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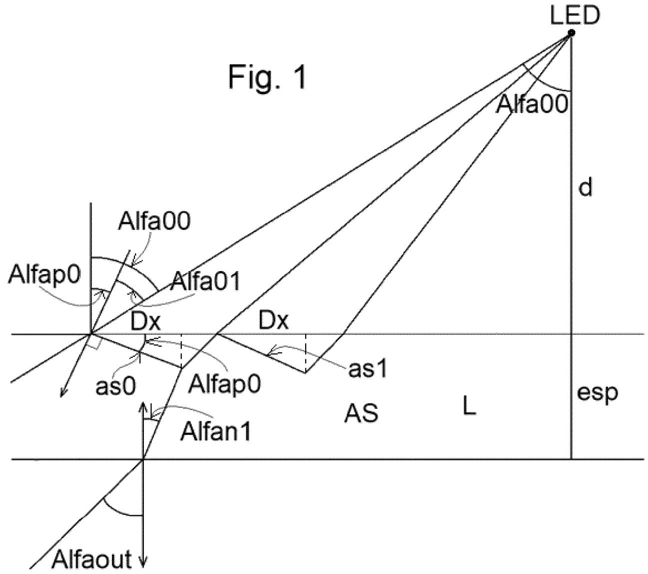
(54) EMERGENCY LUMINAIRE

(57) The present invention relates to an emergency luminaire, provided with a casing through which it is attached to the ceiling or wall, exhibiting a diffuser (D) with a smooth (flat or curved) outer surface (SEx) and an inner surface on which lenses (L) defined by microstructures (Ms) have been shaped that have been calculated by means of an algorithm that determines the configuration of a plurality of sawtooth cuts, with a constant period or peak-to-valley distance from the outside to the centre on the horizontal axis (Dx), the longest edge of which makes up the active face (as0, as1, etc.) thereof, facing the LED, and the opening angle (Alfap0) of the successive sawtooth edges (as0, as1, etc.) increases progressively towards the centre of the lens, so that each ray of light of the output beam through said lenses is adjusted in the desired direction according to the light projection of the application.

Fig. 1



EP 4 160 085 A1

Description

Technical field

[0001] The invention falls within the sector of emergency lighting; in particular the manufacture of luminaires for anti-panic lighting and evacuation routes, as well as backlit signage and emergency beaconing by means of LEDs or other light sources and the corresponding optical elements thereof. The invention is applicable to other lighting solutions.

State of the art

[0002] Generally, an emergency luminaire comprises a casing that contains the electronics -and optionally the batteries thereof- and the light source, in front of which the required optical components (lenses, reflectors, diffusers, etc.) are placed, responsible for diffusing light in all directions or according to an application-specific distribution in accordance with a required photometry. The optical components are made of transparent or opal glass or polymeric materials. Depending on the photometric objectives (distribution of light projection) of the luminaire, only a diffuser or a lens is used, or a combination of several of them.

[0003] Today a large number of luminaires use diffusers and LEDs as a light source, which, when passing through said diffuser, provide a more uniform light distribution. To achieve this effect, a very small and precise roughness has been formed in these diffusers, which is known as microstructure, so that when the light passes through that area, it is diffused or diverted in one direction.

[0004] This technique is now well known and in most cases employs a double layer microstructure system in which the diffuser comprises a first microstructured surface formed by a plurality of smooth saw teeth or other surface irregularities.

[0005] Document EP2204604 describes a lamp for illuminating building surfaces, which includes as a light source, a secondary optics that integrates several collimators with several LEDs, the light rays of which are transmitted in the same direction, perpendicular to a tertiary optics that is formed by a flat translucent element exhibiting light-directing microstructures, with a fixed pattern in shape and orientation, which extend along the entire length of said translucent element, diffusing the beam of each lens body at an angle of refraction α, for which reason the function of this lamp is to illuminate a surface or an object in the most homogeneous way possible.

Description of the invention

[0006] Differentiating from the prior art, an object of the present invention is to provide a compact optical component for an emergency luminaire that can be suited as:

- Anti-panic luminaire, to illuminate a large area under the luminaire, which is attached to the ceiling.
- Evacuation luminaire, also placed on the ceiling, intended in this case to illuminate the route to be followed in the event of an evacuation, as well as the fire extinguishers or other safety elements located along said route.
- Evacuation luminaire, in this case intended to be placed on the wall, with light output from the lower portion for lighting security points as well as evacuation routes.

[0007] This luminaire can be used in other photometric patterns, although in all of them it has one or more LEDs with a Lambertian emission pattern on a support integrated into a casing exhibiting a protection cover by way of a diffuser, formed by a part made of polycarbonate or a similar plastic material, which is transparent or translucent and which can be manufactured by means of a simple injection process, exhibiting a smooth (flat or curved) outer surface. On the inner face of said part, in at least one area a lens has been shaped, which is defined by a microstructure that receives the light emitted by an LED located at a distance from said microstructure such that it receives direct light from the LED within the opening angle of the - normally- Lambertian projection thereof to achieve maximum light use. The configuration of said microstructure is such that it converts each ray into another outer ray with the desired angle to provide a shape for the projection of the output light according to the lighting requirements that the luminaire must meet, either as an anti-panic, evacuation of ceiling or wall luminaire.

[0008] Said internal microstructure to the diffuser, which gives it lens properties in certain areas, for which reason said areas have been called lenses throughout this description, is present in at least one area of the inner face of said diffuser, preferably in different areas in a number comprised between 1 and those required to achieve lighting objectives, and for each of these lenses there is an internal LED that projects individual light on each of them. According to an important feature of the present invention, the internal microstructure of said lenses has been created by means of an algorithm that allows the calculation of the sawtooth points of said microstructure so that each ray of light of the output beam is adjusted in the desired direction depending on the angle refracted inside the microstructure with respect to the position of the LED that illuminates this lens from inside the luminaire.

[0009] Referring to Fig.1 wherein a portion of one of the lenses (L) shaped in the diffuser of this luminaire has been represented, in which the following have been indicated:

- Dx = period of the microstructure, or peak-to-valley distance, from the outside to the inside of the microstructure, on the horizontal axis.
- Alfaout = output angle of the light ray in that area of the microstructure.
- d = distance from the LED diode to the microstructure.
- esp = thickness of the diffuser (or of the affected area thereof when the diffuser is not flat).
- n1 = refractive index of the material used. 1,585 for polycarbonate.

[0010] In any of the cases, the area of the microstructure is on the inner face of the diffuser and at a fixed distance from the LED, corresponding to the focal point, which in a preferred application would be about 4 mm, although this focal length can be parameterised. In all the microstructures, the facet that defines the crest of the sawtooth (as0, as1, etc.) is the face facing the LED and therefore the active portion of the microstructure, since it is where it exhibits the maximum light transmission. According to an important feature, the period of the microstructure (or peak-to-valley distance from the outside to the inside on the horizontal axis) is fixed and what changes along the same is the opening angle of the edge of the sawtooth (Alfap0) that increases progressively towards the centre of the lens. Therefore, the method for calculating the microstructure consists of determining the Alfap0 angle in the successive microstructured facets starting from the outermost (as0) facet of the microtexturised surface, which is bathed by the light of the LED in the Lambertian thereof; when the LED is placed at the focal distance it subtends to about 60°, or the opening angle that corresponds to the LED used to achieve maximum light use.

[0011] The initial angle of Alfap0 is determined by the maximum angle of incidence of the LED to the microstructure (Alfa00) and by the angle with which the ray impinges on the second surface (Alfan1), this ray is not always the same since it depends on the angle that impinges on the microstructured portion and the direction of the ray that goes to the second surface.

[0012] This angle fulfils the following equation:

$$\text{Alfap0} = \text{arctang}((\sin(\text{Alfa00}) - \text{n1}*\sin(\text{Alfan1}))) \qquad [1]$$

[0013] As we have already mentioned, the peak-to-valley distance (from the outside to the inside of the microstructure) of the microstructure (Dx) is constant and what varies is the angle Alpap0 obtained from formula [1]. A refraction occurs on the second surface of the lens, which is given by Snell's Law, whereby the following output angle is obtained:

$$\text{Alfaout} = \arcsin(\sin(\text{Alfa01}) / \text{n1} \qquad [2]$$

[0014] Once the first crest of the sawtooth (as0) has been defined, a loop is programmed to determine the following points of the microstructure assuming that, as we have already indicated, the peak-to-valley period (Dx) of the same remains constant and so does the distance to the light source (d).

[0015] When carrying out the calculations of each Alfap0 angle, it may happen that it has a value such that when tracing the ray that impinges on the microstructure, that ray "collides" with the front edge of the same; therefore, this angle is considered critical and therefore it is necessary to check that Alfap0 is always less than said angle; for this, in this assumption it is considered that Alfap0 is slightly less than said critical angle Alfa0x, coming from the LED.

[0016] This algorithm applies to the different types of emergency lighting, although each of them exhibits certain peculiarities:

- The anti-panic luminaire has lenses that are built from the linear model described, with axial rotation, shaping concentric microstructures with respect to the centre of the lens in the vertical of which the corresponding LED diode is placed.
- The lenses of a ceiling evacuation luminaire are similar to the anti-panic model, with the only nuance that guide lines are applied to deflect the light in the desired axis according to the same method, and the microstructures between them are calculated by linear interpolation of peak-to-peak distances and maintaining depth.
- The lenses of a wall evacuation luminaire are obtained from a model similar to those of the anti-panic luminaire, to which an angle is added for light output from the wall towards the ground; while the upper portion of the microstructured area is placed for light use for the purpose of uniform illumination of an external sign placed at a focal distance from the outside of the calculated surface.

[0017] The manufacturing process is carried out by plastic injection using traditional techniques to achieve the replication of the microstructures of the mould in the final part, obtaining in a single process a single diffuser part that integrates at least one microstructured lens with beam shaping capabilities. according to the specific requirements of the application. Optionally, for the purpose of improving the replication of the mould, an injection-compression process can be applied at the end of the classic injection process, this process allowing adjustments of injection parameters to achieve dimensional objectives, warping, etc. of the diffuser as a whole. The compression is carried out on tempered steel inserts of the dimensions of the lens, which are obtained through a microtexturing process with femtosecond laser, which does not require subsequent micropolishing processes, the radius of the laser beam being that which defines the dimensional parameterisation of the microstructures (depths and periods). The inserts could be made using other processes and/or in other materials that would support the process and the repetitiveness of the injection.

Description of the drawings

[0018] As a complement to the description being made, and for the purpose of helping to make the features of the invention more readily understandable, the present specification is accompanied by a set of drawings which, by way of illustration and not limitation, represent the following:

- As we have already indicated, Fig. 1 represents a portion of one of the lenses (L) shaped in the diffuser (D) of this luminaire in order to facilitate the understanding of the development of the calculation algorithm used in the construction of the microstructures (Ms).
- Fig. 2 schematically shows a luminaire made according to the invention.
- Fig. 3 represents the distribution of the light of the LED diode on one of the lenses (L) of an anti-panic luminaire.
- Fig. 4 represents in greater detail a partial section of one of the lenses (L) of an anti-panic luminaire.
- Fig. 5 shows a plan view of the light distribution in a ceiling evacuation luminaire.
- Figs. 6 and 7 represent a vertical cross-section view of one of the lenses of a wall evacuation luminaire, and the manner in which the light is distributed in this type of lens.

Embodiment of the invention

[0019] This luminaire can be easily suited to different emergency lighting modalities, simply by modifying the parameters of the microstructure configuration (Ms) existing in the lenses (L) thereof, allowing its use for:

- Anti-panic lighting (of large areas) with luminaires placed on the ceiling.
- Lighting of evacuation routes, by means of luminaires placed on the ceiling.
- Lighting of security and anti-panic points/evacuation routes by means of luminaires placed on the wall with light exiting from the lower portion.
- Or other projection shaping applications (photometry) of light.

[0020] As can be seen in the referenced figures, the invention relates to an emergency luminaire that is shaped from a casing through which it is attached to the ceiling or wall, inside of which an electronic circuit is assembled for ignition of at least one LED diode, assembled on a support that allows it to be kept at a certain focal distance with respect to an optical component that we will indicate as a diffuser (D) in order to illuminate a specific area, depending on the type of luminaire that is used, as explained in more detail below.

[0021] The diffuser (D) is a single-piece body, made of polycarbonate or another transparent/translucent plastic material that allows the manufacture thereof by means of an injection process; externally it exhibits a smooth (flat or curved) surface (SEx), while on the inner surface at least one lens (L) has been shaped, which is defined by a microstructure (Ms) that upon receiving the light emitted by an LED converts each ray received into another outer ray with the desired angle to provide a shape for the output light beam according to the application of the luminaire, either as an anti-panic, ceiling or wall evacuation luminaire, or that desired objective photometry

[0022] According to an important feature of the invention, behind each of the lenses (L) defined by microstructures shaped in the diffuser (D) and in correspondence to the centre of each of them, an LED is located, placed at a focal distance (d) from said predetermined microstructure so that it is in correspondence to the focal point, in such a manner that the lens (L) located in front of it receives the radiation with a Lambertian emission pattern for maximum use. In a preferred embodiment, the focal length (d) of the LED diode to the microstructure is approximately 4 mm, so that the maximum angle (Alpha00) at which the LED subtends is 60° (or that of the LED aperture, which can be parameterised in the calculation algorithm) leads to target dimensions of the microstructure. Although the Alpha00 angle and this focal length can be parameterised, the angle corresponds to the Lambertian aperture of the light source and the focal length could be considered parameterisable from 0.5mm to 8mm.

[0023] The thickness (sp) of the diffuser (D) is also preferably constant, although it is likely to be variable, including the area or areas in which the lenses (L) are microstructured and in a preferred embodiment in the example it is about 2 mm in polycarbonate, which corresponds to the requirement for regulatory compliance with IK04 impact resistance, but can also be parameterised in the calculation algorithm. In any case, this thickness will always be a minimum of 10 times the greatest depth of the microstructure.

[0024] According to another important feature of the invention, the microstructure (Ms) defined on the inner face of the diffuser (D), which shapes each of said lenses (L), has been calculated by means of an algorithm that determines the configuration of a plurality of sawtooth cuts the greater edge (as0, as1, etc.) of which makes up the active face thereof, since it is the one located in front of the LED. Said microstructure is distributed with a constant peak-to-valley distance from the outside to the inside on the horizontal axis (Dx) of the aforementioned saw teeth, while the opening angle (Alfap0) of the successive sawtooth edges (as0, as1, ...) increases progressively towards the centre of the lens, so that each light ray of the output beam through said facets is adjusted in the desired direction depending on the internal angle of the microstructure, with respect to the position of the LED that illuminates this lens from inside the luminaire. More specifically and as we have explained previously, the algorithm that determines the opening angle (Alfap0) in the successive active faces (as0, as1, ...) of the microstructures (Ms) is provided by equation [1]. For its part, the angle of the output rays (Alfaout) in this part of the microstructure is given by equation [2].

[0025] In a preferred embodiment, the period of the microstructure, or peak-to-valley distance (from the outside to the inside of the microstructure) on the horizontal axis, (Dx) of the same is approximately 100 microns; although this measurement can range from 5 to 300 microns depending on the beam radius of the femtosecond laser used in the manufacture thereof.

[0026] Fig. 2 shows an embodiment of a luminaire made according to the invention, wherein the number of microstructured areas by way of lenses (L) present on the inner face of said diffuser (D) is 6 and they are aligned. This number can vary widely, and although the usual arrangement is also aligned, it is possible to think of other types of groupings, for example forming a circle in the case of luminaires with a more circular or more rounded form factor; however, what always remains is that behind each of these lenses (L) an LED is located in correspondence with the centre thereof and at the distance calculated for the microstructure, which do not have to be the same.

[0027] Fig. 3 and 4 show the lenses (L) of an anti-panic luminaire, intended to illuminate a large area under a luminaire attached to the ceiling. In this type of luminaire, each of the lenses (L) shaped in the diffuser (D) is defined by a microstructure (Ms) built from the linear model described above, forming an axial rotation in order to form successive concentric microstructures with respect to the centre of the lens in the vertical of which the corresponding LED diode is placed. Fig. 4 shows the manner in which the angle of the sawtooth edge of the microstructure is increasing towards the centre of the lens, which corresponds to an area in which there is an inverted frustoconical approximation hole (Ht), which protrudes through the inner face of the diffuser (D) and which shapes a surface in which the rays that the LED focussed on said microstructure emits towards the centre are deflected towards the sides in order to achieve a substantially uniform photometry/diffusion on the illuminated circular surface (as seen in Fig. 3), allowing optimal projection (photometry) in terms of uniformity of light on the ground

[0028] Fig. 5 shows the distribution of light in a luminaire for lighting evacuation routes and security points, placed on the ceiling. In this case, each of the lenses (L) shaped in the diffuser is divided into four sectors, of which the two that are aligned with the evacuation route exhibit different microstructures shaped following parabolic-shaped guide curves calculated to direct the rays in the direction of the evacuation route, 3 guide curves have been used, the microstructures between them being the linear interpolation of the peak-to-peak distances and maintaining the depth. The different sectors are separated by radial lines calculated for maximum light use. In the transverse sectors with respect to the evacuation route, each of these lenses exhibits a local microstructure (Ms2) that shapes light beams intended to illuminate specific points on the sides of the route where, for example, safety elements (fire extinguishers, etc.) are located.

[0029] The calculation of the guide curves is carried out according to the same method as that described for the anti-panic lens, its curvature being calculated for the maximum guidance of the light in the directions of interest.

[0030] Fig. 6 and 7 show a luminaire for lighting evacuation routes and security points of those that are placed attached to a wall. In this luminaire, each of the lenses (L) shaped in the diffuser (D) exhibits several concentric circumferential microstructures in which a first lower microstructured area (Ms4) with a circular configuration is defined, built from the linear model described above and a second upper microstructured area (Ms3) with a constant angle and on the external face a prism (PO) guiding the light rays vertically and downwards (ground).

[0031] Having sufficiently described the nature of the invention, as well as a preferred embodiment thereof, it is evident that the invention can have industrial applicability in the indicated sector.

[0032] Likewise, it is stated for the appropriate purposes that the materials, shape, size and arrangement of the elements described may be modified, as long as this does not imply an alteration of the essential features of the invention that are claimed below:

Claims

1. An emergency luminaire, provided with a casing through which it is attached on the ceiling or on the wall, **comprising:**

   - a diffuser (D) formed by a single-piece body made of polycarbonate or a transparent or translucent plastic material that allows the manufacture thereof by means of an injection process, exhibiting a smooth (flat or curved) outer surface (SEx) and an inner surface on which, in at least one area, a lens (L) defined by a micro-structure (Ms) has been shaped, which receives the light emitted by an LED and shapes each ray received into another outer one with the desired angle to provide a shape for the output light beam according to the requirements of the luminaire, whether as an anti-panic, ceiling or wall evacuation luminaire;
   - an LED located behind each of the lenses (L) defined by microstructures shaped in the diffuser (D) and in correspondence to the centre of each of them, which is placed at a distance from said microstructure corresponding to the focal point, such that said lens (L) receives the light within the opening angle of the -normally-Lambertian projection thereof for maximum use;

   wherein the internal microstructure that defines each of said lenses (L) has been shaped by means of an algorithm that determines the configuration of a plurality of sawtooth cuts, the longest edge of which makes up the active face (as0, as1, etc.) thereof, facing the LED, said microstructure being distributed with a constant period or peak-to-valley distance of the same (Dx), while the opening angle (Alfap0) of the successive sawtooth edges (as0, as1, etc.) increases progressively towards the centre of the lens, so that each ray of light of the output beam through said lenses is adjusted in the desired direction depending on the internal angle of the microstructure, with respect to the position of the LED that illuminates this lens from inside the luminaire.

2. The luminaire, according to claim 1, **characterised in that** the algorithm that determines the opening angle (Alfap0) in the successive active faces (as0, as1, ...) of the microstructures (Ms), starting from the outermost (as0) face of the microstructured surface that is bathed in the light of the LED in the Lambertian projection thereof with maximum light use, is determined by the maximum angle of incidence of the LED to the microstructure (Alfa00) and by the angle (Alfan1) with which the LED ray impinges on the second surface (as1), according to the following equation: Alfap0 = arctang((sin(AlfaOO) - n1*sin(Alfan1))); wherein n1 is the refractive index of the material in which the lens is made, in which a refraction is produced that determines that the angle of the output rays in this portion of the microstructure fulfils the following equation: Alfaout = arcsin(sin(Alfa01)/n1 wherein Alpha01 is the input angle at the next active face of the microstructure (as1); and having defined the angle Alfap0 for the active face (as0) of the first sawtooth cut, the following points of the same are determined, starting from the fact that the period (Dx) of the microstructure and the distance (d) to the LED which makes up the light source thereof, remain constant.

3. The luminaire, according to claim 2, **characterised in that** when carrying out the calculations of any of the Alfap0 angles that the successive active faces (as0, as1, etc.) of the microstructures (Ms) must adopt, it has a value such that the ray from the LED to the microstructure impinges on the front, non-active edge of the sawtooth, said angle Alfap0 is corrected until the ray from the LED to the microstructure impinges on the active edge (as0, as1, etc.) of the microstructure.

4. The luminaire, according to any of the preceding claims, **characterised in that** the period of the microstructure, or peak-to-valley distance (from the outside to the inside of the microstructure) of the same, (Dx), is comprised between approximately 5 and 300 microns.

5. The luminaire, according to any of the preceding claims, **characterised in that** the distance from the LED diode to the microstructure (d) is comprised between 0.5 mm and 8 mm, depending on the opening angle (AlphaOO) of the LED.

6. The luminaire, according to any of the preceding claims, **characterised in that** the thickness of the diffuser (D) is constant, including the area or areas in which the lenses (L) are microstructured and approximately 2 mm.

7. The luminaire, according to any of the preceding claims, **characterised in that** said areas microstructured by way of lenses, present in at least one area of the inner face of said diffuser, are arranged in alignment and in correspondence with each of them there is a single LED that projects direct light towards each of said lenses.

8. The anti-panic luminaire, intended to illuminate a large area under the luminaire, which is attached to the ceiling, according to any of the preceding claims, **characterised in that** each of the lenses (L) shaped in the diffuser (D) is

defined by a microstructure built from the linear model of claim 2, with axial rotation, shaping concentric microstructures with respect to the centre of the lens in the vertical of which the corresponding LED diode is placed.

9. The anti-panic luminaire, according to claim 8, **characterised in that** each of the microstructured lenses in the diffuser exhibits an inverted frustoconical hole (Ht) in the centre, which protrudes from the inner face of the diffuser that shapes a surface on which the rays that the LED focussed on said microstructure emits towards the centre are deflected to the sides in order to achieve a photometry for uniform projection on the illuminated circular surface.

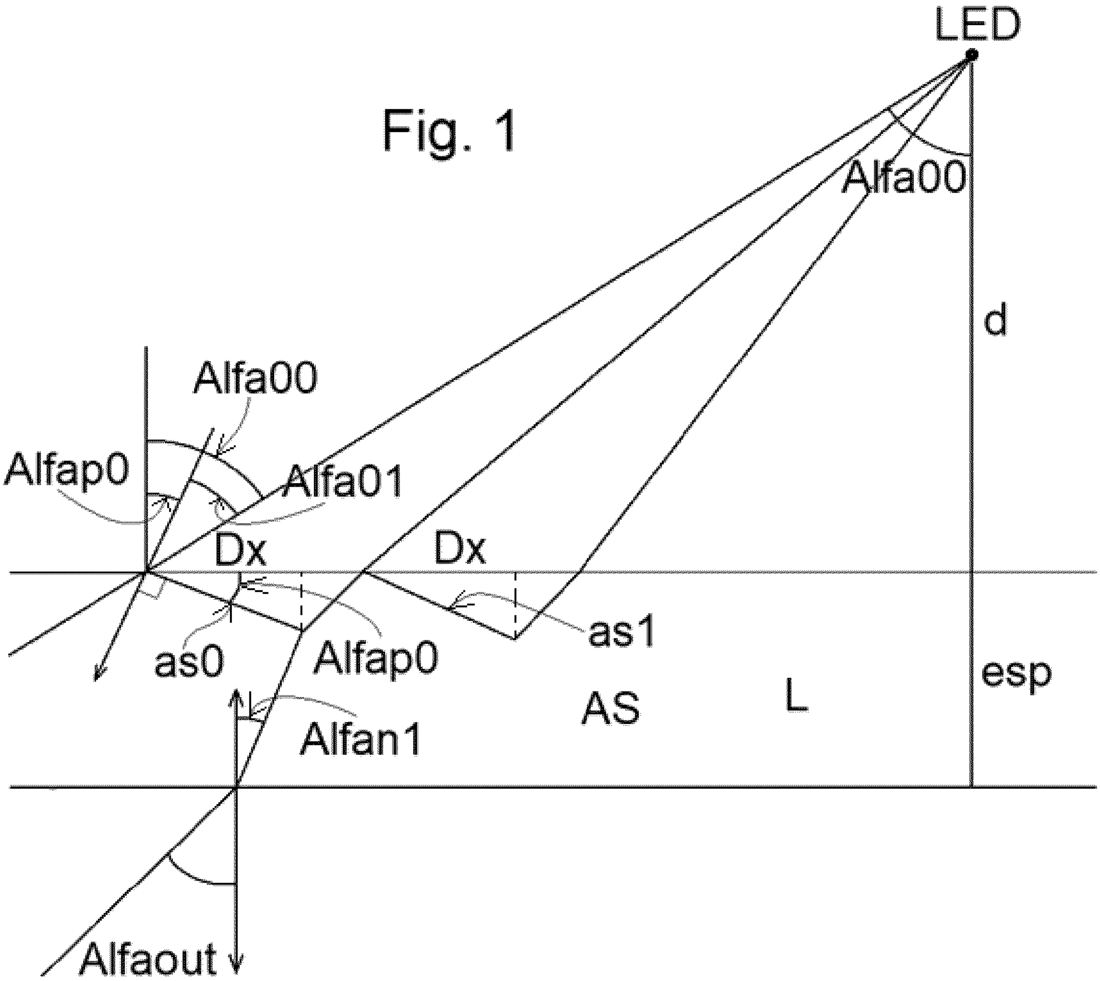
10. The luminaire for lighting evacuation routes and security points, placed on the ceiling, according to claims 1-7, **characterised in that** each of the lenses that are shaped in the diffuser is divided into four sectors, of which the two that are aligned with the evacuation route exhibit various microstructures shaped following parabolic-shaped guide curves calculated to direct the rays in the direction of the evacuation route, the microstructures among them being the linear interpolation of the peak-to-peak distances and maintaining the depth, built from the linear model of claim 2.

11. The luminaire, according to claim 10, **characterised in that** each of the microstructured lenses in the diffuser exhibits in the transverse sectors with respect to the evacuation route a local microstructure calculated in at least one guide line, the microstructures between them being the linear interpolation of the peak-to-peak distances and maintaining the depth, which shapes light beams intended to illuminate specific points on the sides of the route where there are security elements.

12. The luminaire for lighting evacuation routes and security points, placed on the wall, according to claims 1-7, **characterised in that** each of the lenses (L) shaped in the diffuser (D) exhibits different concentric circumferential microstructures in which the following is defined:

- a first lower microstructured area (Ms4), with a circular configuration, built from the linear model of claim 2;
- a second upper microstructured area (Ms3) with a constant angle, and
- on the external face it exhibits a prism (PO) intended to guide the light rays downwards.

Fig. 1


LED
Alfa00
d
Alfa00
Alfap0
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as1
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Fig. 2

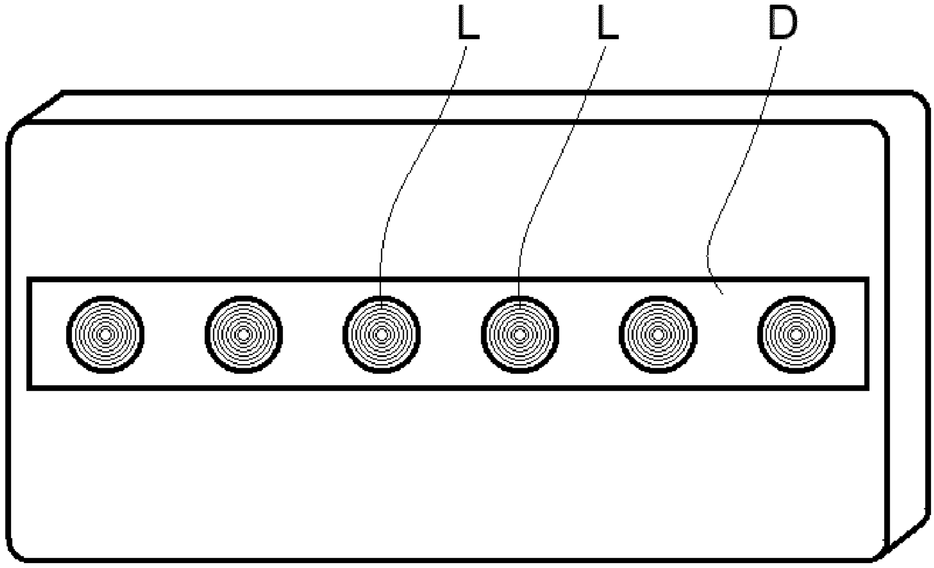
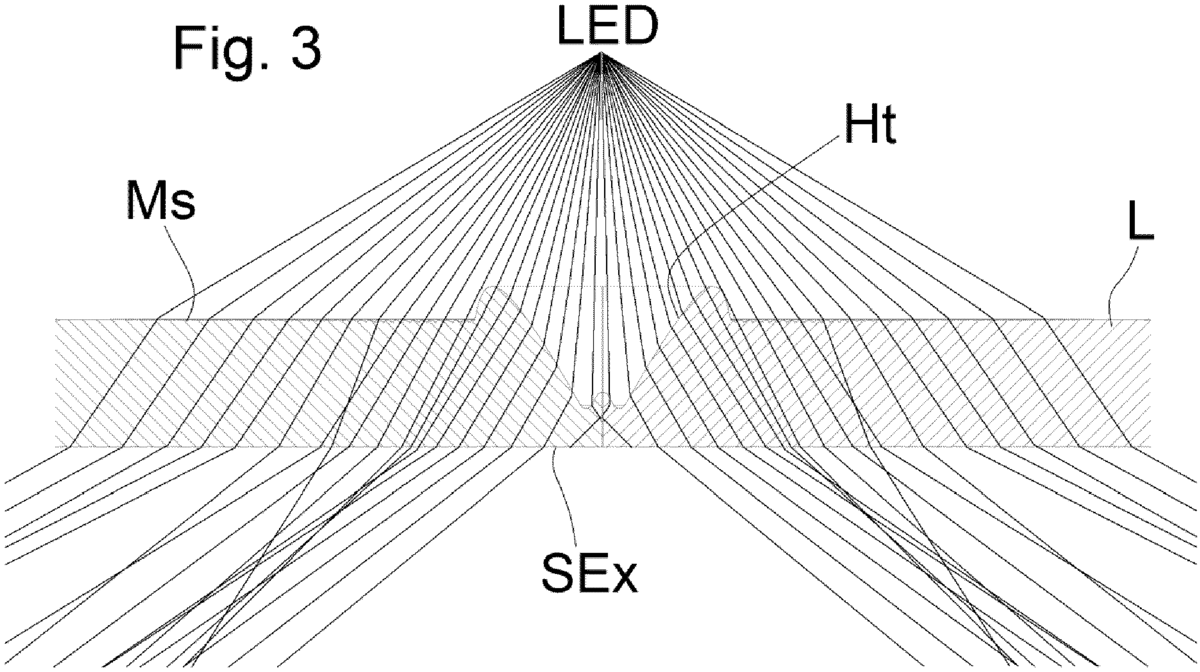


Fig. 3



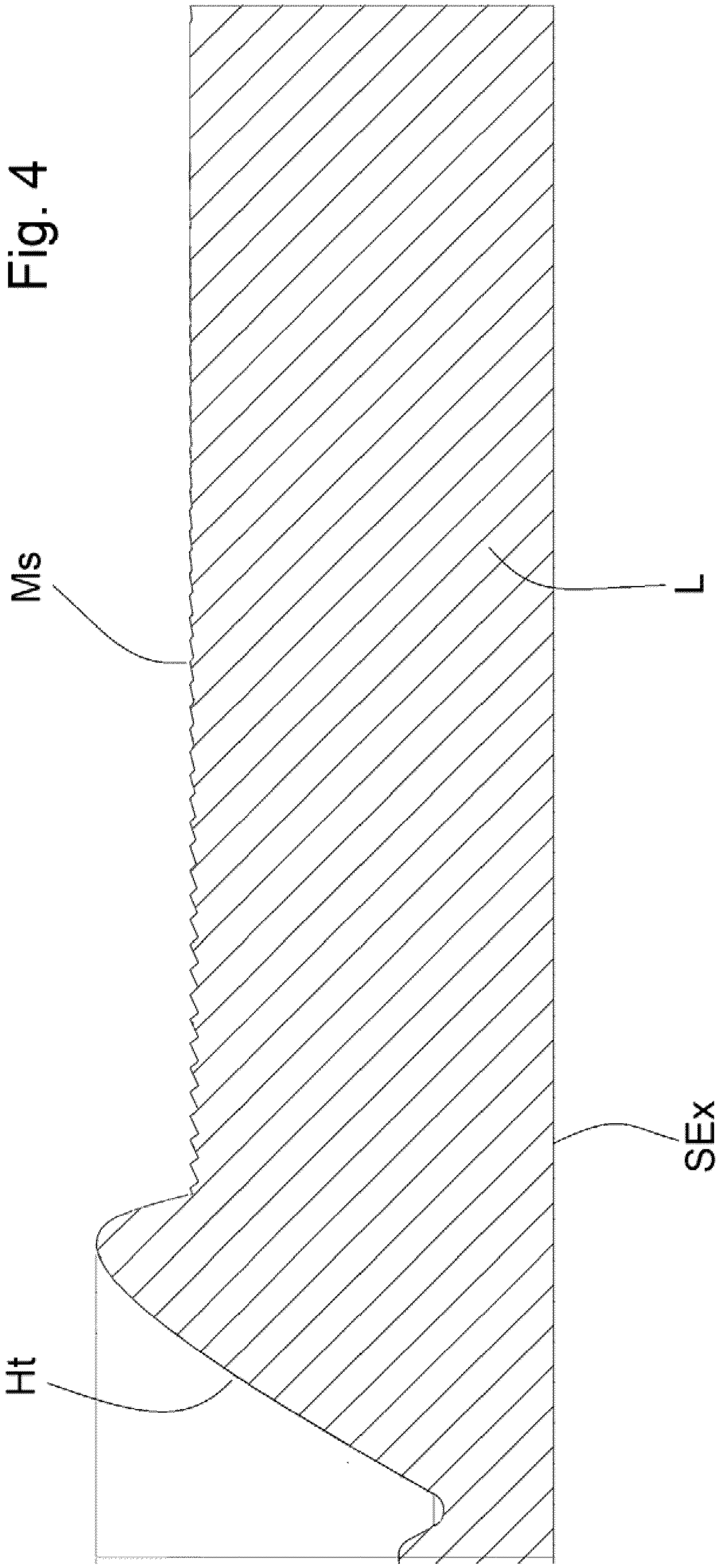


Fig. 4

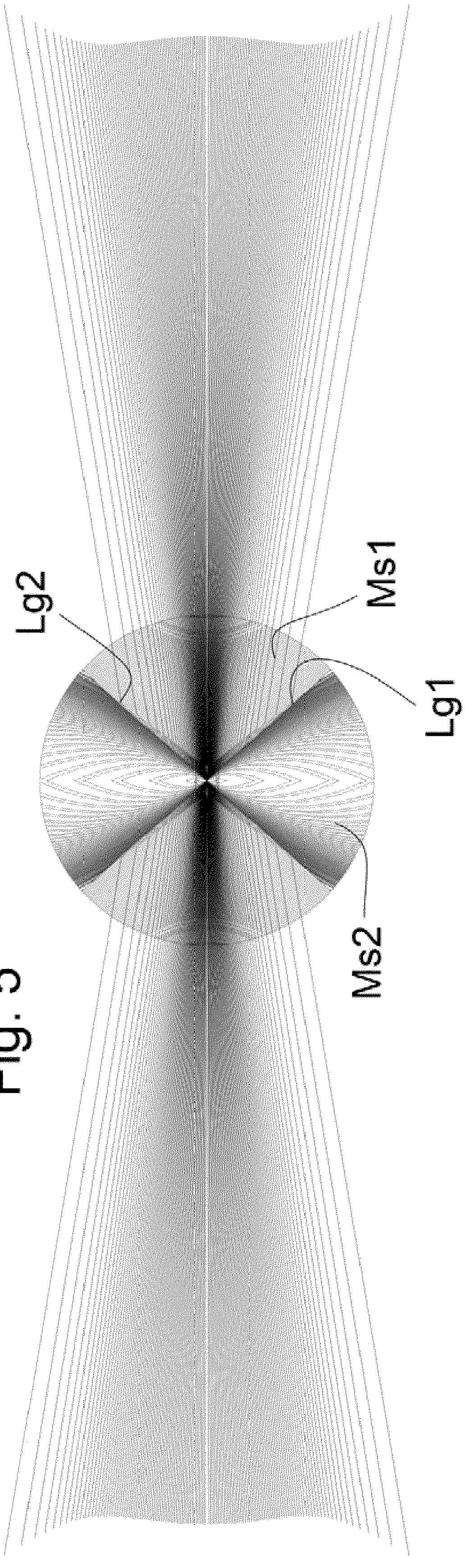


Fig. 5

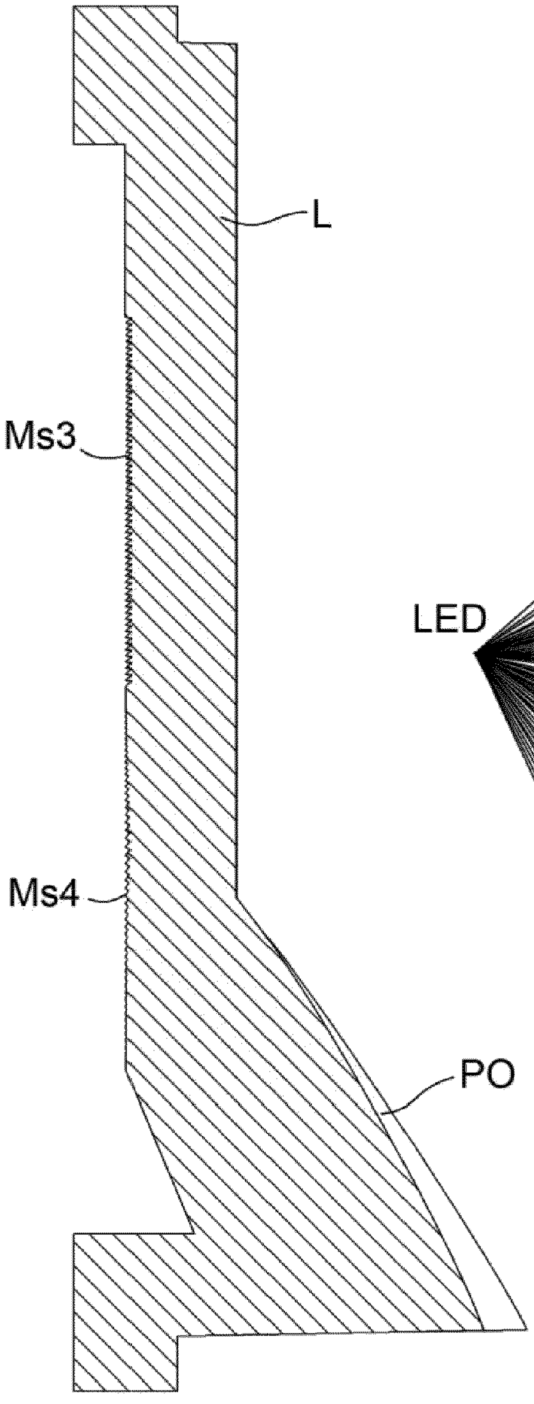


Fig. 6

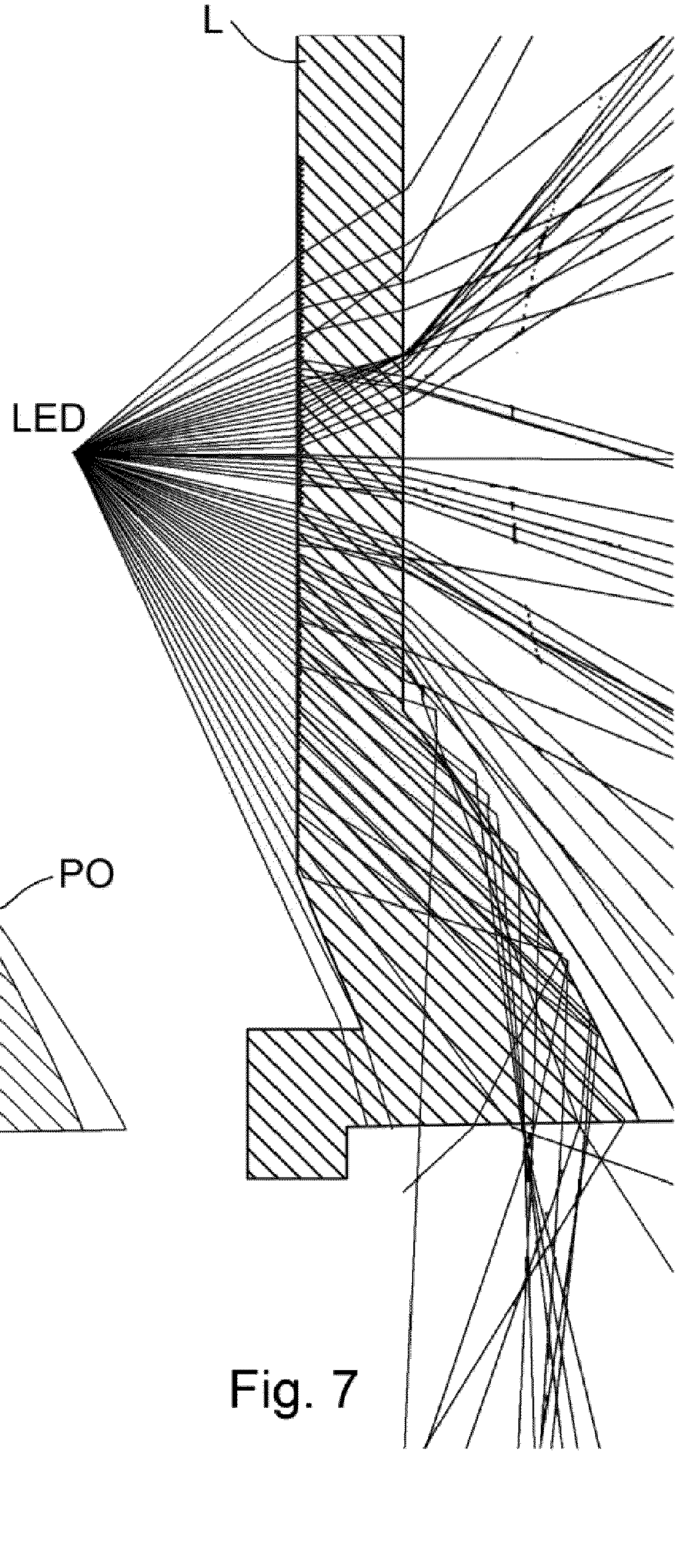


Fig. 7

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European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 22 38 2867

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	EP 3 686 484 A1 (EATON INTELLIGENT POWER LTD [IE]) 29 July 2020 (2020-07-29) * paragraphs [0028], [0045] * * figures 7, 14, 15 * -----	1,4,5,7	INV. F21V5/00 F21V5/04 ADD. F21S9/02 F21Y103/10 F21Y115/10
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Place of search	Date of completion of the search	Examiner
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