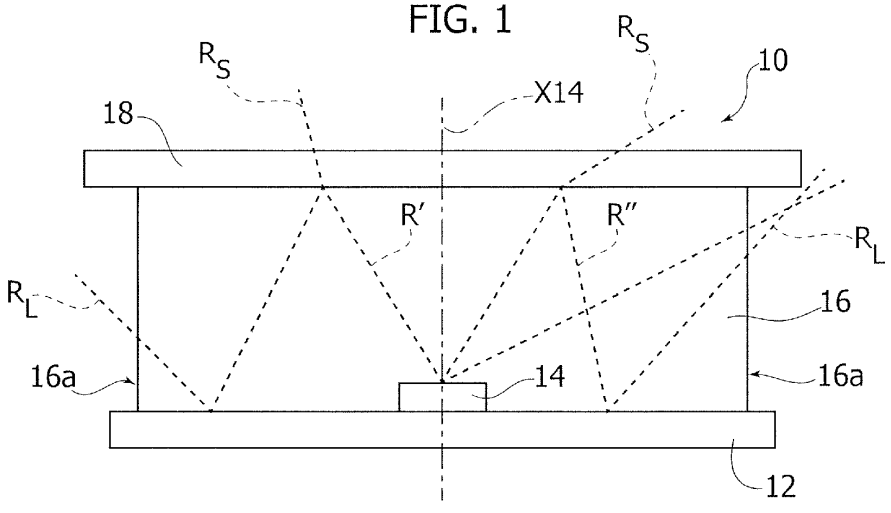
(74) Representative: **Bosotti, Luciano**
Buzzi, Notaro & Antonielli d'Oulx
Corso Vittorio Emanuele II, 6
10123 Torino (IT)

(54) A LIGHTING DEVICE AND CORRESPONDING METHOD

(57) A lighting device (10), e.g. for signage applications, includes:
- a light-reflective (12a) planar substrate (12) with one or more light radiation sources (14), e.g. LED sources, thereon,
- a light-reflective cover layer (18) arranged facing the planar substrate (12),
- a light-permeable support structure (16) arranged between the planar substrate (12) and the cover layer (18).

The support structure (16) includes opposite end walls (16a) extending between the planar substrate (12) and the cover layer (16), said end walls (16a) providing light emission surfaces of light from at least one light radiation source (14).

FIG. 1



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Description

Technical Field

[0001] The present description relates to lighting devices.

[0002] One or more embodiments may refer to lighting devices employing electrically powered light radiation sources such as solid-state light radiation sources, e.g. LED sources.

Technological Background

[0003] An important sector in the lighting field regards illuminated signage applications.

[0004] For such applications it is possible to use back-illuminated signs, which however may pose strict requirements as regards the uniform appearance of lighting.

[0005] This may be the case, for example, of small-sized signs requiring a high luminance uniformity. In this regard, a difficulty may be due to the fact that the space available to uniformly diffuse the light emitted by the single emitting elements decreases as the size is reduced; in the case of signs representing letters or numbers (e.g. capital or small alphabetical letters in an illuminated sign) the height may amount to 10-30 cm.

[0006] If the size is small, the manufacturing process may be different from the solutions chosen for bigger symbols; the latter may include channel-shaped hollow structures wherein there are arranged the light radiation sources.

[0007] For this purpose it is possible to use solid blocks of light-diffusive material. Cavities or reception holes are implemented (in practice, dug) therein for accommodating the light radiation sources.

[0008] Another approach involves coating with reflective materials the side walls and the surface opposed to the light radiation output surface, so that the light radiation may be "recycled"; the light radiation output surface may be coloured.

[0009] For the light radiation sources (e.g. the LED sources) themselves, a specific optical solution may not be provided; the light radiation sources are inserted into the hollow portions and the distribution of the emitted light radiation is favoured only by the structure of the sign body: for example, the symbol may implemented with a thickness which makes some space available for diffusing the light radiation, while including reflective materials into the symbol itself.

[0010] More complex and sophisticated solutions have also been proposed (see for example US 7 172 324 B1), which envisage coupling LED sources with specific optics, including e.g. a light guide and shaped reflective elements. A disadvantage of such solutions is due to the costs and to the need, in order to achieve the desired optical effect, of mounting all components with high precision.

[0011] Another proposal (see e.g. US 7 246 921 B1) entails the use of reflectors instead of reflective materials. Such solutions are more suitable to implement backlighting on a large surface, because they exhibit intrinsic limits as regards e.g. the minimum distance between the lighting module and the surface to be illuminated.

Object and Summary

[0012] An object of one or more embodiments is contributing to overcome such drawbacks as outlined in the foregoing.

[0013] According to one or more embodiments, said object may be achieved thanks to a lighting device having the features set forth in the claims that follow.

[0014] One or more embodiments may also refer to a corresponding method.

[0015] The claims are an integral part of the technical teaching provided herein with reference to embodiments.

[0016] One or more embodiments may be used e.g. to provide a uniform backlighting.

[0017] One or more embodiments are based on an "umbrella" lighting concept.

[0018] One or more embodiments may offer one or more of the following advantages:

- possibility of implementing simple light engines, adapted to favour a uniform illumination of symbols such as e.g. letters or numbers,
- compatibility with lighting devices protected against the penetration of external agents, e.g. having an IP protection degree,
- possibility of using conventional solutions in the manufacturing process,
- possibility of implementing shapes which may favour the insertion and firm retention of the light radiation sources within the symbol (e.g. a letter or a number),
- the optical coupling between the light radiation source and the symbol does not exhibit critical aspects.

Brief Description of the Annexed Figures

[0019] One or more embodiments will now be described, by way of non-limiting example only, with reference to the annexed Figures, wherein:

- Figure 1 generally exemplifies the principles of one or more embodiments,
- Figures 2, 3 and 4 exemplify possible steps in the implementation of embodiments,
- Figures 5 and 6 exemplify possible features of embodiments,
- Figures 7 and 8 exemplify possible features of embodiments.

[0020] It will be appreciated that, for clarity and simplicity of illustration, the various Figures may not be drawn to the same scale.

[0021] Moreover, elements or features exemplified with reference to any one of the annexed Figures may be employed, alone or in mutual combination, also in embodiments exemplified in other Figures annexed herein.

Detailed Description

[0022] In the following description, various specific details are given to provide a thorough understanding of exemplary embodiments. The embodiments may be practiced without one or several specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials or operations are not shown or described in detail in order to avoid obscuring the various aspects of the embodiments.

[0023] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the possible appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring exactly to the same embodiment. Furthermore, particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0024] The headings provided herein are for convenience only, and therefore do not interpret the extent of protection or scope of the embodiments.

[0025] One or more embodiments may favour manufacturing light engines having such optical and mechanical properties as to be employed for the implementation of a wide range of luminous signs, e.g. luminous symbols such as letters and numbers.

[0026] Moreover, it is also possible to envisage a protection against the penetration of external and environmental agents, e.g. an IP protection degree, and/or the implementation of simple, rapid and economical manufacturing processes, irrespective of the shape (e.g. irrespective of the letter or the number represented by the symbol, whether it is a capital or small letter, in block or italic characters, irrespective of the font, etc.).

[0027] Therefore, the various annexed Figures generally refer to a part or portion of a symbol such as e.g. a letter or a number, this part or portion being represented in cross section, while the symbol may have any shape.

[0028] As exemplified in Figure 1, the "symbol" (e.g. a letter or a number), which will be generally identified in the following as a lighting device 10, may include a substrate 12 which may have a structure substantially resembling a printed circuit board (PCB). For example, it may be a printed circuit board assembly (PCBA) including a substrate 12 (e.g. of a light colour such as white) hosting one or more electrically powered light radiation sources 14. In one or more embodiments, such sources may be solid-state light radiation sources, e.g. LED sources.

[0029] PCBA structures as described in the foregoing are known in themselves in the state of the art, which makes it unnecessary to provide a more detailed description herein: this may regard e.g. the provision, on substrate 12, of electrically conductive lines (not visible in the Figures) which are adapted to supply power to the light radiation source (s) 14, and optionally to perform control functions on the same sources.

[0030] In one or more embodiments as exemplified herein, the structure including the substrate 12 and the light radiation source(s) 14 may be coupled to a structure 16 (which may be solid or hollow and which is denoted as "cage" in the following) which is permeable to the light radiation emitted by source(s) 14.

[0031] One or more embodiments as exemplified herein may include a cover layer 18 of a highly reflective material, and optionally being adapted to allow for a certain light radiation propagation therein, with the structure 16 being interposed between substrate 12 and cover layer 18.

[0032] In this way, as schematically shown by the paths R', R" of Figure 1, the light radiation emitted by the source(s) 14 may propagate through cage 16 (which is light-permeable because it is hollow or because, as schematically shown in the Figures, it includes a light-permeable material, i.e. an at least partially transparent material), impinging onto the cover layer 18 to be reflected backwards, towards the surface of substrate 12 (and optionally slightly propagating outside layer 18, as schematically shown in a dash-dot line at R_S).

[0033] In one or more embodiments, substrate 12 may be implemented so as to possess in turn light-reflective properties (e.g. because it is made of a light-coloured, e.g. white, material), so that the radiation sent back towards substrate 12 is reflected again towards the cage 16 and the cover layer 18.

[0034] In this way, a reduced and virtually inexistent fraction (denoted as R_S in Figure 1) of the light radiation emitted by source(s) 14 passes through layer 18, while the radiation may exit laterally outwards of device 10 (as schematically shown at R_L in Figure 1) through the end walls 16a of cage 16, which extend between the substrate 12 and the cover layer 18.

[0035] In one or more embodiments, the cover layer 18 may be arranged centred with respect to axis X14 (e.g. orthogonally to the general extension plane of substrate 12) which identifies the main direction of radiation emission from source(s) 14.

[0036] In one or more embodiments, it is therefore possible to achieve a masking action of the light radiation emitted along axis X14 of the source(s) 14, with the radiation being diffused laterally towards the side walls 16a of cage 16.

[0037] In one or more embodiments, it is possible to reduce (and virtually eliminate) the possible appearance of lighting peaks or spots on the outer surface of layer 18.

[0038] Figure 2 exemplifies possible embodiments wherein substrate 12 is not wholly made of a highly re-

flective material (e.g. of a white material), the reflective behaviour being supported by applying (on the side facing towards cage 16 and cover layer 18) a layer 12a having reflective properties.

[0039] In one or more embodiments, it is thus possible to further widen the range of materials which may be used for implementing substrate 12. The layer 12 may include e.g. a highly reflective solder mask, a layer of a highly reflective material such as aluminium, silver, gold, or e.g. a silicone material adapted to be used in potting processes.

[0040] Irrespective of the specific implementation solutions adopted, the relative sizes of substrate 12 and of cage 16 are mutually independent, the possibility being given e.g. of implementing the two components so as to favour a form fitting and thus the assembly of each symbol (e.g. a letter or a number).

[0041] By way of example, moreover, substrate 12 may be wider than cage 16, so that (see for example Figures 3 and 4) the assembly may have the general shape of a mushroom.

[0042] As exemplified in Figures 3 and 4, if the substrate 12 is larger than cage 16 (and than cover layer 18), the assembly may be coupled to a body or casing 20 adapted to form the body or casing of a luminous symbol, e.g. by inserting it into a cavity 20a present in the body or symbol itself, with the head portion of the mushroom-like shape, defined by substrate 12, abutting against the edge of cavity 20a.

[0043] If substrate 12 is larger than cage 16, said assembly of parts may be inserted into opening 20a as a sort of plug adapted to favour sealing, without requiring the provision of a sealing mass.

[0044] The sealing (having e.g. an IP protection degree) with respect to the edge of cavity 20a may optionally be supported by a sealing mass 22 (e.g. silicone) applied from the back side of substrate 12 opposed to cage 16.

[0045] Figure 4 shows a situation wherein, in the presence of said sealing mass (e.g. a potting mass known in itself), generally denoted as 22, the plug effect into cavity 20a may reduce and virtually eliminate the risk of the potting mass 22 accidentally penetrating into cavity 20a.

[0046] As stated in the foregoing, the selection of shapes in the described components may be very wide; the same applies to the shape of cavity 20a as well.

[0047] For example, the cavity 20a receiving the source or each source 14 may have a circular shape; however, this choice is by no means mandatory, being it possible to resort to wholly different shapes (flat, polygonal, etc.).

[0048] Such concepts are exemplified in Figures 3 and 4, wherein the assembly of the previously described components (substrate 12, sources 14, cage 16 and cover layer 18) is shown as inserted into the body 20 of the symbol (e.g. a letter or a number), which is in turn shown in cross section.

[0049] In one or more embodiments, cage 16 may in itself favour the achievement of a protection against the penetration of external agents (e.g. an IP degree protection) in the light engine or at least in the light radiation source 14 and the surrounding area.

[0050] In one or more embodiments, cage 16 may include a body (optionally a hollow body, as already stated in the foregoing) having various light radiation propagation properties (e.g. as regards transparency/opacity/colour) .

[0051] In one or more embodiments, cage 16 may be coupled to substrate 12 (optionally including layer 12a, if present) by means of different fixation techniques, e.g. by gluing.

[0052] In one or more embodiments, cage 16 may be obtained by dispensing, onto substrate 12 (once again optionally including layer 12a), a material (e.g. a silicone potting mass) which may be applied in such a way as to encapsulate source (s) 14; the material may subsequently be solidified, e.g. by means of thermal crosslinking and/or photo-crosslinking.

[0053] It will be appreciated that such solutions do not impose specific constraints as regards the overall structure of cage 16.

[0054] In one or more embodiments, the cover layer 18 may include a layer of e.g. plastic material, which may be moulded (e.g. co-moulded) with cage 16.

[0055] In one or more embodiments, layer 18 may include a foil which is applied (e.g. glued) onto cage 16, or a material (e.g. a polymer material such as silicone) which is dispensed onto cage 16, so as to perform a reflective function of the light radiation.

[0056] In one or more embodiments, the cover layer 18 may favour the reflection of the radiation emitted by source(s) 14 backwards, towards substrate 12. This may be true e.g. as regards the portion of maximum brightness of the radiation emitted by source(s) 14 along their main axis.

[0057] Figure 5 shows (of course, by way of example) that the cover layer 18 may be implemented so as not to completely cover the surface of cage 16 towards which layer 18 faces: in this way, a given portion of the light radiation R' R" emitted by source(s) 14 may exit the cage 16 directly at the portions left uncovered by layer 18, as shown at R_S in Figure 5. Moreover, the feature of a lateral exit from cage 16 through walls 16a is preserved, as shown at R_L in the same Figure 5.

[0058] In one or more embodiments, the shape of the cover layer 18 may be adjusted to the emission features of source (s) 14 (for example to the distribution of the light radiation emission) so as to favour the achievement of particular lighting effect.

[0059] Figure 6 further exemplifies the possibility of implementing cage 16 with a light-permeable (transparent or translucent) material, such as silicone, polyurethane (deposited e.g. by means of potting techniques) on substrate 12. Said material may also be coupled to substrate 12 as an extruded part, which may then be cut to length and glued onto substrate 12.

[0060] In one or more embodiments, cage 16 may per-

form a protective action (e.g. an IP degree protection) of the light engine; for example, with the surface opposed to the source (s) 14, it may act as a support surface for the cover layer 18.

[0061] As previously stated, the cover layer 18 may be implemented by depositing, onto cage 16 (e.g. by means of potting techniques) a layer of reflective material (e.g. white silicone) or by applying, e.g. by means of gluing, a reflective layer or foil, or by performing a co-extrusion process while manufacturing cage 16.

[0062] Figure 7 exemplifies one or more embodiments, wherein cage 16 may be implemented as a hollow structure (e.g. filled with air) adapted to perform a support action of the cover layer 18 at the periphery thereof.

[0063] In one or more embodiments as exemplified in Figure 7, the cage 16 may include light-permeable, e.g. transparent or translucent, material.

[0064] Figure 7 exemplifies the possibility of fixing the cage 16 onto substrate 12 and layer 18 according to different solutions.

[0065] For example, an adhesive connection may be implemented at the periphery of substrate 12, and/or a form fitting may be achieved e.g. by means of complementary formations (e.g. projections and/or grooves) as exemplified at 16a and 16b on the right and left of Figure 7.

[0066] As exemplified in the central part of Figure 7, the cover layer 18 may be coupled to the peripheral walls of cage 16 e.g. by means of gluing or by means of co-moulding, or it may be coupled by resorting to various solutions of mechanical coupling.

[0067] Figure 9 exemplifies that the inner surface of cover layer 18, i.e. the surface 18a facing towards substrate 12, may have a configuration shaped in such a way as to favour the distribution of the light radiation of source(s) 14 laterally of device 10.

[0068] For example, Figure 8 shows a configuration of the surface 18a (which may be defined as "batwing" configuration) which favours re-directing the light radiation of source (s) 14 towards the side ends 16a of cage 18, while reducing the reflections towards the surface of substrate 12.

[0069] A lighting device (e.g. 10) according to one or more embodiments may include:

- a light-reflective (e.g. 12a) planar substrate (e.g. 12) with at least one electrically powered light radiation source (e.g. 14) thereon,
- a light-reflective cover layer (e.g. 18) arranged facing the planar substrate,
- a light-permeable support structure arranged between the planar substrate and the cover layer, the support structure including opposite end walls (e.g. 16a) extending between the planar substrate and the cover layer, the end walls providing light emission surfaces of light from at least one light radiation source.

[0070] In one or more embodiments, the planar substrate may include:

- light-reflective material, or
- non-reflective material with a light-reflective layer (e.g. 12a) applied onto the non-reflective material in a position facing the support structure.

[0071] In one or more embodiments, the support structure may include:

- a solid body including light-permeable material, or
- a hollow body extending between said opposed end walls.

[0072] In one or more embodiments, the cover layer may be partially permeable to light (R_S).

[0073] In one or more embodiments, the device may include a mushroom-like shape, with the planar substrate wider than the support structure and the cover layer.

[0074] In one or more embodiments:

- the at least one light radiation source may have a main emission axis (e.g. X14) of light radiation, and
- the cover layer may be arranged centred with respect to said main light radiation emission axis.

[0075] In one or more embodiments:

- the at least one light radiation source may have a main emission axis of light radiation, and
- the cover layer may include a reflective surface (e.g. 18a) facing towards the planar substrate, said reflective surface including surface sculpturing deflecting light away from the cover layer, which may be centred with respect to said main light radiation emission axis.

[0076] One or more embodiments may include a portion of the support structure left uncovered by the layer, the uncovered portion providing a light emission surface for light from the at least one light radiation source.

[0077] One or more embodiments may include an outer light-permeable casing (e.g. 20) with at least one cavity (e.g. 20a) having an edge, and with the support structure and the cover layer (18) inserted in said cavity (20a) and the planar substrate (12) abutting against the edge of the cavity (20a).

[0078] One or more embodiments may include an outer light-permeable casing with at least one cavity having an edge, and with the support structure and the cover layer inserted into said cavity and a sealing mass (e.g. 22) sealingly coupling the planar substrate with the edge of the cavity.

[0079] In one or more embodiments, the at least one light radiation source may include a LED source.

[0080] A method according to one or more embodiments of providing a lighting device may include:

- providing a light-reflective planar substrate with at least one electrically powered light radiation source thereon,
- arranging a light-reflective cover layer facing the planar substrate,
- arranging, between the planar substrate and the cover layer, a light-permeable support structure having opposite end walls extending between the planar substrate and the cover layer, the end walls providing light emission surfaces of light from at least one light radiation source.

[0081] Of course, without prejudice to the basic principles, the implementation details and the embodiments may vary, even appreciably, with respect to what has been described herein by way of non-limiting example only, without departing from the extent of protection.

[0082] The extent of protection is defined by the annexed claims.

LIST OF REFERENCE SIGNS

Lighting device	10
Planar substrate	12
Light-reflective	12a
Radiation source	14
Support structure	16
End walls	16a
Cover layer	18
Partial light permeability	R_S
Outer casing	20
Cavity	20a
Sealing mass	22
Emission axis	X14

Claims

1. A lighting device (10), including:

- a light-reflective (12a) planar substrate (12) with at least one electrically-powered light radiation source (14) thereon,
- a light-reflective cover layer (18) arranged facing the planar substrate (12),
- a light-permeable support structure (16) arranged between the planar substrate (12) and the cover layer (18), the support structure (16) including opposite end walls (16a) extending between the planar substrate (12) and the cover layer (18), the end walls (16a) providing light emission surfaces of light from at least one light radiation source (14).

2. The lighting device (10) of claim 1, wherein the planar substrate (12) includes:

- light-reflective material, or
- non-reflective material with a light-reflective layer (12a) provided on the non-reflective material facing the support structure (16).

3. The lighting device (10) of claim 1 or claim 2, wherein the support structure (16) includes:

- a solid body including light-permeable material, or
- a hollow body extending between said opposed end walls (16a).

4. The lighting device (10) of any of the previous claims, wherein the cover layer (18) is partially permeable to light (R_S).

5. The lighting device (10) of any of the previous claims, the device including a mushroom-like shape with the planar substrate (12) wider than the support structure (16) and the cover layer (18).

6. The lighting device (10) of any of the previous claims, wherein:

- the at least one light radiation source (14) has a main emission axis (X14) of light radiation, and
- the cover layer (18) is arranged centered with respect to said main light radiation emission axis (X14).

7. The lighting device (10) of any of the previous claims, wherein:

- the at least one light radiation source (14) has a main emission axis (X14) of light radiation, and
- the cover layer (18) includes a light-reflective surface (18a) facing the planar substrate (12), the light-reflective surface (18a) including surface sculpturing deflecting light away from said main light radiation emission axis (X14).

8. The lighting device (10) of any of the previous claims, including a portion of the support structure (16) left uncovered by the cover layer (18), said uncovered portion providing a light emission surface for light from the at least one light radiation source (14) .

9. The lighting device (10) of any of the previous claims, including an outer light-permeable casing (20) including at least one cavity (20a) having an edge with the support structure (16) and the cover layer (18) inserted in the cavity (20a) and the planar substrate (12) abutting against the edge of the cavity (20a).

10. The lighting device (10) of any of the previous claims, including an outer light-permeable casing (20) including at least one cavity (20a) having an edge with

the support structure (16) and the cover layer (18) inserted in the cavity (20a) and a sealing mass (22) sealingly coupling the planar substrate (12) with the edge of the cavity (20a).

11. The lighting device (10) of any of the previous claims, wherein the at least one light radiation source (14) includes a LED source.

12. A method of providing a lighting device (10), the method including:

- providing a light-reflective (12a) planar substrate (12) with at least one electrically-powered light radiation source (14) thereon,
- arranging a light-reflective cover layer (18) facing the planar substrate (12),
- arranging between the planar substrate (12) and the cover layer (18) a light-permeable support structure (16) the support structure (16) including opposite end walls (16a) extending between the planar substrate (12) and the cover layer (18), the end walls (16a) providing light emission surfaces of light from at least one light radiation source (14).

FIG. 1

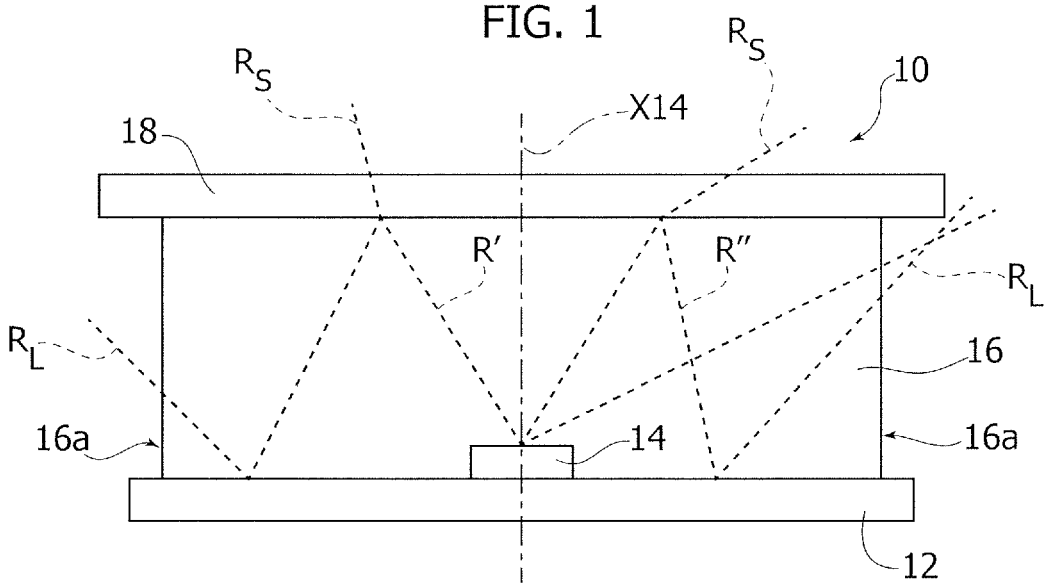


FIG. 2

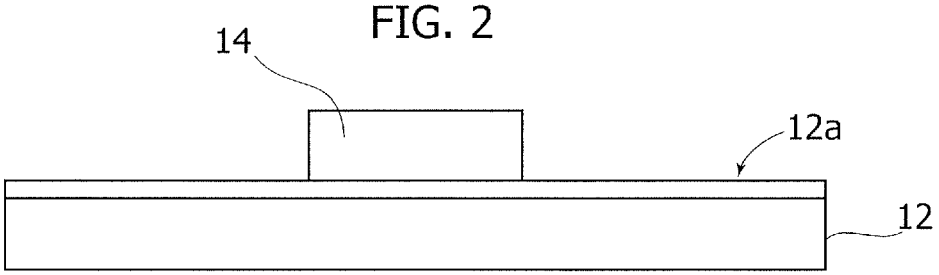


FIG. 3

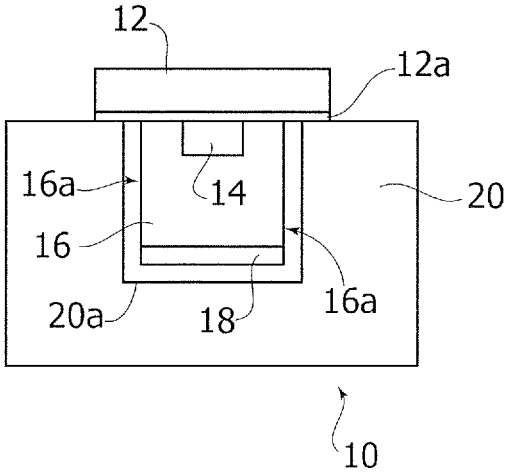


FIG. 4

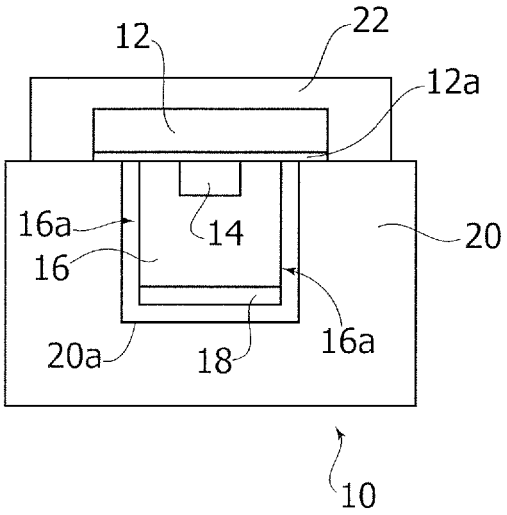


FIG. 5

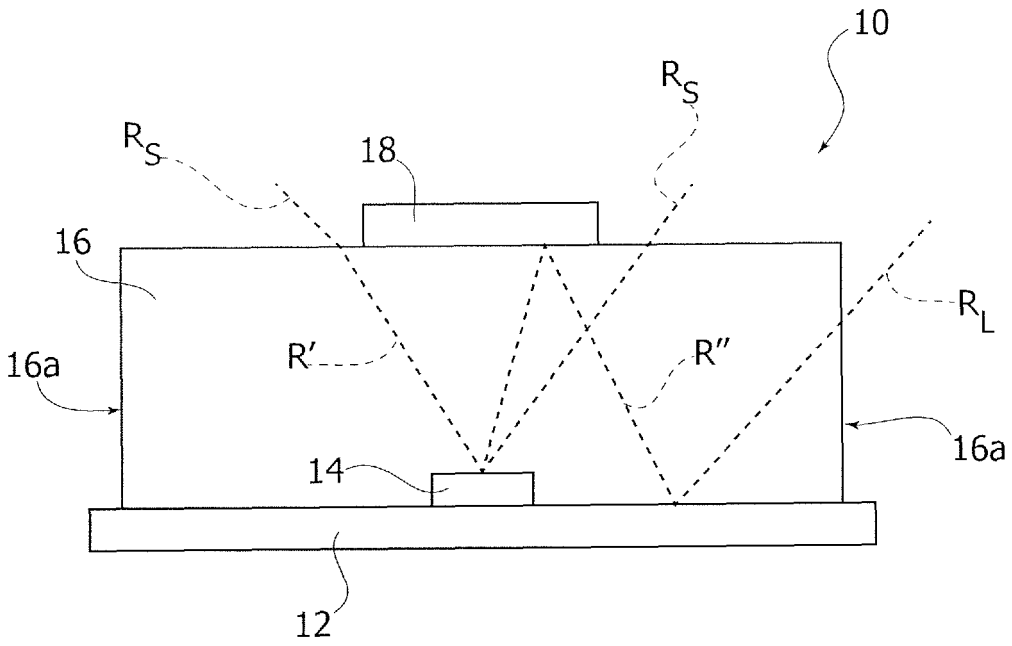


FIG. 6

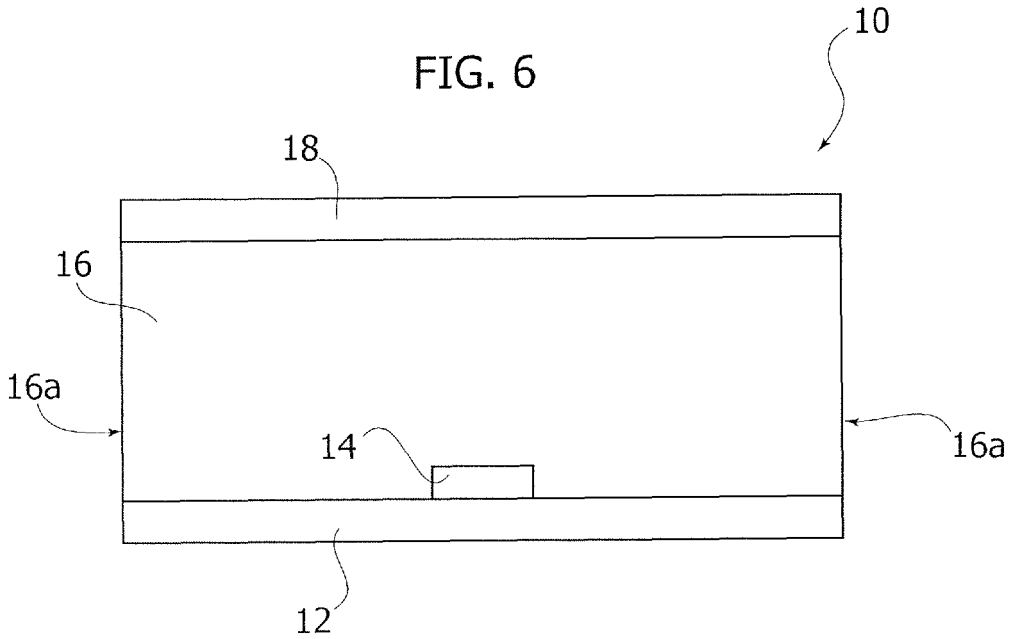


FIG. 7

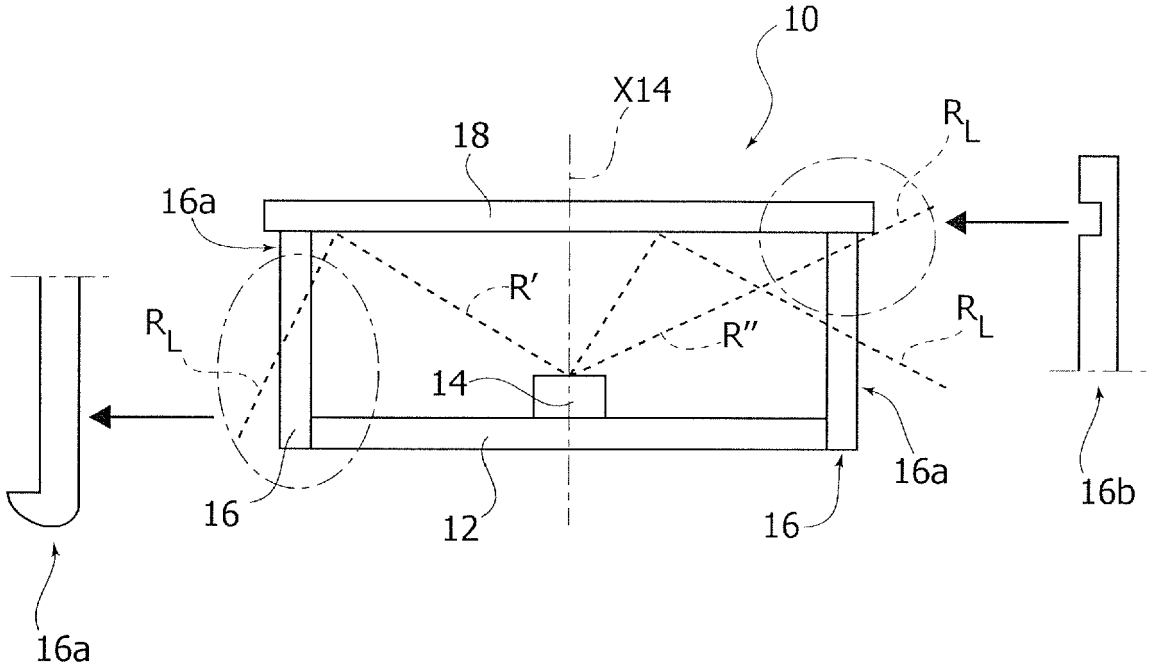
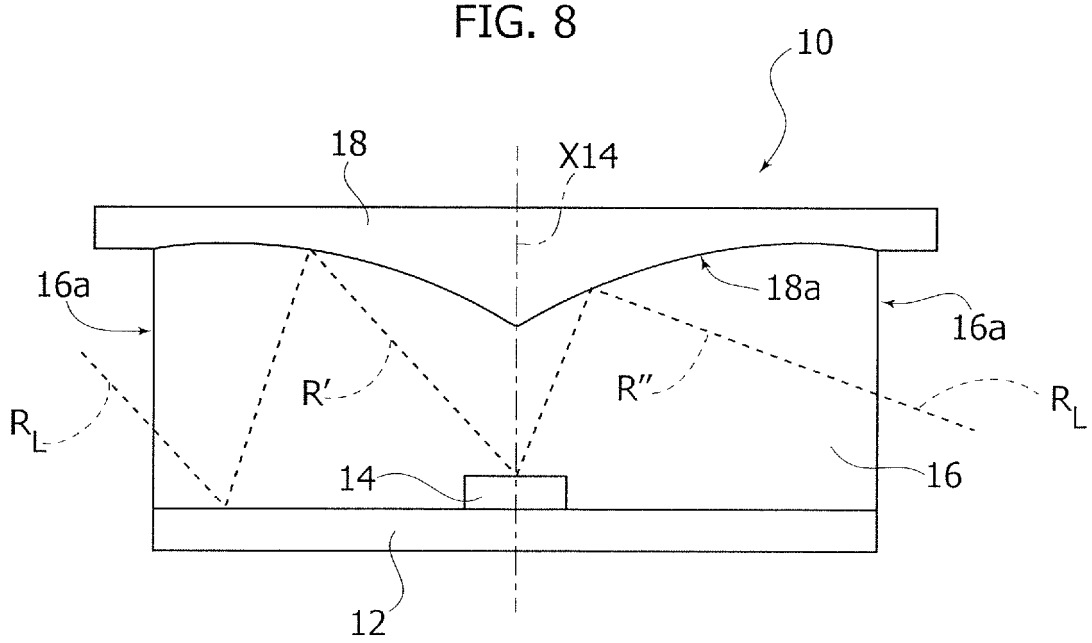

10
X14
18
16a
R_L
R'
R''
R_L
R_L
14
16a
16b
16
12
16
16a

FIG. 8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EUROPEAN SEARCH REPORT

Application Number
EP 18 16 8004

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2011/018020 A1 (JAGT HENDRIK JOHANNES BOUDEWIJN [NL]) 27 January 2011 (2011-01-27) * paragraph [0036] - paragraph [0042] * * figures 1,4 *	1-3,6,7, 11,12	INV. F21V7/00 F21K9/68 ADD. F21V7/05 F21V15/01 F21V31/00 F21Y115/10
X	US 2005/002194 A1 (KIKUCHI SATORU [JP] ET AL) 6 January 2005 (2005-01-06) * paragraph [0017] - paragraph [0019] * * figures 1,3 *	1-4,6,8, 11,12	
X	US 2014/354145 A1 (FISHER DANIEL J [US] ET AL) 4 December 2014 (2014-12-04) * paragraph [0039] - paragraph [0040] * * paragraph [0050] * * figures 3,9,10 *	1-3,5-7, 11,12	
X	US 2007/138494 A1 (PUGH MARK [US] ET AL) 21 June 2007 (2007-06-21) * paragraph [0016] - paragraph [0024] * * figures 1,2 *	1-4,6, 8-12	TECHNICAL FIELDS SEARCHED (IPC)
X	US 2014/126224 A1 (BRUNT JR HAROLD W [US] ET AL) 8 May 2014 (2014-05-08) * paragraph [0035] * * paragraph [0038] * * figures 1,2,5-7 *	1-3,5-7, 11,12	F21V F21K F21Y H01L
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 September 2018	Soto Salvador, Jesús

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X : particularly relevant if taken alone
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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