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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:
- **ALFIER, Alberto**
  I-31050 Vedelago (Treviso) (IT)
- **PASQUALINI, Dina**
  I-33100 Udine (IT)

(74) Representative: **Bosotti, Luciano**
Buzzi, Notaro & Antonielli d'Oulx S.r.l.
Via Maria Vittoria, 18
10123 Torino (IT)

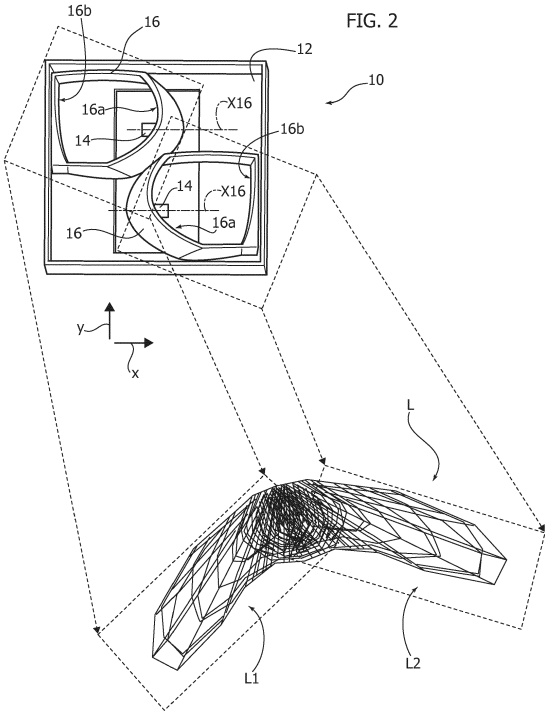
(54) A LIGHTING DEVICE AND CORRESPONDING METHOD

(57) A lighting device, e.g. for technical streelighting applications, includes:
- a support member with a support surface (12) with a plurality of mounting locations for light radiation sources (14), e.g. LED sources, and
- a plurality of reflectors (16) surrounding said mounting locations on said support surface (12).

The reflectors (16) include first (16a) and second (16b) lateral reflective surfaces for reflecting away from support surface (12) light radiation from a respective mounting location of said plurality of mounting locations for a light radiation source (14).

The first reflective surface (16a) is closer to said mounting location than second reflective surface (16b).

FIG. 2



EP 2 995 855 A1

Description

Technical Field

[0001] The present description relates to lighting devices.

[0002] One or more embodiments may refer to lighting devices employing solid state light radiation sources such as, for example, LED sources.

[0003] One or more embodiments may refer to lighting devices adapted to be used, e.g., for streetlighting applications.

Technological Background

[0004] In applications such as technical streetlighting, it is possible to resort to wide light distribution patterns, which are adapted to provide a uniform illuminance distribution on a plane, such as the plane of a road. The so called "batwing-like" distribution is an example of such distribution.

[0005] Such lighting arrangements are the object e.g. of norm EN13201. The classes known as S and CE are examples of possible classifications of such lighting devices. In such applications, the lighting uniformity may be expressed as minimum illuminance or as minimum ratio between minimum illuminance and average illuminance. Illuminance is the total light flux impinging on a plane per surface unit, and provides a measure of the surface lighting by the impinging light.

[0006] It has been found that distributions such as "batwing-like" distributions enable to achieve a good illuminance uniformity on the road plane, the angular position of the batwing peak being adapted to determine the extent of the area uniformly lit.

[0007] The previously mentioned classes S and CE are mainly intended for pedestrians and pedal cyclists on footways, cycleways, emergency lanes and other road areas lying separately from or along the carriageway of a traffic route, and/or for residential roads, pedestrian streets, parking places, schoolyards etc.

[0008] In order to achieve such lighting distributions it is possible to use devices employing lenses. The lenses are adapted to exert an effective control action on the light radiation, because the light radiation coming from the source touches the lens profile and can therefore be properly directed.

[0009] Nevertheless, lenses exhibit limits as regards tailoring the light distribution at high angles, where Fresnel reflections play a relevant role.

[0010] Lenses may have other limits when they are used with solid state lighting devices, such as LED sources, for example in a streetlighting scenario.

[0011] One first limit is given by the sensitivity to the nature of the light radiation source: lenses are usually designed considering the near field radiation of a specific light radiation source. If the light radiation source changes, there may occur a change in the near field distribution, so that the performance of the lens may be altered, too.

[0012] Moreover, since lenses are normally small in comparison to the light radiation source (e.g. a LED sources), even small (as small as 0,1 mm) tolerances on the positioning of the light radiation source may generate considerable deviations in the expected radiation distribution.

[0013] Le lenses which are designed to work e.g. with a cluster of LEDs may moreover show a certain degree of instability in case of possible modifications of the LED number and arrangement within the cluster.

[0014] Another approach to obtaining wide, e.g. batwing-like light distributions is the use of reflectors.

[0015] By adopting this solution, a part of the light radiation is not reflected on the reflector and is output directly. In order to control this portion of light radiation and to shape the resulting illuminance distribution, e.g. according to a batwing-like profile, a solution envisages additional reflector components mounted on the light radiation source, so that straight rays may be reflected at high angles.

[0016] Beside being quite complex, also from the point of view of design, this solution has the drawback that the additional components require additional assembling steps and tolerances, and moreover exhibits functional limits due to the high number of reflections, which may lead to a decreased efficiency.

[0017] Documents exemplary of the prior art include, e.g.:

- US 2012/0026728 A1, which discloses substantially symmetrical optical elements including three light source clusters, a central one and two close to the end walls;
- EP 2 051 001 A2, which describes a non-modular device including LED sources distributed over one or more boards, with reflectors fixed between the LEDs, preferably of the wide-angle type; and
- EP 2 019 250 A, which discloses using tilted light sources of the wide-angle type, having specific chromatic characteristics.

Object and Summary

[0018] One or more embodiments aim at overcoming the previously outlined drawbacks.

[0019] According to one or more embodiments, said object is achieved thanks to a lighting device having the features specifically set forth in the claims that follow.

[0020] One or more embodiments may also concern a corresponding method.

[0021] The claims are an integral part of the technical teaching provided herein with reference to the embodiments.

[0022] One or more embodiments enable to achieve a wide, e.g. batwing-like light distribution (as used for applications such as streetlighting) by optionally resorting to a modular approach.

[0023] In detail, one or more embodiments may solve one or several of the following problems:

- achieving a wide, e.g. a batwing-like lighting distribution, by resorting to an approach based on the use of reflectors,
- obtaining a desired distribution even when the features of the light radiation source are already set, i.e. in conditions wherein it is impossible to impart a desired position and/or the compliance with particular optical design needs to the light radiation source,
- optimizing efficiency with a minimum number of reflections deriving from the presence of a reflector,
- achieving a robust structure, unaffected by the type of light radiation source and/or by the extension thereof.

[0024] One or more embodiments may achieve one or more of the following advantages:

- e.g. in a streetlighting application, a desired light distribution may be obtained by overcoming mechanical constraints, optionally dividing the light distribution into a plurality of parts;
- wide, e.g. batwing-like, distributions may be achieved with a small number of light rays reflections, i.e. with high efficiency,
- additional reflector components may be omitted,
- reflectors may be implemented as separate components, adapted to provide a portion (for example a half) of the desired distribution, with the possibility to obtain the full distribution by using a plurality of reflectors,
- the reflector is stable versus light source size, keeping performances substantially unchanged on the lit plane,
- the applications are flexible, as the solution enables e.g. a scaling of the device on the basis of the application, while keeping the characteristics of (each) reflector unchanged,
- the flux intensity of the light radiation sources may be scalable, too, while keeping the reflector unchanged.

Brief description of the figures

[0025] One or more embodiments will now be described, by way of non-limiting example only, with reference to the enclosed figures, wherein:

- Figure 1 shows a possible application scenario of embodiments,
- Figure 2 schematically shows the operating principle on which one or more embodiments are based,
- Figure 3 - including three portions respectively denoted by a), b) and c) - and Figure 4 - including two portions respectively denoted by a) and b) - show possible details of embodiments,
- Figures 5 to 8 show, from different viewpoints, features of components of embodiments, and
- Figures 9 to 12 schematically exemplify possible adaptability criteria of embodiments.

[0026] It will be appreciated that, for better clarity of illustration, the parts visible in the figures may not be necessarily drawn to scale.

Detailed Description

[0027] In the following description, numerous specific details are given to provide a thorough understanding of one or more 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 to avoid obscuring various aspects of the embodiments. 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 to the same embodiment. Furthermore, particular features, structures, or characteristics may be combined in a suitable manner in one or more embodiments, and/or may be associated to the embodiments in a different way from what is shown herein, so that e.g. a feature herein exemplified in connection to a figure may be applied to one or more embodiments exemplified in a different figure.

[0028] The headings provided herein are for convenience only, and therefore do not interpret the extent of protection or the scope of the embodiments.

[0029] One or more embodiments may find application in a streetlighting environment, as exemplified e.g. in Figure 1.

[0030] It will be appreciated, however, that the reference to the application in streetlighting must not be interpreted as limiting the scope of the embodiments.

[0031] In Figure 1, reference S denotes a road scenario which is lit by lighting device 10, mounted on poles or other support / suspension means with respect to road plane S.

[0032] For example, the support may consist of poles P arranged at a distance d, adapted to be much longer (e.g. up to 7 - 9 times) than the height h at which lighting devices 10 are arranged. As exemplified in Figures 11 and 12 described in the following, lighting devices 10 may be arranged either along a side of road S (see Figure 11) or centrally with respect to the road (see Figure 12). In an application scenario as exemplified in Figure 1, the lighting devices 10 may be desired to produce a wide light distribution, which may be for example batwing-like.

[0033] In the case of classes S or CE mentioned in the

introduction of the present description (always keeping in mind that the reference to this possible application field has a merely exemplary function), the light distribution is defined according to planes, i.e. denoted as C0-C180, longitudinal to the road plane, and according to planes C90-C270 transversal to the road plane, with plane C90 facing the street. Planes C0-C180 and the immediately surrounding planes have High Candela (CD) Peaks at high angles (>60°). The possibility is given for planes C0-C180 and the immediately surrounding planes (e.g. in a neighbourhood of $\Delta C = \pm 5°$) to express about 50% of the total flux.

[0034] As previously stated, it may be desired that such illuminance distribution may be made independent from the type and the distribution of the light radiation sources mounted on devices 10, e.g. when such light radiation sources - as it is envisaged in one or more embodiments - comprise solid state light radiation sources, such as LED sources, for instance conventional LED sources, of a Lambertian type.

[0035] It has been observed that such a distribution may be achieved by using a reflector for each light radiation source.

[0036] Such a reflector may be subject to mechanical constraints, due to the housing wherein it is mounted.

[0037] For example, assuming a light radiation source having a longest side a, the length of reflector along axis x (the x direction being parallel to the lengthwise direction of road S) may be constrained to be $\leq 8a$, the width of the reflector along the y direction (transverse to road S) may be constrained to be $\leq 3a$ and the height of the reflector along the z direction (perpendicular to x and y) may be constrained to be $\leq 2a$.

[0038] In this regard it is possible to use an open reflector, the lateral walls whereof collect the light flux of the light radiation source and project it towards the lit plane, determining the shape (e.g. a batwing-like shape) and the position of the candela peaks.

[0039] It has been found that the possibility to create a batwing profile with the desired peaks (with an availability of approximately 50% of the lighting flux) may be jeopardized in a reflector wherein the sum of the light radiation flux coming from the source and being output directly towards the lit plane (i.e. without interactions with the reflector) and the flux collected by the reflector walls, which is addressable to planes C0-C180 and the surrounding planes, is lower than 15%. By resorting to additional reflector elements mounted on the reflector, so as to intercept a higher percentage of the light radiation flux from the sources, it is possible to generate a batwing profile. In this case, more than 85% of the light rays undergo at least one reflection, with a consequent efficiency reduction.

[0040] In one or more embodiments, as exemplified in Figure 2, these critical aspects may be countered by resorting to a modular structure of device 10, including a support element which defines a support structure 12, e.g. a plane structure, whereon there are arranged a plurality of light radiation sources 14 associated to a respective reflector 16, so that each light radiation source 14, with a respective reflector 16 coupled thereto, supplies a respective portion of light distribution L.

[0041] The latter may be, as exemplified in Figure 2, a batwing-like distribution L, including two wings respectively denoted as L1 and L2.

[0042] For example, in one or more embodiments, one of the light radiation sources 14, with the respective reflector 16 associated thereto, may be arranged to cover planes C270-C90, passing through plane C0, while the other light radiation source 14, with the respective reflector associated thereto, covers planes C90-C270 passing through plane C180.

[0043] In one or more embodiments, the modular elements of lighting device 10 (for example each light radiation source 14 and the reflector 16 associated thereto) may be all identical.

[0044] In one or more embodiments, such modular elements of lighting device 10 may be different from each other.

[0045] In one or more embodiments, the distribution portions of the light radiation generated by each module comprising source 14 and reflector 16 may be identical or different from each other.

[0046] In one or more embodiments, the presently exemplified principle (each module comprising source 14 and reflector 16 being adapted to provide a half of the light radiation distribution) may be extended to a higher number of modules (three or more) comprising light radiation source 14 and reflector 16, which may be identical to or different from each other.

[0047] In one or more embodiments, the generation of the full light distribution of device 10 through the contribution of a plurality of modules, each comprising source 14 and reflector 16, may involve a different orientation of such modules.

[0048] For example, in the schematic representation of Figure 2, two modules comprising source 14 and reflector 16 are so to speak arranged back-to-back, the main axes X16 of reflectors 16 being parallel to each other.

[0049] The schematic view of Figure 2 exemplifies moreover a possible orientation of both modules, and specifically of reflectors 16, with respect to axis x, which is parallel to the longitudinal direction of road plane S and to axis y, extending in a transversal direction with respect to road plane S.

[0050] Figure 3, comprising three portions respectively denoted as a), b) and c), as well as Figure 4, comprising two portions respectively denoted as a) and b), exemplify various possible mountings of light radiation sources 14 at mounting positions or locations on a support element 12. In one or more embodiments, support element 12 may consist of a Printed Circuit Board (PCB).

[0051] Figures 3 and 4 exemplify the fact that, in one or more embodiments, light radiation sources 14 may have different shapes, e.g. rectangular, square, circular.

Of course, these are only some possible shapes and some possible mounting positions of light radiation sources.

[0052] Although Figures 3 and 4 envisage the presence of two light radiation sources 14, in one or more embodiments it is possible to envisage a higher number of light radiation sources.

[0053] The two parts of Figure 4 exemplify the fact that light radiation sources 14 may have the same size and may be arranged in different mounting positions / locations, according to the application needs; for example, in order to achieve a cost reduction, the same value of coordinate x may be used for the mounting location or position of light radiation sources 14.

[0054] In one or more embodiments, the portions of light radiation source distribution generated by each module, comprising source 14 and reflector 16, may be identical to each other.

[0055] In one or more embodiments, the portions of light radiation source distribution generated by each module, comprising source 14 and reflector 16, may be different from each other.

[0056] In one or more embodiments, the light radiation sources may consist of solid state light radiation sources, e.g. LED sources.

[0057] In one or more embodiments, the light radiation sources may be composite and may comprise e.g. a plurality of LEDs, with the possibility to use arrays of e.g. 4, 6 or 8 single light radiation sources.

[0058] Figures 5 to 8 exemplify possible embodiments of reflectors 16 (in the following it will be assumed for simplicity that such reflectors are identical to each other).

[0059] Such reflectors may be implemented for example as moulded elements (such as moulded plastic material) having a general ribbon-like shape and a general loop-shaped structure (closed loop, in the examples shown in the figures).

[0060] In one or more embodiments, reflector 16 may have two reflective lateral inner surfaces 16a, 16b, adapted to receive the radiation coming from the mounting position of light radiation source 14 on surface 12, and to reflect the light radiation source away from surface 12, towards the lit plane (for example towards road surface S).

[0061] The reflectivity features of surfaces 16a, 16b may be achieved according to any proper means, e.g. by making or treating such surfaces with a material which reflects light radiation, such as for example an aluminization layer.

[0062] In one or more embodiments, the first reflective surface 16a may be closer to the mounting position of light radiation source 14 than the second reflective surface 16b.

[0063] In one or more embodiments, the first reflective surface 16a, which is closer to the mounting position of light radiation source 14, may intercept a portion of the light radiation flux allowing to form a respective portion (e.g. portion L1 or portion L2, referring to the case exemplified in Figure 2) of the resulting light distribution, e.g. batwing-shaped.

[0064] This result (which may be extended, as previously stated, to a higher number of sources 14 / reflectors 16) may be used to implement reflectors 16 as distinct moulded parts, which are assembled separately on support 12, or as moulded parts of a piece, so as to form a single component.

[0065] In one or more embodiments, reflector 16 may be a sort of "winding" reflector, the reflective surfaces 16a and 16b being arranged facing each other along a main axis X16 of reflector 16.

[0066] As already mentioned with reference to Figure 2, in one or more embodiments reflectors 16 may be arranged with their reflective surfaces 16a adjacent each other, and/or with their main axes X16 parallel to each other.

[0067] As visible in Figures 7 and 8, in one or more embodiments at least one of the reflective surfaces (e.g. the first reflective surface 16a, or optionally both surfaces 16a, 16b) may be seen as including several stripes 160, extending along a perpendicular direction to support structure 12.

[0068] In one or more embodiments, stripes 160 may in turn be seen as comprising portions in sequence along the longitudinal extension of the stripe.

[0069] It will moreover be appreciated that such a surface structure of surfaces 16a, 16b may be seen, in a complementary way, as comprising stripes extending along a direction parallel to support structure 12, these stripes comprising in turn portions arranged in a string along the lengthwise extension of the stripe.

[0070] In one or more embodiments, the final result is a surface which may be defined a matrix surface structure.

[0071] In one or more embodiments, the surface profile of stripes 160 may be described with a parametric equation, e.g. in the form of a parabola having the focus adapted to correspond to the mounting position of light radiation source 14, so as to direct the light rays towards the lit plane (e.g. the road surface).

[0072] In one or more embodiments it is possible to reduce the number of rays intersecting the reflector at least once to a value approximately amounting to 70%, without jeopardizing the possibility of achieving a desired light distribution, e.g. a batwing distribution, with the corresponding peaks.

[0073] Figure 8 exemplifies the possibility, in one or more embodiments, to apply onto reflective surfaces 16a and/or 16b, e.g. on at least a part of stripes 160, pillow lenses 162, by acting upon the illumination uniformity with a possible peak alternation, e.g. when discrete light radiation sources (e.g. LED sources) are used.

[0074] Figures 9 to 12 exemplify the possibility to "play" on the position and/or the orientation of reflective surfaces 16a, 16b in order to achieve a particular light distribution.

[0075] For example, Figure 9 shows the possibility to

vary the extension of reflective surfaces 16a, 16b, so as to achieve a desired shaping action of the lighting beam.

[0076] Figure 10 exemplifies the possibility to modify the distance separating the reflective surfaces (e.g. surface 16a) from the mounting position of light radiation source 14.

[0077] Figures 11 and 12 exemplify the possibility to modify the orientation (Figure 11) or the position (Figure 12) of said reflective surfaces (once again we refer to the example of surface 16a), for example in conditions wherein lighting device 10 is placed on a side of the road surface (Figure 11) or at the centre of the road surface (Figure 12).

[0078] For example, in an application on the side of road surface (Figure 11), the reflective surface may be "twisted" towards the road surface.

[0079] If stripes 160 are present, having e.g. a parabola surface profile, the parabola axes are made to lie in or around plane C0-C180, optionally with an orientation towards the peak position of the batwing profile.

[0080] In one or more embodiments, in order to obtain a high flux on planes C0-C180, the parabolas describing the profile of stripes 160 may be oriented so that their axes lie in these planes, the parabolas being optionally oriented towards angular position G of the Candela Peak (CD) beyond 60°.

[0081] The tests carried out by the Applicants show that a lighting device as exemplified herein exhibits a low sensitivity of performances to the possible change of the size and shape of light radiation sources.

[0082] The experiences carried out by the Applicants show moreover that a lighting device as exemplified herein meets the requirements of streetlighting with output fluxes of reflectors 16 amounting to 3800 lm.

[0083] Of course, without prejudice to the basic principles, the 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.

[0084] The extent of protection is defined by the annexed claims.

Claims

1. A lighting device, including:

- a support member with a support surface (12) with a plurality of mounting locations for light radiation sources (14),
- a plurality of reflectors (16) surrounding the mounting locations of said plurality of mounting locations on said support surface (12), the reflectors (16) including first (16a) and second (16b) lateral reflective surfaces for reflecting away from said support surface (12) light radiation from one mounting location of said plurality of mounting locations for light radiation sources (14), wherein said first reflective surface (16a) is closer to said one mounting location than said second reflective surface (16b).

2. The lighting device of claim 1, wherein said first (16a) and second (16b) reflective surfaces are arranged facing each other along an axis (X16) of the reflector (16).

3. The lighting device of claim 1 or claim 2, including at least one pair of reflectors (16) arranged with their first reflective surfaces (16a) adjacent, preferably back-to-back, to each other.

4. The lighting device of claim 2 and claim 3, wherein said at least one pair of reflectors (16) are arranged with their axes (X16) parallel to each other.

5. The lighting device of any of the previous claims, wherein said reflectors (16) have a ribbon-like structure with said first (16a) and second (16b) reflective surfaces including first and second sides of said ribbon-like structure.

6. The lighting device of any of the previous claims, wherein at least one of said first (16a) and second (16b) reflective surfaces includes a plurality of stripes (160).

7. The lighting device of claim 6, wherein said stripes (160):

- extend in a direction perpendicular to said support surface (12), and/or
- have a parabolic profile with a focus at said one mounting location.

8. The lighting device of claim 6 or claim 7, including pillow lenses (162) coupled to at least some of said stripes (160).

9. The lighting device of any of the previous claims, including solid state light radiation sources (14), preferably LEDs, at said mounting locations.

10. A method of providing a lighting device, including:

- providing a support member with a support surface (12) with a plurality of mounting locations for light radiation sources (14),
- arranging a plurality of reflectors (16) surrounding the mounting locations of said plurality of mounting locations on said support surface (12), the reflectors (16) including first (16a) and second (16b) lateral reflective surfaces for reflecting away from said support surface (12) light radiation from one mounting location of said plurality of mounting locations for light radiation sources

(14), wherein the method includes arranging said reflectors (16) with said first reflective surface (16a) closer to said one mounting location than said second reflective surface (16b).

FIG. 1

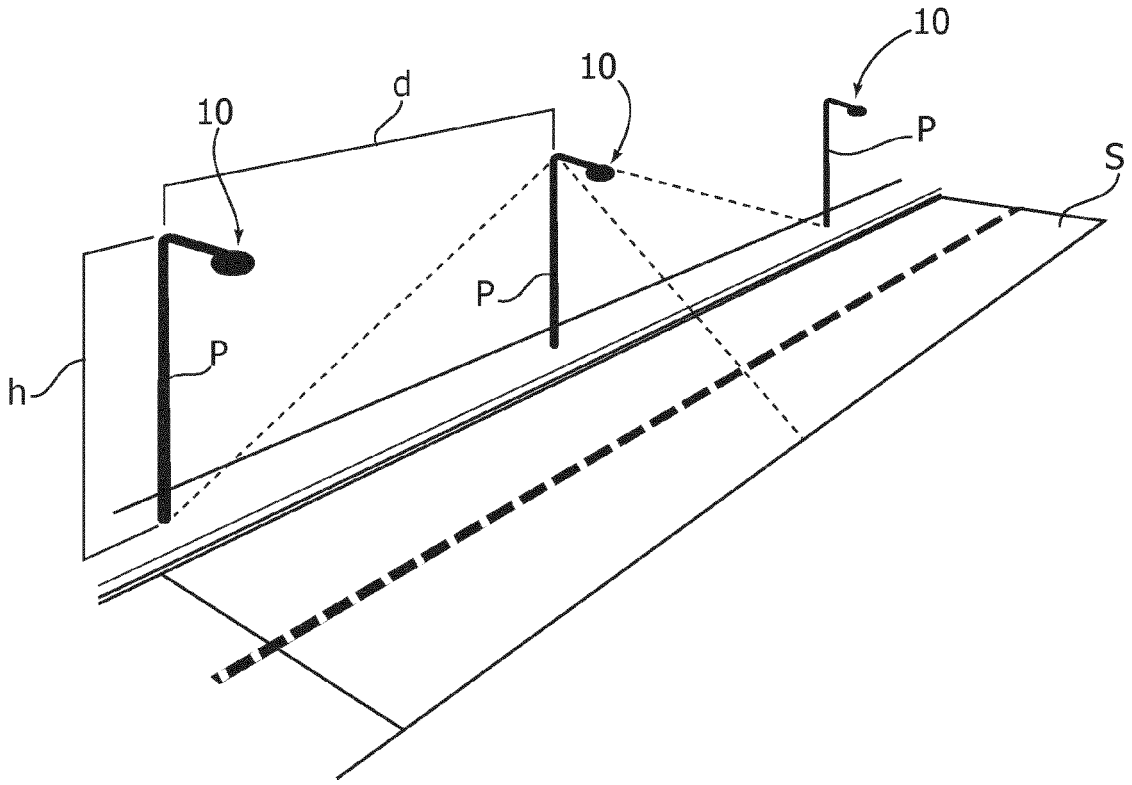


FIG. 2

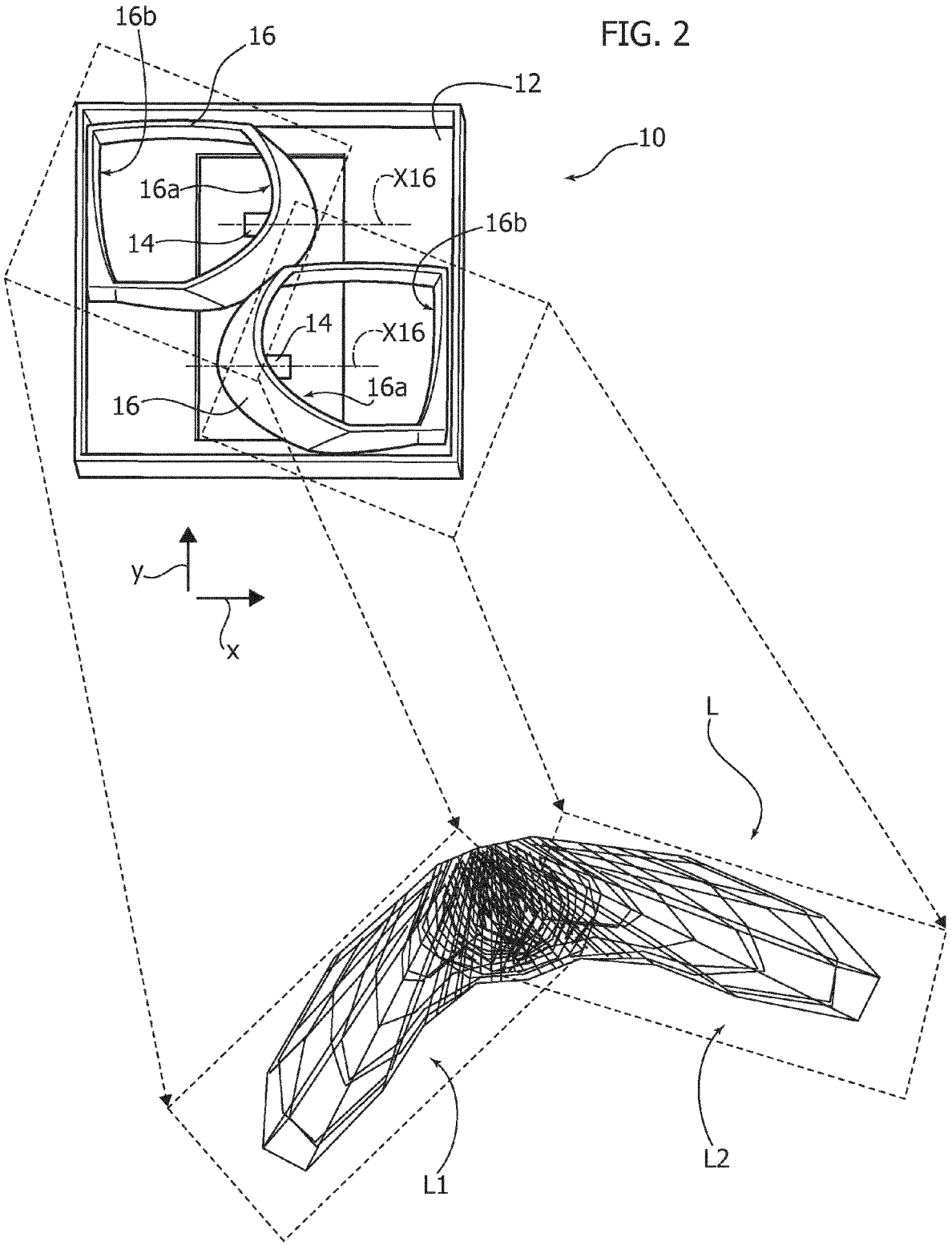
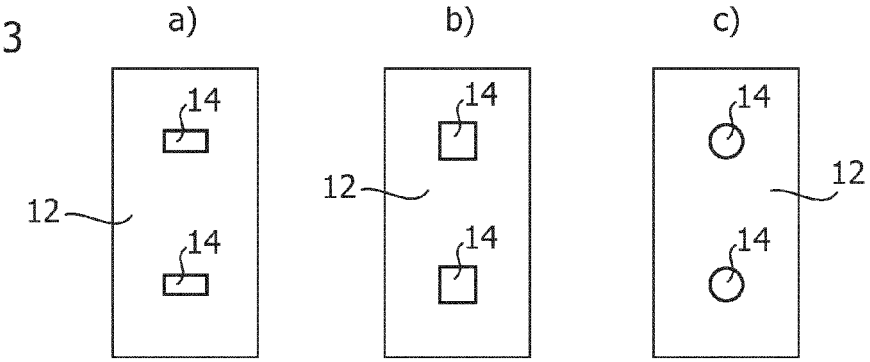


FIG. 3



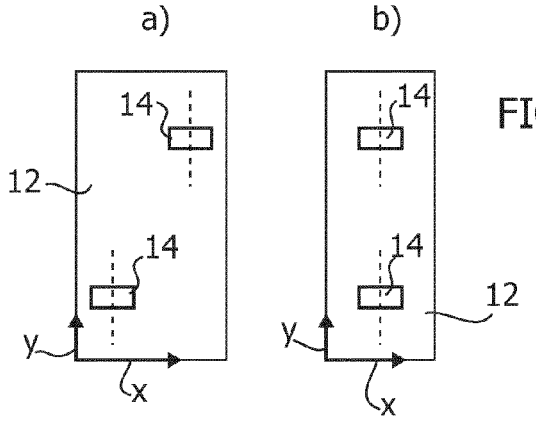


FIG. 4

FIG. 5

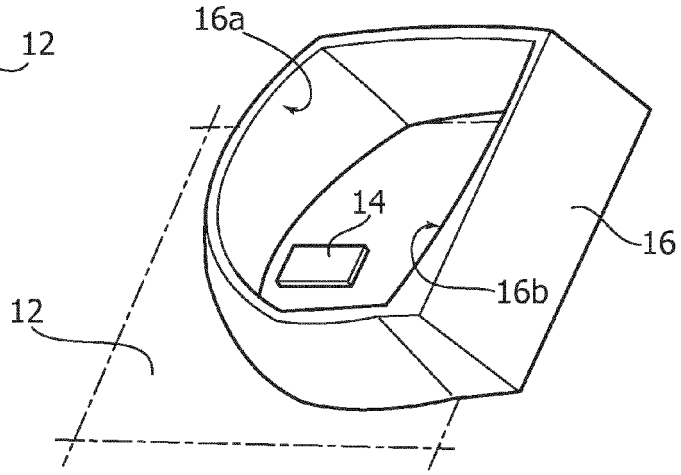


FIG. 6

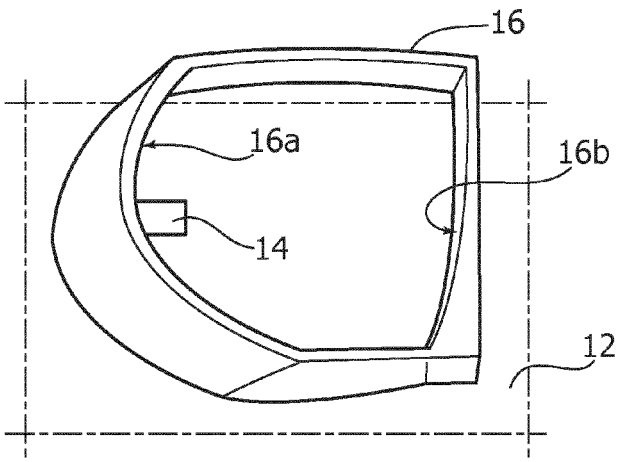


FIG. 7

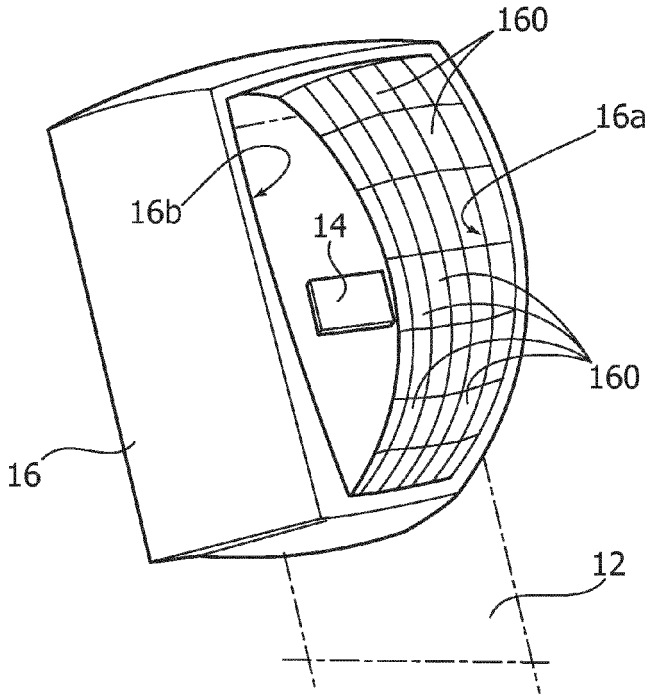


FIG. 8

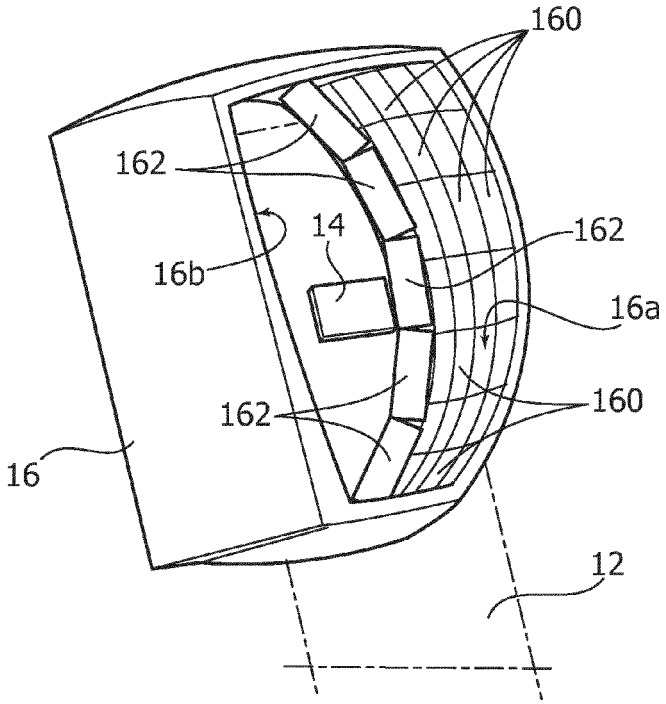


FIG. 9

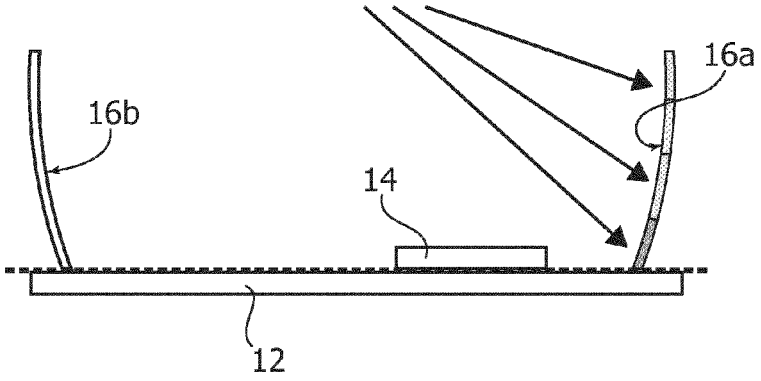
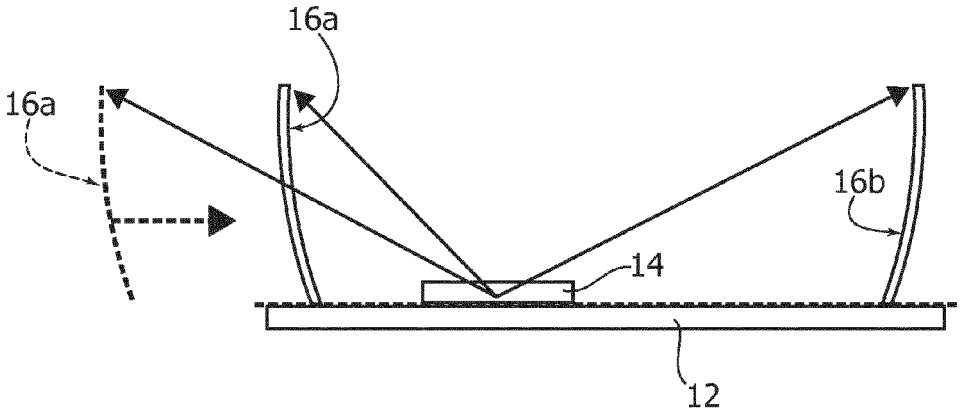


FIG. 10



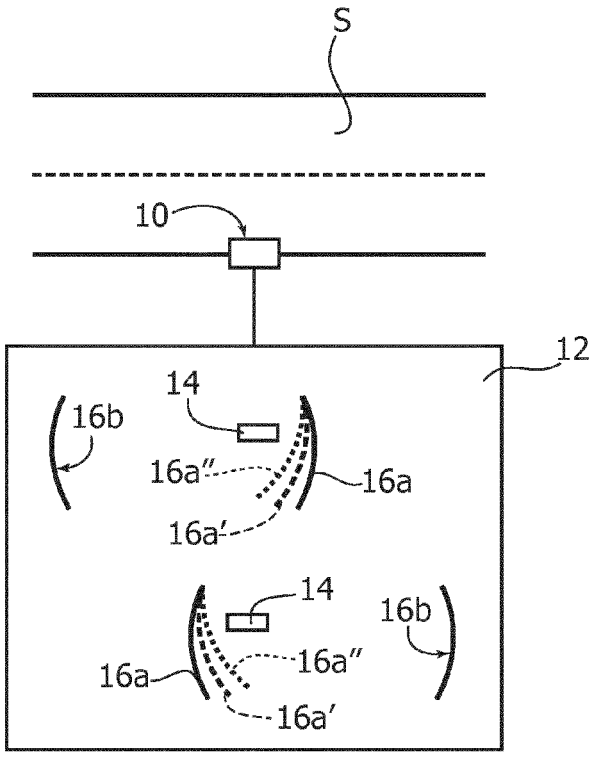

S
10
12
14
16b
16a″
16a
16a′
14
16b
16a
16a″
16a′

FIG. 11

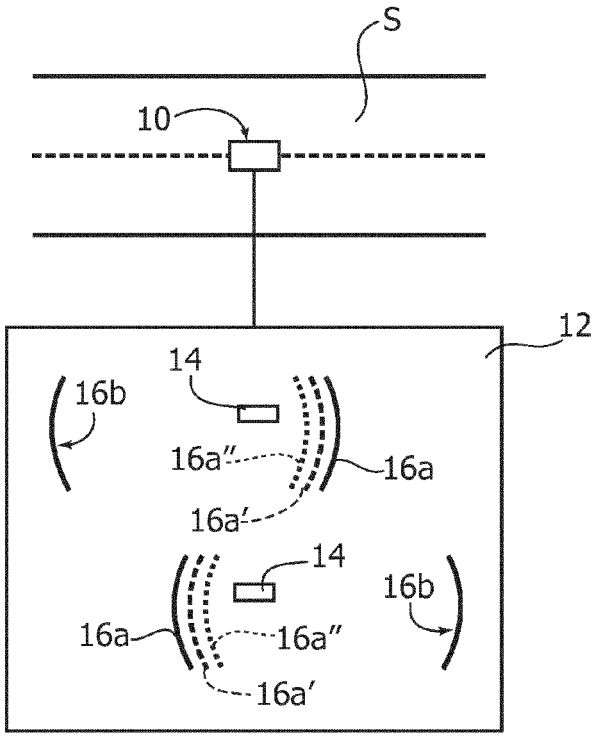

S
10
12
14
16b
16a″
16a
16a′
14
16b
16a
16a″
16a′

FIG. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 15 18 3833

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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	12 January 2016	Schulz, Andreas

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