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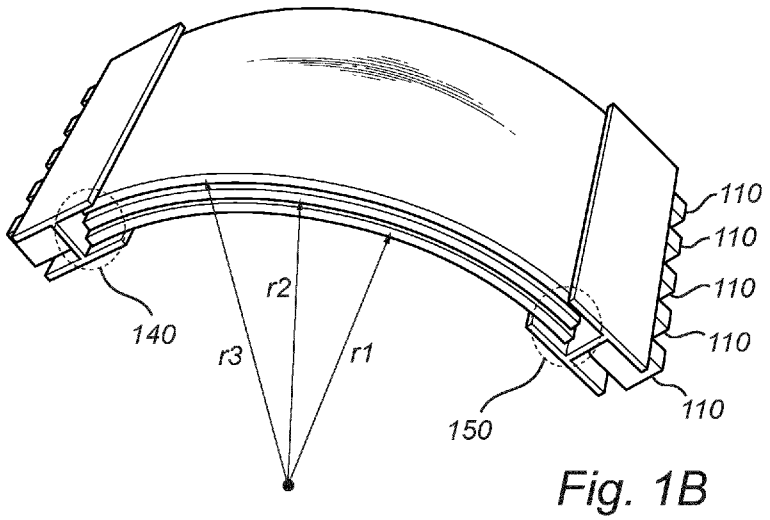


Fig. 1B

(57) Abstract: A light guide device (100) comprising a plurality of sheet elements (130) configured to guide light, wherein each sheet element has a first surface and a second surface oppositely arranged from each other and wherein each sheet element further has a first edge surface and a second edge surface oppositely arranged from each other. The sheet elements of the light guide device are superimposed such that said plurality of sheet elements comprises a set of adjacently arranged first edge surfaces (140) and a set of adjacently arranged second edge surfaces (150). The light guide device further comprises a support structure (120) arranged to hold at least one of the set of adjacently arranged first edge surfaces and the set of adjacently arranged second edge surfaces. Moreover, the light guide device comprises a light source (110) at least partially enclosed by the support structure, wherein the light source is configured to emit light into the plurality of sheet elements via at least one of the set of adjacently arranged first edge surfaces and the set of adjacently arranged second edge surfaces. Furthermore, at least one sheet element of the plurality of sheet elements comprises a light outcoupling element (220) configured to couple light impinged thereupon from the light source out of the plurality of sheet elements via at least one of the first and second surfaces of the at least one sheet element.

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Light guide device

FIELD OF THE INVENTION

The present invention generally relates to a lighting arrangement comprising a plurality of light guiding elements. More specifically, the present invention is related to a multi-layer planar light guide device.

BACKGROUND OF THE INVENTION

The use of light guides in lighting devices is increasingly being seen in functional lighting applications. Compared to lighting devices using only incandescent bulbs, neon tubes or even only LED, light guides provide several advantages such as wider and more evenly distributed light throughout its surface.

In particular, there is currently an increasing interest in lighting devices using light guides of different shapes in order to obtain a desired decorative lighting for applications such as luminaires. Such lighting devices typically comprise light emitting sources transmitting light into a light guiding material which is given a desired shape such as waved shape, edges, circular bending, etc.

However, it may be cumbersome to obtain shapes involving sharp angles or a plurality of angles without compromising the efficiency of light transmission from the light source into the light guiding material resulting in a poor light intensity of the lighting device. Furthermore, lighting devices involving such complex shapes may require a manufacturing process generating high costs.

Hence, it is an object of the present invention to try to overcome at least some of the deficiencies regarding the difficulty of obtaining complex shapes and high manufacturing cost of the present lighting devices using shaped light guides.

SUMMARY OF THE INVENTION

Hence, it is of interest to overcome at least some of the deficiencies of present lighting devices using shaped light guide, in order to improve the flexibility of said light guides without compromising their light distribution properties.

This and other objects are achieved by providing a multi-layer planar light guide having the features in the independent claim. Preferred embodiments are defined in the dependent claims.

Hence, according to the present invention, there is provided a light guide device. The light guide device comprises a plurality of sheet elements configured to guide light, wherein each sheet element has a first surface and a second surface oppositely arranged from each other and wherein each sheet element further has a first edge surface and a second edge surface oppositely arranged from each other. The sheet elements of the light guide device are superimposed in the light guide device such that said plurality of sheet elements comprises a set of adjacently arranged first edge surfaces and a set of adjacently arranged second edge surfaces. The light guide device further comprises a support structure arranged to hold at least one of the set of adjacently arranged first edge surfaces and the set of adjacently arranged second edge surfaces. Moreover, the light guide device comprises a light source at least partially enclosed by the support structure, wherein the light source is configured to emit light into the plurality of sheet elements via at least one of the set of adjacently arranged first edge surfaces and the set of adjacently arranged second edge surfaces. Furthermore, at least one sheet element of the plurality of sheet elements comprises a light outcoupling element configured to couple light impinged thereupon from the light source out of the plurality of sheet elements via at least one of the first and second surfaces of the at least one sheet element. Finally, each sheet element is flexible to thereby allow the light guide device to be bent into a shape wherein the plurality of sheet elements is curved such that each sheet element has a radius of curvature.

Thus the present invention is based on the idea of providing a light guide device comprising a plurality of sheet elements configured to guide light emitted from a light source. Said plurality of sheet elements may be superimposed on their first and second surfaces (i.e. the surfaces represented by the plane formed by the length and width of the sheet element) such that their combined thickness, therefore the total thickness of the plurality of sheet elements, may be sufficient to receive enough transmitted light from at least one light source to obtain an efficient light distribution. Such total thickness may be large enough to permit use of e.g. mid-power LEDs or any other type of light emitting source providing accurate light efficiency for a variety of lighting applications. In the light guide device each individual sheet element is thin enough to reach a flexibility allowing the light guide device to be efficiently and easily bent to a shape wherein the plurality of sheet elements is curved such that each sheet element has a radius of curvature, e.g. without

requiring extensive manufacturing processes. Moreover, the superimposition of the plurality of sheet elements is advantageous in that it allows for the oppositely arranged first edge surfaces and second edge surfaces of each sheet element to be superimposed as well, thus forming a set of adjacently arranged first edge surfaces and a set of adjacently arranged second edge surfaces. The set of adjacently arranged first edge surfaces and/or the set of adjacently arranged second edge surfaces may form a planar light-receptive surface for light to be transmitted thereupon by the light source and may be supported by at least one support structure.

The at least one support structure may further allow for one or both of the set of adjacently arranged first edge surfaces and set of adjacently arranged second edge surfaces to be supported thus allowing the plurality of sheet elements to remain superimposed during flexion or bending. In addition, the at least one support structure is further advantageous in that it allows for movement of the set of adjacently arranged first edge surfaces and/or the set of adjacently arranged second edge surfaces generated during flexion or bending of the plurality of sheet elements. Furthermore, the at least one light outcoupling element allows for light emitted from the at least one light source and transmitted into the plurality of sheet elements to be distributed within said plurality of sheet elements and out of at least one of their first surfaces and second surfaces. Such at least one light outcoupling element allows distribution of light via refraction and/or reflection and may be positioned on and/or at least partly comprised in either or both of the first surface and second surface of at least one sheet element of the plurality of sheet elements. By the term “light outcoupling element”, it is here meant an element, structure, unit, or the like, which is configured to distribute, scatter, spread, direct, refract and/or reflect light impinged on at least one surface of such element. The at least one light outcoupling element may further comprise a solid material and may be positioned on at least one first surface and/or second surface of at least one sheet element according to the desired lighting distribution in terms of illumination and/or decorative purposes. Furthermore, the at least one light outcoupling element may be selected based on the area of the at least one sheet element across which the light transmitted from the at least one light source needs to be distributed.

According to an embodiment of the present invention, at least one support structure of the light guide device may be reflective. The present embodiment is advantageous in that it allows for the at least one support structure to even further improve the intensity and distribution of the light emitted from the light source into the light-receiving surface formed by the set of adjacently arranged first edge surfaces and/or the set of

adjacently arranged second edge surfaces. Such improved light intensity and distribution therefore results in the improvement of the transmission into the plurality of sheet elements.

According to an embodiment of the present invention, at least one light source of the light guide device may be displaceably arranged in at least one support structure. Such displacement of the at least one light source may be performed along the thickness of the light guide device formed by the set of adjacently arranged first edge surfaces and/or the set of adjacently arranged second edge surfaces. The present embodiment is advantageous in that the possibility of movement of the position of the at least one light source in the at least one support structure may allow for different light intensity distributions to be obtained according to the desired illumination and/or decorative application of the light guide device. In other terms, positioning the at least one light source such that the intensity of its light emission is e.g. higher towards the top sheet elements of the superimposed plurality of sheet elements may result in a different light intensity distribution as opposed to positioning the at least one light source such that the intensity of its light emission is stronger towards the lower sheet elements of the superimposed plurality of sheet elements.

According to an embodiment of the present invention, at least one sheet element of the plurality of sheet elements of the light guide device may comprise a transparent polymer material. It will be appreciated that preferably more than one sheet element comprises a transparent polymer material. An example of this embodiment may also be to have N-1 sheet elements comprising a transparent polymer material (in which N represents the total number of sheet elements) allowing the inferior sheet element of the plurality of sheet elements to be represented by a reflector. An alternative example may be to have N-2 sheet elements comprising a transparent polymer material allowing the inferior sheet element of the plurality of sheet elements to be represented by a reflector and the superior sheet element of the plurality of sheet elements to be represented by a diffuser. Such reflector and/or diffuser sheet elements may allow different light intensity distribution to be obtained beneath and above the light guide device. Furthermore, such transparent polymer material may be characterized by its transparency which in turn may be understood as a physical property of such material allowing light to pass through it without being scattered. The transparent polymer material is at least partially light transmissive being advantageous in that it permits an improved distribution of the light emitted by the at least one light source and the light reflected and redirected from the at least one light outcoupling element throughout the at least one sheet element. The present embodiment is therefore advantageous in that it may even further improve the light distribution from the light guide device.

According to an embodiment of the present invention, at least two sheet elements of the plurality of sheet elements of the light guide device may be separated by at least one spacing element. By "spacing element" it is here meant an element, structure, unit, or the like, which is configured to create a distance between at least two superimposed sheet element such that contact between the first surface and second surface of said superimposed sheet elements is prevented. For example, the at least one spacing element may be represented by e.g. a small protrusion or separate particles. By "small protrusion" it is here meant e.g. a lump, bump and/or a bulge, comprised in at least one first surface and/or second surface of the at least two sheet elements allowing said surface to be at least partly separated from the opposing surface of the opposing superimposed sheet element. By "separate particle" it is here meant a spacing element representing a different entity positioned on or at least partly enclosed in the surface of the at least two sheet elements allowing said surface to be at least partly separated from the opposing surface of the opposing superimposed sheet element. Furthermore, the at least one spacing element may comprise a transparent material. The present embodiment is advantageous in that the at least one spacing element comprising transparent material allows the prevention of leakages of liquid generated by moisture and/or heat condensation between at least two sheet elements which surfaces are at least partially in contact. The at least one spacing element thus improves the lifespan of the light guide device as well as the protection of the surroundings of said light guide device. There is provided preferably at least three, and more preferably at least four spacing elements.

According to an embodiment of the present invention, at least one sheet element of the plurality of sheet elements of the light guide device may have a first thickness at a central portion of the sheet element and a second thickness at an end portion of the sheet element, wherein the first thickness is smaller than the second thickness. By "end portion" it is here meant a portion of the at least one sheet element in which at least one of the first edge surfaces or the second edge surfaces of said at least one sheet element is (are located. By "central portion" it is here meant a portion of the at least on sheet element located at the centre of its length. Such non-uniformity of thicknesses across the length of the at least one sheet element of the plurality of sheet elements allows for the improvement of the flexibility of the at least one sheet element as a thinner central portion allows for a greater radius of curvature. The present embodiment is further advantageous in that the second thickness being larger than the first thickness allows for the end portion of at least one sheet element to have a larger light-receiving surface into which the at least one light source may emit light resulting in an improved light transmission efficiency thus improving the light distribution

within the at least one sheet element. The thickness difference between the central portion and the end portion of the at least one sheet element thus allows for the reduction of the number of sheet elements needed in the plurality of sheet elements to obtain efficient light transmission into said plurality of sheet elements.

According to an embodiment of the present invention, at least one of the first edge surfaces of the set of adjacently arranged first edge surfaces and the second edge surfaces of the set of adjacently arranged second edge surfaces of the light guide device may be attached. It will be appreciated that such attachment is achieved by the usage of substantially any means and/or method for attaching the first edge surface(s) and/or second edge surface(s), respectively, such as glue, clamps, and/or by at least partly melting the first edge surface(s) and/or the second edge surface(s) together. The present embodiment is advantageous in that is allows the attached least one first edge surfaces of the set of adjacently arranged first edge surfaces and/or attached second edge surfaces of the set of adjacently arranged second edge surfaces to remain sufficiently aligned during flexion and/or bending of the light guide device, resulting in an improved light-receiving surface into which the light source may emit light. The present embodiment therefore results in an improved light transmission efficiency thus improving the light distribution within the at least one sheet element and/or between at least two sheet elements.

According to an embodiment of the present invention, a first light outcoupling element of the plurality of light outcoupling element may have a first shape and a second light outcoupling element of the plurality of light outcoupling element may have a second shape, wherein the first shape is different from the second shape. By “shape” it is here meant the form and/or orientation of the reflective surfaces and/or the pattern of said reflective surfaces of the at least one light outcoupling element which may distribute the reflected light. Such shape difference allows for different directions of light distribution to be obtained when light emitted by the at least one light source, or reflected from other light outcoupling elements, impinges said at least one first or second light outcoupling element. In other words, the at least one first light outcoupling element having a first shape may provide different angle of reflection of light impinged thereon or different light scattering pattern than the at least one second light outcoupling element. The present embodiment is further advantageous in that it allows for the adjustment of the light intensity distribution of the light guide device according to the desired application based on the light intensity impinging the differently shaped light outcoupling elements. Furthermore, the light intensity distribution of the light guide device may be adjusted by the selection of the composition of the superimposed sheet

elements on which the differently shaped light outcoupling elements may be arranged in a particular manner.

In the light guide device according to the present invention, each element of the plurality of sheet elements is flexible to allow the light guide device to be bent into a shape wherein the plurality of sheet elements of the light guide device is curved such that each sheet element has a radius of curvature. By "radius of curvature" it is here meant the radius of a circle fitting the curved sheet element. Moreover, by the superimposition of the plurality of sheet elements, any flexion or bending of the light guide device will generate a radius of curvature in each sheet elements of said plurality of sheet elements. Such radius of curvature may be measured from the same centre of curvature for each sheet element of the plurality of sheet elements as they are superimposed and subjected to the same bending movement. Furthermore, it will be appreciated that each sheet of the plurality of sheet elements may have a plurality of radius of curvature in the events of a plurality of flexion or bent of the plurality of sheet elements.

According to an embodiment of the present invention, a first sheet element of the plurality of sheet elements of the light guide device may have a first curvature and a second sheet element of the plurality of sheet elements may have a second curvature, wherein the first curvature is different from the second curvature. Such difference of curvature is advantageous in that it allows for a decorative light effect to be reached when bending the light guide device.

According to an embodiment of the present invention, at least one support structure may comprise a plurality of steps configured to abut at least one of the first edge surfaces and the second edge surfaces, wherein the plurality of steps projects in the direction of the longitudinal axis of the plurality of sheet elements, wherein a first step of the plurality of steps has a first length in said direction and a second step of the plurality of steps has a second length in said direction, wherein the first length is different from the second length. The plurality of steps comprised in the at least one support structure allows the light-receptive surface formed by the first edge surfaces and the second edge surfaces to be at least substantially parallel to the surface of the steps via which the light emitted from the light source is transmitted to at least one sheet element. The plurality of steps of the at least one support structure therefore allows for the improvement of the light transmission to the at least one sheet element when said at least one sheet element is flexed or bent to a particular radius of curvature. The present embodiment is further advantageous in that it allows for the same sheet elements of a plurality of sheet elements to be used for different curvatures provided

that a consequent change of the first length and the second length of the first step and the second step of the plurality of steps of the at least one support structure. In other words, if the curvature is increased (i.e. increased radius of curvature of the at least one sheet element) the first length and the second length of the first step and the second step of the plurality of steps may be increased to insure an effective abutment of at least one of first edge surface and the second edge surface.

According to an embodiment of the present invention, a first sheet element of the plurality of sheet elements of the light guide device may have a first length and a second sheet element of the plurality of sheet element has a second length, wherein the first length is different from the second length. Such length difference allows for the surface of at least one of the edge surfaces of the set of adjacently arranged first edge surfaces and/or at least one of the edge surfaces of the set of adjacently arranged second edge surfaces to be at least substantially parallel to the surface of the at least one support structure via which the light emitted from the light source is transmitted into the at least one sheet element when the plurality of sheet elements are submitted to a bending movement or flexion. Such length difference therefore allows for the improvement of the light transmission to the plurality of sheet elements when the light guide, and therefore each sheet element of the plurality of sheet elements, is bent to a particular radius of curvature. Furthermore, the first length of the at least one first sheet element and the second length of the at least one second sheet element are inversely proportional to their respective radius of curvature when the light guide, and therefore the plurality of sheet elements, is bent to a particular curvature. In other words, the at least one sheet element with the greater radius of curvature will have the shorter length.

According to an embodiment of the present invention, the light guide device may comprise a single support structure arranged to hold the set of adjacently arranged first edge surfaces and the set of adjacently arranged second edge surfaces. In order to for a single support structure to hold both sets of adjacently arranged edge surfaces, the plurality of sheet elements may be bent at a plurality of places along their length. The present embodiment is advantageous in that the thickness of the first edge surfaces and the thickness of the second edge surfaces held by said single support structure may be reduced by half without compromising the efficiency of light transmissivity from the light source to the sheet elements. In other words, as the surface on which the light emitted from the light source is transmitted (i.e. the light-receiving surface) consists of both the first edge surface and second edge surface of each sheet element held by said single support, the total dimension

(thickness) of both surfaces may be reduced by half. Such reduced thickness further results in an improved flexibility of the plurality of sheet elements.

According to an embodiment of the present invention, there is provided a luminaire comprising a light guide device according to any one of the preceding embodiments. The luminaire further comprises a cover comprising an at least partially light transmissive material, wherein the cover at least partially encloses the light guide device. The luminaire further comprises an electrical connection connected to the light guide device for a supply of power to the at least one light source of the light guide device.

Further objectives of, features of, and advantages with, the present invention will become apparent when studying the following detailed disclosure, the drawings and the appended claims. Those skilled in the art will realize that different features of the present invention can be combined to create embodiments other than those described in the following.

BRIEF DESCRIPTION OF THE DRAWINGS

This and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing embodiment(s) of the invention.

Fig. 1A schematically shows a light guide device according to an exemplifying embodiment of the present invention,

Fig. 1B schematically shows a flexed or bent light guide device according to an exemplifying embodiment of the present invention,

Fig. 2A-2B schematically shows a portion of a plurality of sheet elements with a displaceable light source position according to an exemplifying embodiment of the present invention,

Fig. 2C schematically shows a reflected light beam from a light outcoupling element according to an exemplifying embodiment of the present invention,

Figs. 3 schematically show a disposition of light outcoupling elements according to an exemplifying embodiment of the present invention,

Figs. 4A-4B schematically show a light guide device comprising sheet elements having non-uniform thicknesses across their lengths according to exemplifying embodiments of the present invention,

Fig. 5A-5B schematically shows a light guide device comprising an attached set of adjacently arranged edge surfaces according to an exemplifying embodiment of the present invention.

Fig. 6 schematically shows a light guide device comprising sheet elements with different curvatures according to an exemplifying embodiment of the present invention,

Fig. 7 schematically shows a light guide device with a support structure comprising steps according to an exemplifying embodiment of the present invention,

Fig. 8 schematically shows a light guide device comprising a plurality of sheet elements with different lengths according to an exemplifying embodiment of the present invention, and

Fig. 9 schematically shows a light guide device in which both sets of adjacently arranged first edge surfaces and second edge surfaces are held by a single support structure according to an exemplifying embodiment of the present invention.

DETAILED DESCRIPTION

Fig.1A schematically shows a side view and a top view of a light guide device 100 comprising a plurality of flexible sheet elements 130. The number of sheet elements 130 may preferably be at least 3, more preferably be at least 5 and most preferably be at least 7 e.g. 8 or 10 sheet elements 130. Each sheet element 130 may preferably have a length D and a width W for which the length D is larger than the width W. It may also be envisaged as an alternative embodiment that the width W of each sheet element 130 may be equal or larger than their length D. D is preferably at least 10 cm, more preferably at least 15 cm, and most preferred at least 20 cm. W is preferably at least 10 cm, more preferably at least 15 cm, and most preferred at least 20 cm.

The plurality of sheet elements 130 may preferably have a total thickness t which may range from 1 mm to 20 mm, more preferably from 4 mm to 12 mm, most preferably from 6 mm to 10 mm. The plurality of sheet elements 130 may be superimposed such that the first edge surfaces and second edge surfaces of each sheet element 130 form a set of adjacently arranged first edge surfaces 140 and a set of adjacently arranged second edge surfaces 150. The plurality of sheet elements may have a cladding which prevents an outcoupling of light where it is not desired. The cladding preferably comprises a lower index of refraction with respect to the material of the plurality of sheet elements.

The set of adjacently arranged first edge surfaces 140 and the set of adjacently arranged second edge surfaces 150 may be held by the support structure 120. The support structures 120 may preferably have a width w at least equal or greater than the width W of the plurality of sheet elements 130 i.e. the width of the set of adjacently arranged first edge surfaces 140 and the set of adjacently arranged second edge surfaces 150. Furthermore,

support structures 120 may preferably comprise larger dimensions than the light sources 110 to be at least partly supported by the support structures 120. Fig. 1A shows at least partially supported light sources 110 but it may also be envisaged as an alternative embodiment that the light sources 110 be completely recessed within the support structure 120. The support structures 120 may have a H shaped cross section forming two cavities allowing the set of adjacently arranged first edge surfaces 140 or the set of adjacently arranged second edge surfaces 150 to be held within a first cavity and for the light sources 110 to be held within the second cavity. In addition, the support structures 120 may be highly reflective and preferably provide a reflectance greater than 80%, more preferably greater than 90% and most preferably greater than 95%. The light sources 110 may preferably be mid-power LEDs with a size of 3 mm by 3 mm (e.g. 3030 LEDs). The light sources 110 may be arranged along the width w of the support structures 120 and the number of light sources 110 held by each support structure 120. Furthermore, the light guide device 100 shows a "step" or spacing between each light source 110 arranged along the width w of the support structures 120 allowing said light sources 110 to be held efficiently.

Although Fig. 1A only shows a single light guide device 100, it should be noted that a plurality of light guide devices 100 may be combined and/or arranged together.

In the light guide device 100 shown in Fig. 1A, the light emitted by the light sources 110 may be transmitted into the plurality of sheet elements 130 via the light-receiving surface formed by the set of adjacently arranged first edge surfaces 140 and the set of adjacently arranged second edge surfaces 150. Such transmitted light allows for an efficient light intensity distribution throughout the plurality of sheet elements 130 allowing the light guide device 100 to provide light to its surroundings.

It will be appreciated that the light emitted by the light sources 110 is preferably white light. The white light is preferably within 15 SDCM (standard deviation of color matching) from the black body locus (BBL), more preferably within 10 SDCM, most preferably within 8 SDCM such as for example 5 or 3 SDCM. The color temperature of the white light is preferably in the range of 2000 to 6000 K, more preferably in the range from 2500 to 5000 K, most preferably in the range from 2700 to 4000 K. The white light has preferably a CRI of at least 70, more preferably at least 75, most preferably at least 80 such as for example 85 or 90.

Fig. 1B schematically shows a side view and a top view of a flexed or bent light guide device 100. When submitted to a bending movement or flexion, each sheet element 130 reaches a respective radius of curvature r1, r2, r3, wherein r3 is greater than r2,

which in turn greater than r1. A slight shift in superimposition of the set of adjacently arranged first edge surfaces 140 and the set of adjacently arranged second edge surfaces 150 is generated. Such radius of curvature r1, r2, r3 may preferably range from 20° to 170°, more preferably range from 40° to 140° and most preferably from 50° to 120°. The support structures 120 may allow for such movement of the set of adjacently arranged first edge surfaces 140 and a set of adjacently arranged second edge surfaces 150. The light guide device 100 of Fig. 1B indicates a plurality of light sources 110.

Fig. 2A and Fig. 2B schematically illustrates a side view of a portion 200 of a plurality of sheet elements 230 each comprising light outcoupling elements 220 arranged along the length and/or the width of said sheet elements 230. The light outcoupling elements 220 comprises all reflective surfaces and the orientation of the reflective surfaces may differ from one light outcoupling element 220 to another. It will be appreciated that the light outcoupling elements 220 may be not only reflective, but also refractive. The light outcoupling elements 230 may have substantially any shape used to refract or reflect the light by total internal reflection. The light outcoupling elements 220 allow the extraction of light along the length the sheet elements 230 and the distribution of said extracted light in different directions such that an intensity light distribution profile suitable for luminaire applications may be generated. Moreover, the light outcoupling elements 220 may be represented by paint and/or ink dots, sandblasted extraction centers, specular indents, bumps or small protrusions comprising specific curvatures or shape or the like allowing the light to be reflected and/or refracted into different directions outside of the sheet elements 230. The light outcoupling elements 220 are shown in Fig. 2A-2C at least partially enclosed within the sheet elements 230 but it may be anticipated that the light outcoupling elements 220 may also be disposed on the surface of the sheet elements 230. Furthermore, Fig. 2A and Fig. 2B illustrate different arrangements of light outcoupling elements 220 on the surfaces of the sheet elements 230. For example, Fig 2A illustrates two inferior sheet elements 231 on which the light outcoupling elements 220 are partly enclosed within their superior surfaces and two superior sheet element 232 on which the light outcoupling elements 220 are partly enclosed within their inferior surfaces. Moreover, Fig 2A and Fig. 2B schematically show displaceable light sources 210 configured to transfer light into the sheet elements 230. In Fig. 2A, the light sources 210 are shown in a position aligned with the inferior sheet elements 231 which allows the light outcoupling elements 220 disposed thereon to be impinged with a greater light intensity then the light outcoupling elements disposed on the superior sheet elements 232 resulting in a certain light distribution. In Fig. 2B, the light sources 210 are displaced in a

position aligned with the superior sheet elements 232 which allows the light outcoupling elements 220 disposed thereon to be impinged with a greater light intensity then the light resulting in a different light distribution and therefore a different light effect for the light guide device. It may be anticipated that the number and composition of sheet elements 230 as well as the disposition of light outcoupling elements thereon may be selected or adjusted according to the desired light intensity distribution of the light guide device.

Fig. 2C exemplifies a light outcoupling element 220 on which light from a light source is impinging. Fig. 2C further shows reflected light beams 250 having different light reflective directions or angle of reflection. Such array of reflected light beams 250 allows a better distribution of light intensity within a light guide device comprising such light outcoupling elements 220 on the surface of its plurality of sheet elements 230. It will be appreciated that the intensity of the light may be homogeneous or non-homogeneous within the light guide device.

Fig 3 schematically shows a side view of a portion 300 of two superimposed sheet elements 331, 332 on which another exemplification of disposition of light outcoupling elements 320 is shown. In Fig. 3 the light outcoupling elements 320 may be arranged on the superior surfaces of the superimposed sheet elements 331, 332 along their lengths 340 and/or along their width, and may comprise the physical characteristics according the previously exemplified embodiment described in Fig. 2. Furthermore, Fig. 3 shows a disposition of the light outcoupling elements 320 on the superior surface of the sheet element 331 and the disposition of the light outcoupling elements 320 on the superior surface of the of the sheet element 332 such that there is no superimposition of light outcoupling elements 320 along a normal of the respective sheet elements 331, 332. Such disposition may allow for an improved light intensity distribution throughout and out of the sheet elements 331, 332. The light guided in the plurality of sheet elements 331, 332 is guided by total internal reflection. When the light impinges on the light outcoupling elements 320, the light is outcoupled from the sheet elements 331, 332.

Fig. 4A schematically shows a side view of a plurality of sheet elements 430 having non uniform thickness profiles along the direction of their lengths 460. Fig. 4A further shows end portions 450 and central portions 440 for each sheet element 430 for which the thickness of the central portions 440 and smaller than the thickness of the end portions 450 thus improving the flexibility of the plurality of sheet elements 430. The thickness ratio representing the thickness of the end portions 450 over the thickness of the central portions 440 may preferably range from 1.5 to 2. Moreover, Fig. 4B illustrates a light guide device

400 comprising the plurality of sheet elements 430 according to the exemplification of Fig. 4A and submitted to a bending movement or flexion at their central portions 440. The light guide device 400 further comprises support structures 120 and light sources 110 according to the exemplification described in Fig.1A-1B. The larger thickness of the end portions 450 of the sheet elements 430 allows for the light-receiving surfaces 410 formed by the set of adjacently arranged first edge surfaces and the set of adjacently arranged second edge surfaces to be improved and more prominent to light transmission from the light sources 110 when being held in the support structures 120.

Fig. 5A illustrates a side view of a light guide device 500 submitted to a bending movement or flexion and comprising a plurality of sheet elements 530 for which only one of the set of adjacently arranged first edge surfaces or second edge surfaces 520 may be held by a support structure 120 and subjected to light emitted from the light sources 110 also held by the support structure 120. Furthermore, the edge surfaces of the set of adjacently arranged edge surfaces 520 are shown attached together in Fig. 5A allowing said set of adjacently arranged edge surfaces 520 to remain aligned during flexion or bent of the light guide device 500. In addition, the attachment generates a uniform and improved light-receiving surface formed by the set of adjacently arranged edge surfaces 520 into which the light sources 110 emit light. Such attachment may preferably be achieved by the usage of glue and/or clamps and/or by at least partially melting the edge surfaces of the set of adjacently arranged edge surfaces 520 together. The support structure 120 and the light sources 110 may be characterized according to the exemplification described in Fig.1A-1B. Furthermore, Fig. 5A shows an unsupported second set of edge surfaces 540 of the plurality of sheet elements 530 which are free to move independently form one another. Fig. 5B illustrates a plurality of sheet elements being bent or flexed upon a substantially similar center of curvature but it may be envisaged that each sheet element 530 may be bent or flexed upon its own center of curvature and in any possible direction as the second set of edge surfaces 540 are unsupported. Another exemplification may also be that at least one edge surface of the set of second edge surfaces 540 may comprise a plurality of curvatures. The plurality of possible curvatures and bending direction maybe taken by the sheet elements 530 may allow the light guide device 500 to reach a desired decorative shapes according certain lighting applications.

Fig. 5B illustrates a side view of a light guide device 510 according to the exemplification described in Fig. 5A at the exception that the second set of edge surfaces 541 which is held by the support structure 121 therefore preventing any independent movement

of the sheet elements of the plurality of sheet 531. Furthermore, the light guide device 510 shown in Fig. 5B describes an alternative exemplification of the light guide devices presented in any of the above mentioned Figures in which the support structure 121 holding the second set of edge surfaces 541 and the light sources 111 emitting light into the plurality of sheet elements 531 via the light-receiving surface formed by the set of adjacently arranged second edge surfaces 541 may be of a different size. Such difference in size may be anticipated in order to adjust the light intensity distribution of the light guide device 510.

Fig. 6 schematically illustrate a side view of a light guide device 600 submitted to a bending movement or flexion and comprising light sources 110, 111 and support structures 120, 121 characterized according to the exemplification described in Fig. 5B. Moreover, Fig. 6 schematically illustrates a plurality of sheet elements 631, 632 and 633 for which the set of adjacently arranged first edge surfaces 640 and set of adjacently arranged second edge surfaces 650 are held by the support structures 120 and 121 respectively. In this configuration, the sets of first and second edge surfaces 640, 650 are aligned. Moreover, the sheet elements 631, 632 and 633 comprise different curvatures generating distances De1, De2 between each of the ends of the superimposed sheet elements 631, 632 and 633 as well as distances Dm1, Dm2 between the middle portions of the superimposed sheet elements 631, 632, 633. The distance Dm1 between the middle portion of the superimposed sheet elements 631, 632 may be greater than the distances De1 between the ends of the superimposed sheet elements 631, 632 and the distance Dm2 between the middle portion of the superimposed sheet elements 632, 633 may be greater than the distances De2 between the ends of the superimposed sheet elements 632, 633. The separation generated by the aforementioned distances De1, De2, Dm1, Dm2 allows for the light guide device 600 to obtain a different decorative light effect.

Fig. 7 schematically illustrates a side view of a light guide device 700 submitted to a bending movement or flexion comprising support structures 710 which in turn comprise a plurality of steps 720 for which the end surface 721 abuts the light receiving surface formed by the sets of adjacently arranged first edge surfaces and second edge surfaces. The plurality of steps 720 of the light guide device 700 each comprise a height (e.g. 740) projecting in the direction of the length of the sheet elements 730 allowing the light emitted by the light sources 110 to be transmitted to the light-receiving surfaces formed by the first edge surfaces and second edge surfaces of each sheet element 730 via the support structure 710 in an improved manner. The light guide device 700 may further allow the sheet element 730 to be bent or flexed to another curvature (i.e.: greater or smaller radius of

curvature) by increasing or decreasing the height (e.g. 740) of each steps 720 such that an efficient abutment of the end surface 721 of the steps 720 with the light-receiving surface formed by the sets of adjacently arranged first edge surfaces and second edge surfaces may be conserved.

Fig.8 schematically shows a side view of a light guide device 800 comprising a plurality of sheet elements 810, 820, 830 having different lengths, wherein the length of the sheet element 810 is longer that the length of sheet element 820, which in turn is longer than the length of sheet element 830. The light guide device 800 further comprises support structures 120 and light sources 110 characterized according to the exemplification described in Fig. 1A and Fig. 1B. The inferior sheet element 830 has the shortest length followed by center sheet element 820 and the superior sheet element 830 respectively such that when the light guide device 800 is submitted to a bending movement or flexion around the center of curvature c the set of first edge surfaces 840 and the set of second edge surfaces 850 form a flat light-receiving surface 860, 870 at least substantially parallel to the surface of the support structures 120 via which the light emitted by the light sources 110 is transmitted.

Fig. 9 schematically illustrates a side view of a light guide device 900 comprising a single support structure 920. The single support structure 920 in turn comprises two steps 921, 922 located at both ends of the width of the single support structure 920.The light guide device 900 further comprises two sheet elements 931, 932 of similar length and which are bended or flexed at three instances along their length around three different centers of curvature c1, c2, c3. In an alternative exemplification, the light device 900 may comprise more than two sheet elements. Furthermore, the plurality of bents or flexions allow the first edge surfaces and the second edge surfaces of the sheet elements 931, 932 to be held by the same support structure 920. Fig. 9 further shows the first edge surface and second edge surface of the outer sheet element 931 abutted by the steps 921, 922 of the single support structure 920 and the first edge surface and second edge surface of the inner sheet element 931 being held between the steps 921, 922 of the single support structure 920. The plurality of bents or flexions of the sheet elements 931, 932 shown in the exemplification of Fig. 9 further allows for the first edge surfaces and second edge surfaces of said sheet elements 931, 932 to form a light-receiving surface substantially parallel to the surface of the single support structure 920 via which the light emitted from the light source 910 is transmitted into the sheet elements 931, 932.

The person skilled in the art realizes that the present invention by no means is limited to the preferred embodiments described above. On the contrary, many modifications

and variations are possible within the scope of the appended claims. For example, one or more of the sheet elements, light outcoupling elements, etc., may have different shapes, dimensions and/or sizes than those depicted/described.

CLAIMS:

1. A light guide device (100), comprising:

a plurality of sheet elements (130) configured to guide light, wherein each sheet element (130) has a first surface and a second surface oppositely arranged from each other, wherein each sheet element (130) further has a first edge surface and a second edge surface oppositely arranged from each other, and wherein the sheet elements (130) are superimposed in the light guide device (100) such that the plurality of sheet elements (130) comprises a set of adjacently arranged first edge surfaces (140) and a set of adjacently arranged second edge surfaces (150),

a support structure (120) arranged to hold at least one of the set of adjacently arranged first edge surfaces (140) and the set of adjacently arranged second edge surfaces (150),

a light source (110) at least partially enclosed by the support structure (120), wherein the light source (110) is configured to emit light into the plurality of sheet elements (130) via at least one of the set of adjacently arranged first edge surfaces (140) and the set of adjacently arranged second edge surfaces (150),

wherein at least one sheet element (130) comprises a light outcoupling element (220) configured to couple light impinged thereupon from the light source (110) out of the plurality of sheet elements (130) via at least one of the first and second surfaces of the at least one sheet element (130), and

wherein each sheet element (130) is flexible to thereby allow the light guide device (100) to be bent into a shape wherein the plurality of sheet elements (130) is curved such that each sheet element (130) has a radius of curvature (r1, r2, r3).

2. The light guide device of claim 1, wherein the support structure is reflective.

3. The light guide device of claim 1 or 2, wherein the light source (210) is displaceably arranged in the support structure.

4. The light guide device of any one of the preceding claims, wherein at least one sheet element of the plurality of sheet elements comprises a transparent polymer material.

5. The light guide device of any one of the preceding claims, wherein at least two sheet elements of the plurality of sheet elements are separated by a spacing element.

6. The light guide device of any one of the preceding claims, wherein at least one sheet element of the plurality of sheet elements (430) has a first thickness at a central portion (440) of the sheet element and a second thickness at an end portion (450) of the sheet element, wherein the first thickness is smaller than the second thickness.

7. The light guide device of any one of the preceding claims, wherein at least one of the first edge surfaces of the set of adjacently arranged first edge surfaces and the second edge surfaces of the set of adjacently arranged second edge surfaces are attached.

8. The light guide device of any one of the preceding claims, wherein a first light outcoupling element (220) of the plurality of light outcoupling elements has a first shape and a second light outcoupling element of the plurality of distribution element has a second shape, wherein the first shape is different from the second shape.

9. The light guide device of any one of the preceding claims, wherein a first sheet element of the plurality of sheet elements (631, 632, 633) has a first curvature and a second sheet element of the plurality of sheet elements has a second curvature, wherein the first curvature is different from the second curvature.

10. The light guide device of any one of the preceding claims, wherein the support structure comprises a plurality of steps (720) configured to abut at least one of the first edge surfaces and the second edge surfaces, wherein the plurality of steps projects in the direction of the longitudinal axis of the plurality of sheet elements (730), wherein a first step of the plurality of steps has a first length (740) in said direction and a second step of the plurality of steps has a second length in said direction, wherein the first length is different from the second length.

11. The light guide device of any one of the preceding claims, wherein a first sheet element of the plurality of sheet elements (810, 820, 830) has a first length and a second sheet element of the plurality of sheet elements has a second length, wherein the first length is different from the second length.

12. The light guide device of any one of the preceding claims, comprising a single support structure (920) arranged to hold the set of adjacently arranged first edge surfaces and the set of adjacently arranged second edge surfaces.

13. A luminaire, comprising

a light guide device according to any one of the preceding claims,

a cover comprising an at least partially light transmissive material, wherein the cover at least partially encloses the light guide device, and

an electrical connection connected to the light guide device for a supply of power to the light source of the light guide device.

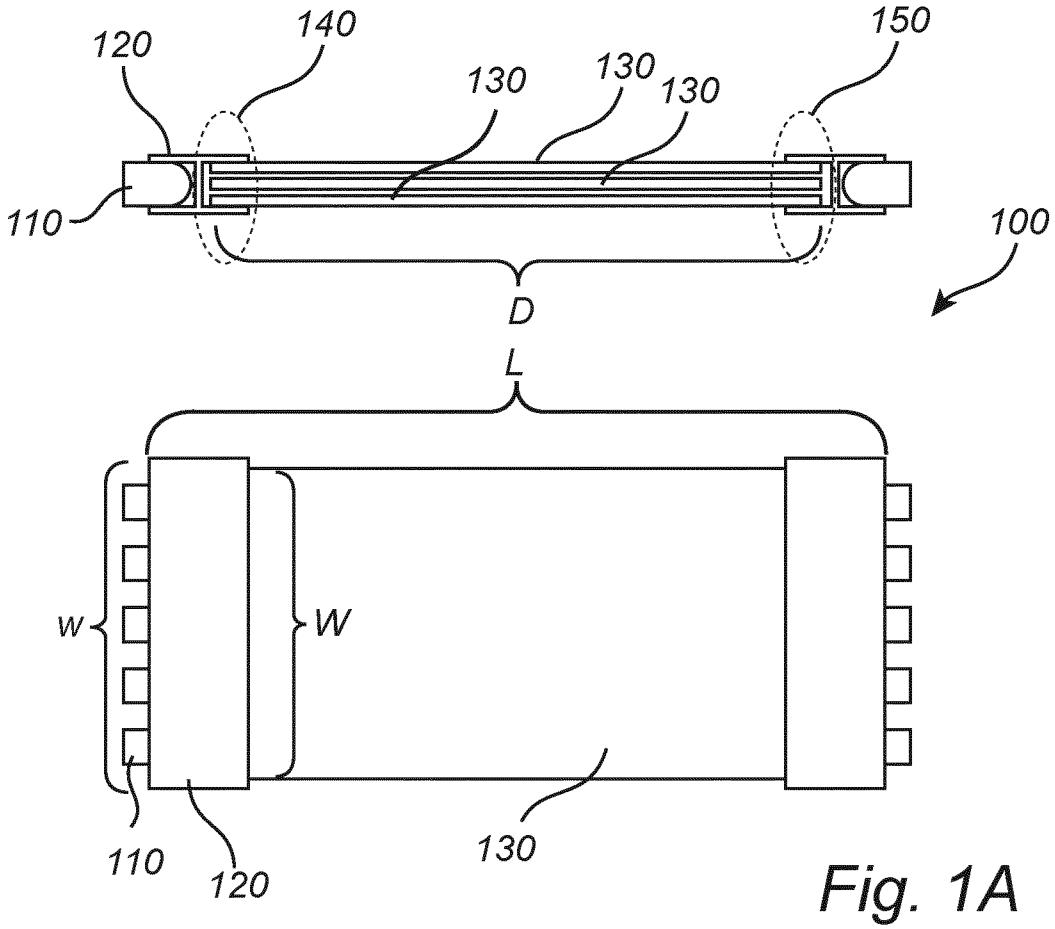

120
140
130
130
130
150
110
100
D
L
w
W
110
120
130

Fig. 1A

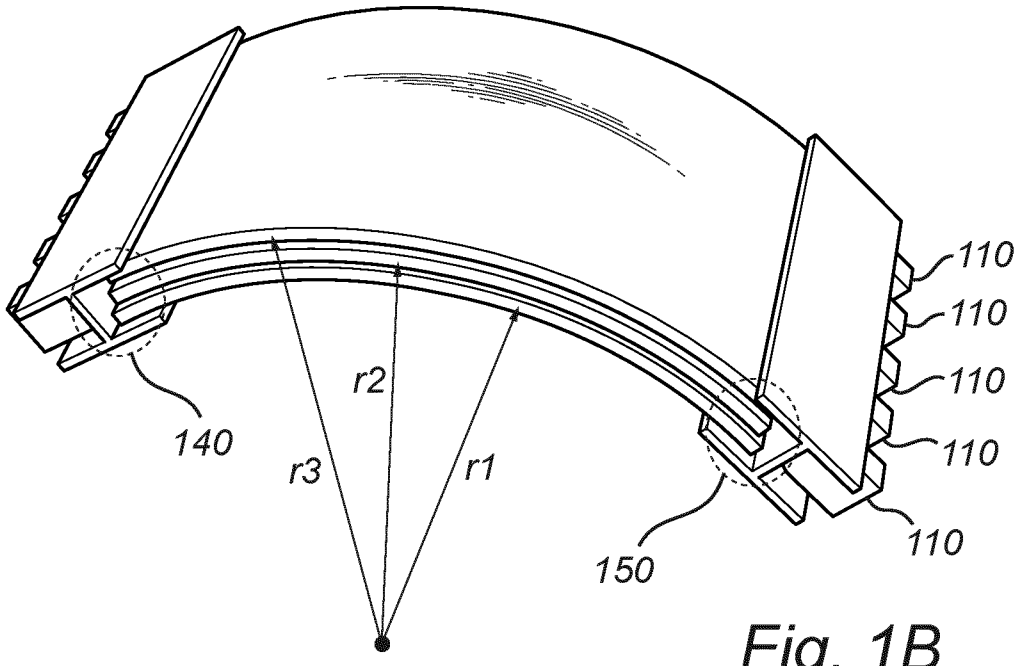

110
110
110
110
110
140
r2
r3
r1
150

Fig. 1B

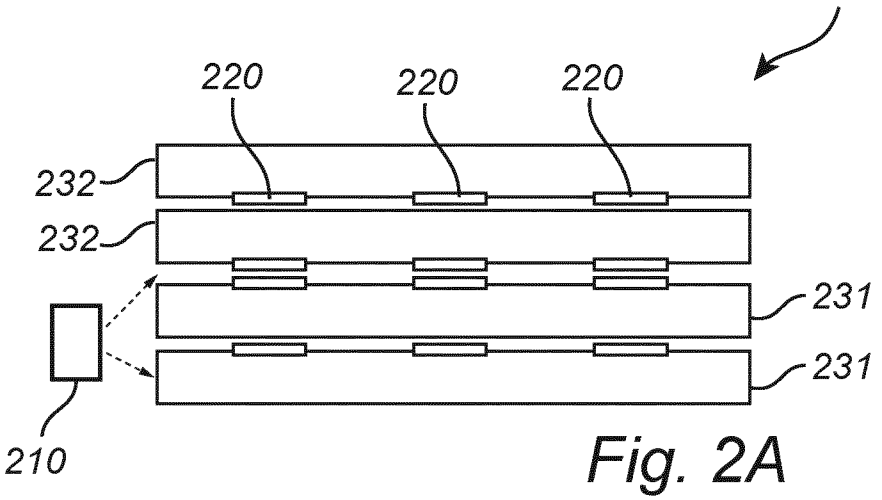


Fig. 2A

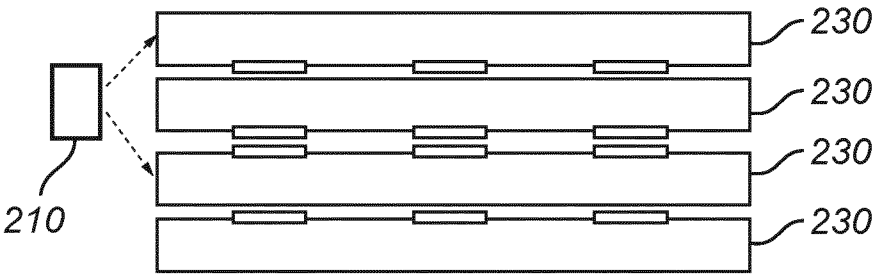


Fig. 2B

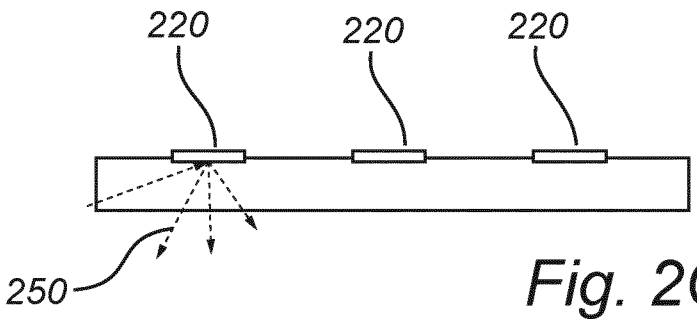


Fig. 2C

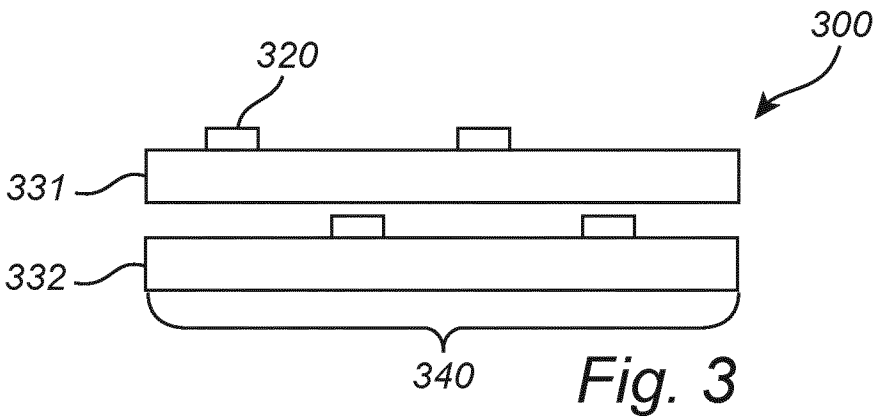


Fig. 3

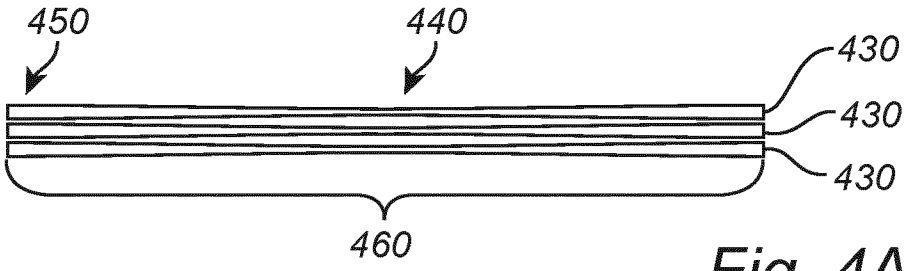


Fig. 4A

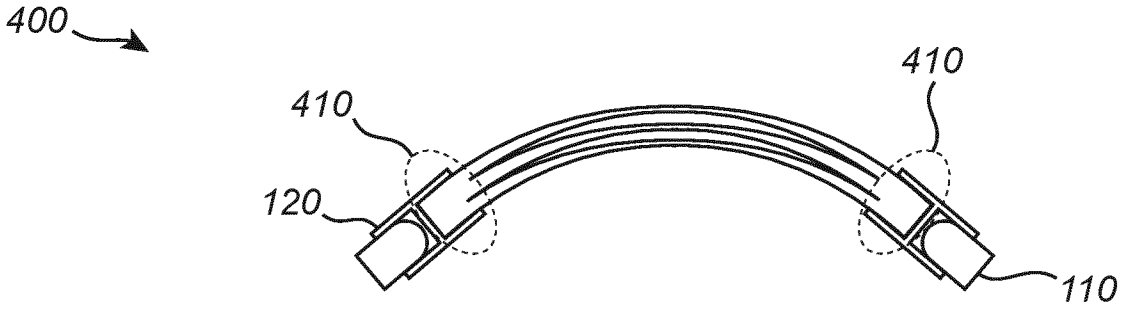


Fig. 4B

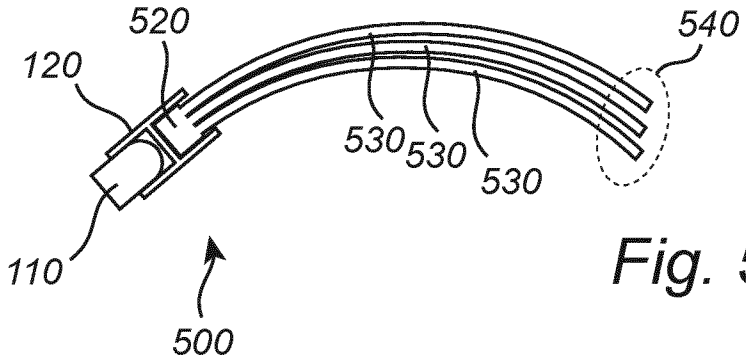


Fig. 5A

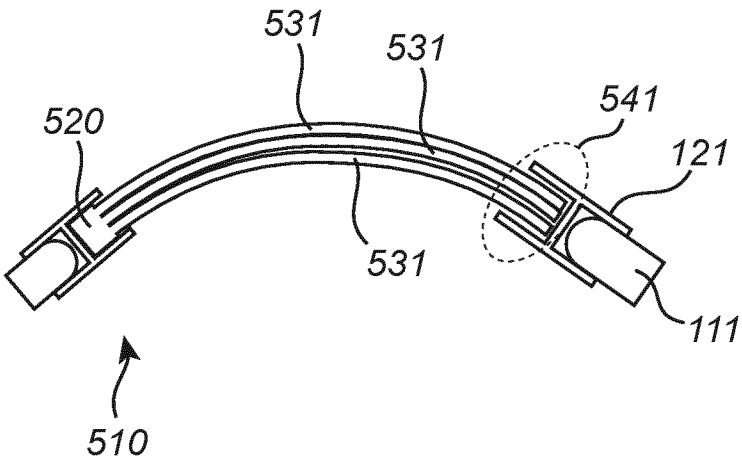


Fig. 5B

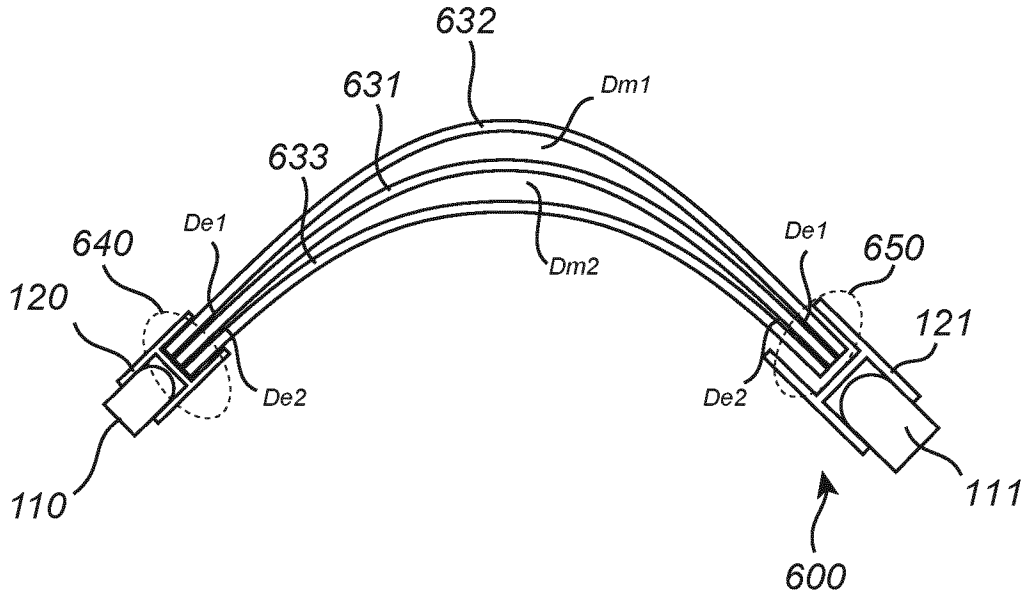

632
631
Dm1
633
De1
640
Dm2
De1
650
120
121
De2
De2
110
111
600

Fig. 6

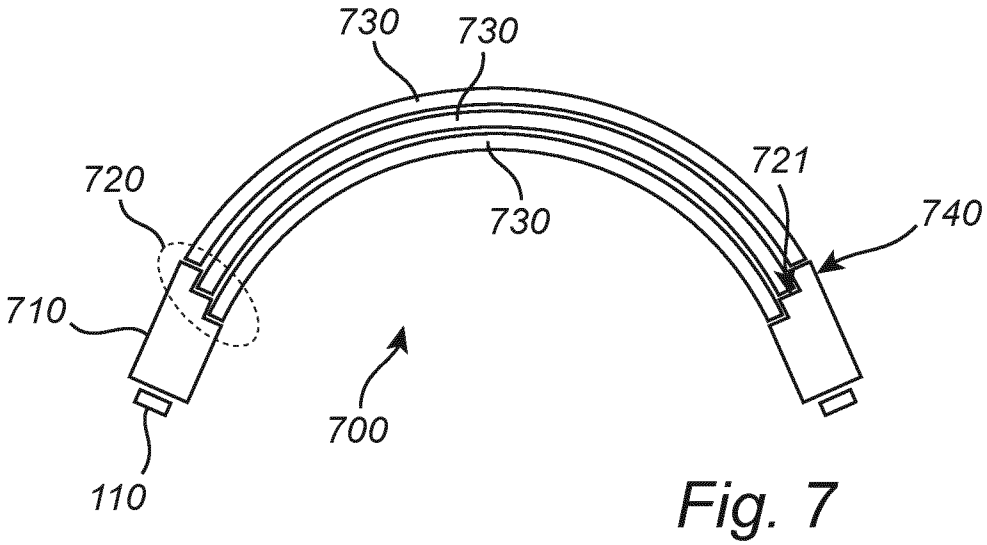
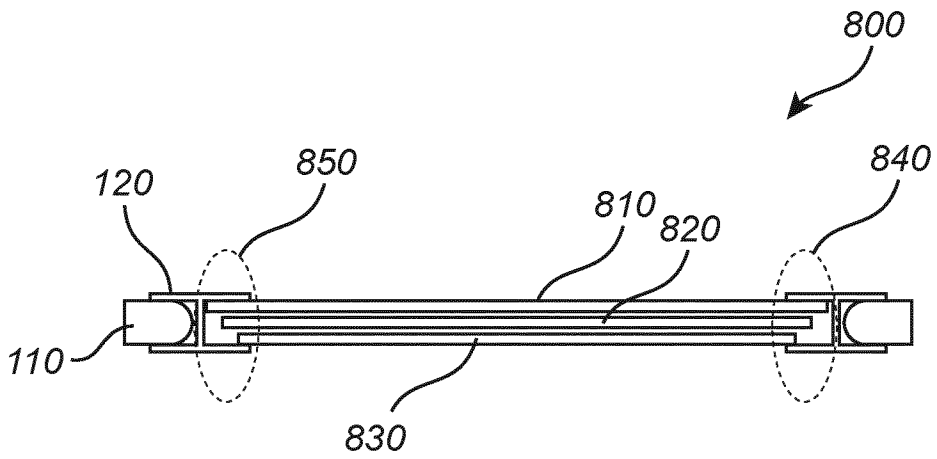
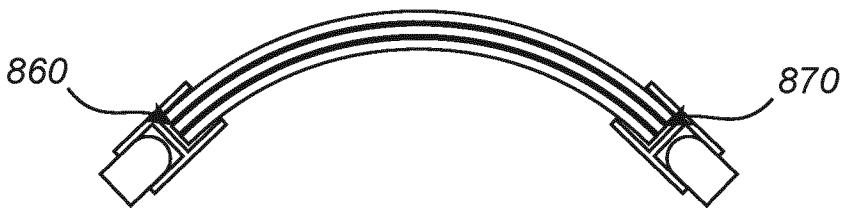

730
730
720
721
730
740
710
700
110

Fig. 7



c



c

Fig. 8

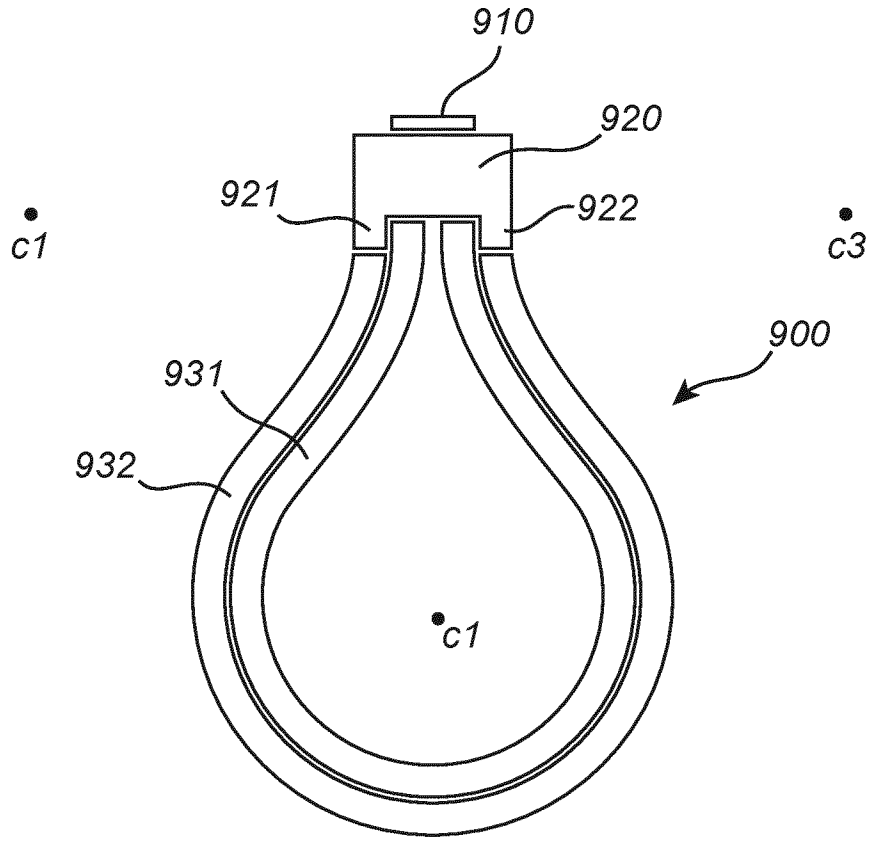


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/059046

A. CLASSIFICATION OF SUBJECT MATTER
INV. F21V8/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02B F21V

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/035945 A1 (LU TAI-WAN [TW]) 15 February 2007 (2007-02-15) figures 1-4 paragraph [0019] -----	1,2,5,7, 13
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X	US 6 308 444 B1 (KI KIL WOONG [KR]) 30 October 2001 (2001-10-30) figures 8,9 col. 11, l. 49-54 -----	1,4,7-12
X	US 2008/285274 A1 (JUNG HAE-RYONG JUNG [US]) 20 November 2008 (2008-11-20) figures 1,2 -----	1,5,7,8, 13
	-/--	

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

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 May 2020	04/06/2020

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

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/059046

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	CN 208 074 647 U (DONGGUAN LIANYANG ELECTRONIC TECH CO LTD) 9 November 2018 (2018-11-09) figures 1,2 -----	1,7

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/EP2020/059046

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