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(72) Inventors:
• **Gottsmann, Dominic**
3370 Waasen (AT)
• **Jung, Mongkwon**
10073 Kimpo-si (KR)

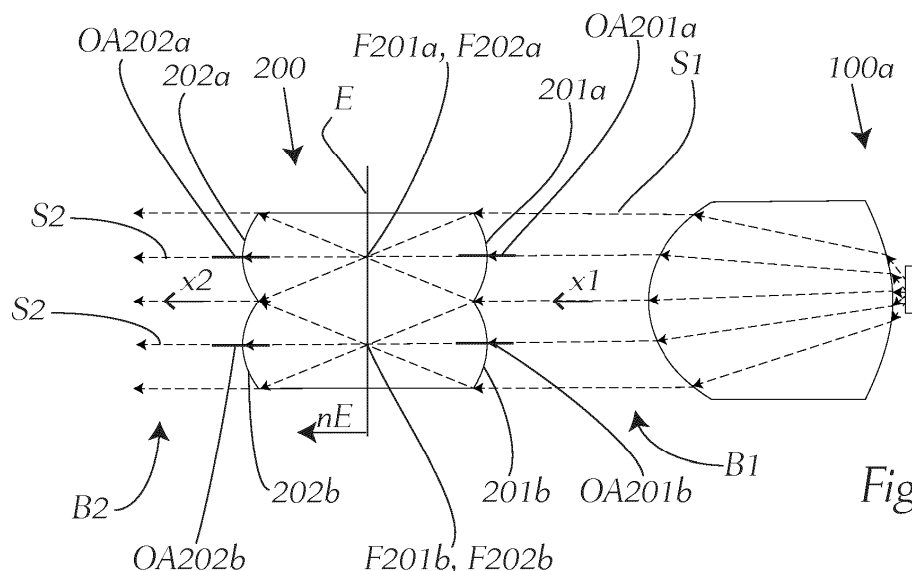
(74) Representative: **Patentanwaltskanzlei Matschnig & Forsthuber OG**
Biberstraße 22
Postfach 36
1010 Wien (AT)

(71) Applicant: **ZKW Group GmbH**
3250 Wieselburg (AT)

(54) LIGHTING DEVICE FOR A VEHICLE

(57) A The invention relates to a lighting device (1) for a vehicle comprising a lighting unit (100a) which emits a light beam (B1) in a first light emission direction (X1), wherein the light rays (S1) of said light beam (B1) are parallel or essentially parallel to the first light emission direction (X1). The lighting unit (100a) is configured to produce for itself alone a light distribution with said light beam (B1) emitted. The lighting device (1) comprises an optical device (200) with first optically effective surfaces (201a, 201b, ..., 201e, ...) and second optically effective surfaces (202a, 202b, ...). The optical axis of said first and second optically effective surfaces which are assigned to each other run parallel to one another, wherein the first optically effective surfaces (201a, 201b, ...) and second

optically effective surfaces (202a, 202b, ...) assigned to each other are arranged relative to one another such that their focal points or focal lines (F202a, F202b) coincide, and wherein the first light emission direction (X1) is parallel to the direction to the optical axes of the first and second optically surfaces, so that the light rays (S1) of the light beam (B1) emitted by the lighting unit (100a) and propagating in the first light emission direction (X1) emerge, after passing through the optical device (200) as a modified light beam (B2) propagating in a second light emission direction (X2), wherein the light rays (S2) of said modified light beam (B2) are parallel or essentially parallel to the second light emission direction (X2).

*Fig. 2b*

Description

[0001] The present invention relates to a Lighting device for a vehicle, in particular a motor vehicle, wherein the lighting device comprises at least one lighting unit which is configured to emit a light beam in a first light emission direction, wherein the light rays of said light beam are parallel or essentially parallel to the first light emission direction

- in cutting planes parallel to a vertical plane containing the first light emission direction, or
- in cutting planes parallel to a horizontal plane containing the first light emission direction, or
- in cutting planes parallel to the vertical plane containing the first light emission direction and in cutting planes parallel to a horizontal plane containing the first light emission direction, wherein

the at least one lighting unit is configured to produce for itself alone a light distribution with said light beam emitted by it in an area in front of the lighting unit, in particular in a traffic area, e.g. on a road.

[0002] The wording "light rays are parallel to each other in a plane" means that the projections of said light rays in this plane are parallel to each other.

[0003] The invention also relates to a vehicle headlight comprising at least one lighting device.

[0004] Finally, the invention relates to a vehicle, in particular a motor vehicle comprising at least one lighting device or at least one vehicle headlight according.

[0005] Lighting devices for vehicles, in particular motor vehicles, for producing a light distribution in front of the vehicle, for example on a road in front of the vehicle, have been sufficiently known from the state of the art for many years. In most cases, these light distributions are so-called main beam distributions, for example, low beam distributions, high beam distributions, and so on.

[0006] The present invention relates to lighting devices for vehicles which have one or more light units, whereby these light units jointly produce a desired light distribution. Each light unit emits a light beam of parallel or essentially parallel light rays, said light beam of parallel or essentially parallel light rays produces or contributes (in the case of two or more light units) to the light distribution. In the case of a lighting device with two or more light units, the emitted light beams of parallel or essentially parallel light beams are preferably parallel to each other, i.e. the propagation directions of the light beams are preferably parallel to each other.

[0007] It is clear to the person skilled in the art that such a light unit not only generates parallel or essentially parallel light rays, but that a light unit also emits light rays to a certain extent that are not parallel to the light beam of parallel or essentially parallel light rays. However, the invention relates to lighting devices with lighting units in which the light beam of parallel or essentially parallel light rays forms the light distribution; in other words, the light-

ing unit(s) project(s) the light distribution to infinity.

[0008] The one or more lighting units are arranged in a headlamp housing, for example, whereby such headlamp housings are often sealed with a transparent cover disc. This usually allows a view of the at least one lighting unit from outside the headlamp housing or from outside the vehicle.

[0009] For design reasons, however, it is often undesirable for the lighting unit(s) to be visible from the outside.

[0010] It is an object of the invention to prevent the lighting unit(s) from being seen when looking at or into the lighting device from the outside.

[0011] This object is solved with a lighting device mentioned at the beginning, wherein according to the invention an optical device is provided after the at least one lighting unit seen in the direction of light propagation, wherein the optical device comprises

- a number of first optically effective surfaces, wherein each first optically effective surface has a first optical axis, wherein light rays of the light bundle coming from the at least one lighting unit are focused by each first optically effective surface into a focus point or a focal line of the respective first optically effective surface, and
- a number of second optically effective surfaces, each second optically effective surface having an optical axis and a respective focal point or focal line, wherein each second optically effective surfaces is configured to form light rays, which emanate from their respective focal point or their respective focal line, into a bundle of parallel or essentially parallel light rays,

wherein each first optically effective surface is assigned in a one-to-one manner to precisely one second optically effective surface,

and wherein the first optically effective surfaces and second optically effective surfaces assigned to each other are arranged relative to one another such that their focal points or focal lines coincide and wherein each focal point or focal line is arranged between its first optically effective surface and its second optically effective surface,

and wherein the optical axes of first optically effective surfaces and second optically effective surfaces assigned to each other run parallel to one another,

and wherein all optical axes of the first and second optically surfaces are parallel to each other,

and wherein the first light emission direction is parallel to the direction to the optical axes of the first and second optically surfaces,

so that the light rays of the light beam emitted by the at least one lighting unit and propagating in the first light emission direction emerge, after passing through the associated first optically effective surfaces and the second, optically effective surfaces as a modified light beam propagating in a second light emission direction, wherein the light rays of said modified light beam are parallel or essentially parallel to the second light emission direction,

- in cutting planes parallel to a vertical plane containing the second light emission direction, or
- in cutting planes parallel to a horizontal plane containing the second light emission direction, or
- in cutting planes parallel to the vertical plane containing the second light emission direction and in cutting planes parallel to a horizontal plane containing the second light emission direction, wherein

wherein the second light emission direction is identical to the first light emission direction.

[0012] In particular, if the light rays of the light beam emitted by the at least one lighting unit are parallel or essentially parallel to the first light emission direction in cutting planes parallel to a vertical plane containing the first light emission direction, the light rays of the modified light beam are parallel or essentially parallel to the second light emission direction in cutting planes parallel to a vertical plane containing the second light emission direction.

[0013] In particular, if the light rays of the light beam emitted by the at least one lighting unit are parallel or essentially parallel to the first light emission direction in cutting planes parallel to a horizontal plane containing the first light emission direction, the light rays of the modified light beam are parallel or essentially parallel to the second light emission direction in cutting planes parallel to a horizontal plane containing the second light emission direction.

[0014] In particular, if the light rays of the light beam emitted by the at least one lighting unit are parallel or essentially parallel to the first light emission direction in cutting planes parallel to a vertical plane containing the first light emission direction and in cutting planes parallel to a horizontal plane containing the first light emission direction, the light rays of the modified light beam are parallel or essentially parallel to the second light emission direction in cutting planes parallel to the vertical plane containing the second light emission direction and in cutting planes parallel to a horizontal plane containing the second light emission direction.

[0015] This has the effect that the light distribution produced by the modified light beam is identical or essentially identical to the light distribution produced by the at least one light unit for itself alone.

[0016] The optical device does not change the direction of propagation of the parallel or essentially parallel light rays emitted by the at least one lighting unit, so that the light distribution is not or only slightly changed.

[0017] The lighting unit(s) do not emit light rays that are not essentially parallel to the first emission direction, thus the light distribution is not or only slightly influenced by the optical device. However, when viewed at daylight from outside, ambient light, which is illuminating the light module from outside enters and exits the module in various different directions. This light, which exits the module and can be viewed from outside, is generally not parallel to the first emission direction and is thus diffused or smeared out by the optical device. Thus, the light module cannot be viewed from an external observer from a direction different to the main emission direction.

[0018] The modifications of the lighting device according to the invention therefore do not or only insignificantly change the generated light distribution, so that identical light distributions or light distributions that are essentially identical with respect to a light distribution, that is generated by the at least one lighting unit alone (i.e., without an optical device according to the invention), are generated.

[0019] A light distribution is defined by its shape, for example the position of a cut-off line, and/or by illuminance values that are to be fulfilled at certain measuring points. These illuminance values are usually specified by standards or laws.

[0020] Light distributions are considered identical or essentially identical, for example, if either all illuminance values are identical at all relevant measuring points or only deviate within certain specified limit values, whereby the deviations must be within the deviations permitted by law or standard.

[0021] Advantageous embodiments of the invention are described in the dependent claims.

[0022] It may be provided that the optical axes of first optically effective surfaces and second optically effective surfaces assigned to each other coincide.

[0023] It may be provided that each first optically effective surface and its associated second optically effective surface define an optically transparent optical body.

[0024] Accordingly, it may be provided that, as will be described later, a first optically effective surface and a second optically effective surface assigned to each other form a (small), optically transparent body, e.g. in the form of a micro lens or on the form of a cylindrical lens. The first optically effective surface forms a light inlet surface of this body, the second optically effective surface forms the light outlet surface of this optical body. Each individual optical body is made of an optically transparent material, preferably all optical bodies are made of the same material. The focal points or focal lines are thus located within the respective optically transparent optical body. The micro lenses have no beam diaphragm or similar between their first optically effective surface and their second optically effective surface.

[0025] Further, it may be provided that the optical bodies are directly adjacent to one another, wherein, for example,

- the individual optical bodies are extending transversely, in particular horizontally, and are arranged one above the other, or
- the individual optical bodies are arranged in an $m \times n$ array of columns and rows, where $m \geq 2$ and $n \geq 2$.

[0026] It may be provided that the first optically effective surfaces are directly adjacent to one another and form a continuous light-inlet surface, and wherein the second optically effective surfaces are directly adjacent to one another and form a continuous light-emitting surface.

[0027] Preferably, it is provided that the optical bodies are connected to one another in one piece and form the optical device.

[0028] It may be provided that the first optically effective surfaces and/or the second optically effective surfaces are curved, in particular convexly curved.

[0029] For example, the first and/or second, preferably the first and second optically effective surfaces are curved both vertically and horizontally. In this case, first and second optically effective surfaces assigned to each other each form a so-called microlens and the optical device is a microlens array. A projection of the optically effective surfaces in a plane normal to the optical axis of the respective optically effective surface forms, for example, a square or a rectangle or a polygon. Associated first and second optically effective surfaces preferably have an identical shape of projection and identical size and preferably coincide identically when projected into the same plane.

[0030] In the case where the first and second optically effective surfaces form micro lenses, a focal point (one focal point for each optically effective first/Second surface, both focal points coincide) is located within the optical body bounded by two optically effective surfaces, as already described in detail. In this case, the deflection occurs at both optically effective surfaces in both horizontal and vertical directions, whereby the direction of the light rays after passing through the optical device is unchanged from the direction before the optical device.

[0031] It may be provided that the focal points or focal lines of the first optically effective surfaces and the second optically effective surfaces lie in a common plane, wherein preferably a normal vector to the common plane is parallel to the first light emission direction of the light beam emitted from the at least one lighting unit.

[0032] These features ensure that first light emission direction and the second light emission directions are parallel to each other.

[0033] Furthermore, it may be provided that the focal lines run horizontally and transversely to the first light emission direction of the light beam emitted by the at least

one lighting unit, in particular perpendicular to said first light emission direction.

[0034] In this case of cylindrical lenses formed by first and second optically effective surfaces the first and/or second, preferably the first and second optically effective surfaces are curved in vertical direction, so that the light rays propagating parallel or essentially parallel to the first light emission direction, which is parallel to the optical axis of the two optically effective surfaces, are deflected twice in vertical direction when passing through the optical device in order to propagate in the second light emission direction after the optical device, wherein the second light emission direction is identical to the first light emission direction.

[0035] It may be provided that a cylindrical lens is provided in the beam path after the at least one lighting unit, the cylinder axes of which cylindrical lens runs vertically and in particular perpendicular to the first light emission direction of the light beam emitted by the at least one lighting unit.

[0036] This embodiment can be useful if the optical device is made up of individual transverse cylindrical lenses as described above. The light entry and exit surface of this cylindrical lens ("macro cylindrical lens", in contrast to cylindrical lenses formed by a first and a second optically effective surface, which may also be denoted as "micro cylindrical lens") are curved in a horizontal direction. Accordingly, said "macro" cylindrical lens generates horizontal deflection of the light rays of the light beam emitted by the at least one lighting unit on both its light entry and its light exit surface, so that after passing through the macro cylindrical lens, the light beam propagates in the same direction as the light beam before the macro cylindrical lens, and the light rays of the light beam after the macro cylindrical lens are parallel or essentially parallel to the direction of the light beam.

[0037] Such a macro cylindrical lens can alternatively or in addition be used to parallelize light that is not emitted in parallel from the lighting unit.

[0038] Light rays (entering the lighting device from outside and reflected back to the outside) are not parallel or not essentially parallel to the first emission direction of the light beam and thus are horizontally scattered to make it difficult or impossible to see the lighting unit(s) from outside from the side.

[0039] Preferably, it is provided that the (macro) cylindrical lens is arranged between the at least one lighting unit and the optical device.

[0040] This ensures that both the lighting unit and the macro cylindrical lens cannot be recognized from the outside.

[0041] Another advantage of the macro cylindrical lens may be that it focuses vertical structures, which is why vertical lines are imaged sharply, and horizontal structures (top and bottom edges) are not, so that a (smooth) transition of the bottom and top edges can be realized.

[0042] It may be provided that the lighting unit is configured to generate the lighting unit is configured to gen-

erate at least one of the following light functions and its corresponding light distribution:

- a light function producing a light distribution with a cut-off line, in particular an essentially horizontally cut-off line;
- a low-beam (light distribution);
- a high beam (light distribution) or a light function producing a part of a high beam light distribution;
- a cornering light (light distribution);
- an adaptive driving beam (ADB) (light distribution);
- a part of a driving beam light (a light function producing a part of a driving beam light distribution);
- a daytime running light (light distribution),
- a turn-indicator (light distribution).

[0043] The invention is explained in more detail below with reference to the drawing:

Fig. 1 shows a lighting device according to the state of the art,

Fig. 1a shows a light distribution produced with a lighting device of Figure 1,

Fig. 2 shows a lighting device according to a first embodiment according to the invention,

Fig. 2a shows a detail D2 of Figure 2 in enlarged view,

Fig. 2b shows a vertical section through a lighting unit and the optical device of Figure 2,

Fig. 2c shows a horizontal section through a lighting unit and the optical device of Figure 2,

Fig. 3 shows a lighting device according to a second embodiment according to the invention,

Fig. 3 a shows a detail D3 of Figure 3 in enlarged view,

Fig. 3b shows a vertical section through a lighting unit and the optical device of Figure 3,

Fig. 3c shows a horizontal section through a lighting unit and the optical device of Figure 3,

Fig. 4 shows a sub-variant of the second embodiment shown in Figure 3,

Fig. 4a shows the behavior of light rays passing through a (macro) cylindrical lens before passing through the optical device in a horizontal section through the lighting device, and

Fig. 5 & 6 show, in purely schematic form, the influence of the invention on non-parallel light beams.

[0044] Figure 1 shows a lighting device 1 for a vehicle, in particular a motor vehicle, wherein the lighting device 1 comprises at least one, in the example shown four lighting units 100a, 100b, 100c, 100d. Each lighting unit 100a, 100b, 100c, 100d comprises a light source 101a, 101b, 101c, 101d, wherein each light source for example comprises one or more LEDs. Furthermore, each lighting unit 100a, 100b, 100c, 100d comprises optical means 102a, 102b, 102c, 102d, for example a reflector, an optically transparent body, etc. wherein said optical means 102a, 102b, 102c, 102d of a lighting unit are configured to bring the light emitted by the light source of the respective lighting unit into a desired shape. In the present case each lighting unit is configured to emit a light beam B1 which propagates in a first light emission direction X1. The light rays S1 of said light beam are parallel or essentially parallel to the first light emission direction X1. In other words, the lighting unit(s) project(s) the light distribution to infinity. For the sake of simplicity, in the following, when it is said that light rays are parallel to a direction, this also means that they can be essentially parallel to said direction.

[0045] In the example shown, the four light units each generate a light beam B1 with a first light emission direction X1, wherein all first light emission directions X1 preferably are identical.

[0046] The at least one lighting unit, in the example shown the four lighting units 100a, 100b, 100c, 100d together, are configured to produce for itself alone, this means without further optical means, a light distribution LV (see **Figure 1a**) with the light beam(s) B1 of parallel light rays S1 emitted by it/them in an area in front of the lighting unit 100a, 100b, 100c, 100d, in particular in a traffic area, e.g. on a road.

[0047] For example, a lighting device 1 as shown in **Figure 1** with lighting units 100a - 100d is configured to generate at least one of the following light functions and its corresponding light distribution:

- a light function producing a light distribution with a cut-off line, in particular an essentially horizontally cut-off line;
- a low-beam (light distribution);
- a high beam (light distribution) or a light function producing a part of a high beam light distribution;
- a cornering light (light distribution);
- an adaptive driving beam (ADB) (light distribution);
- a part of a driving beam light (a light function producing a part of a driving beam light distribution);
- a daytime running light (light distribution),
- a turn-indicator (light distribution).

[0048] **Figure 1a**, as an example, shows an ADB light distribution with five ADB segments arranged next to each other, which are generated with the light modules 100a - 100d of the lighting device 1 according to **Figure 1**, whereby the second and fourth segments are switched off.

[0049] Figures 2, 2a, 2b, and 2c show a first embodiment of a lighting device 1 according to the invention.

[0050] Figure 2a shows a detail D2 of Figure 2 in an enlarged view.

[0051] Figures 2b and 2c show a vertical section and a horizontal section respectively (the sections being parallel to the optical axes of the first/second optically effective surfaces) through one of the four lighting units 100a and a corresponding section of an optical device 200. It is emphasized that Figure 2a and Figure 2b are not to scale with respect to Figure 2 (i.e. the section of the optical device 200 is clearly drawn too large), in order to be able to illustrate the relationships more clearly.

[0052] The lighting device 1 of Figure 2 comprises the four lighting units 100a - 100d of Figure 1 (just for the sake of completeness, it should be mentioned once again that the four lighting units are merely a concrete example, but are in no way restrictive; fewer, e.g. only one lighting unit, but also more than four lighting units can be provided), which emit light beams B1 of light rays S1. Now, according to the invention the optical device 200 as already mentioned is provided after the lighting units 100a, 100b, 100c, 100d seen in the direction of light propagation.

[0053] Said optical device 200 comprises a number of first optically effective surfaces 201a, 201b, ..., 201e, ..., wherein each first optically effective surface 201a, 201b, ..., 201e, ... has a first optical axis OA201a, OA201b.

[0054] The light rays S1 of the light bundle B1 coming from the lighting units 100a, 100b, 100c, 100d are focused by each first optically effective surface 201a, 201b, ..., 201e, ... into a focus point F201a, F201b, of the respective first optically effective surface 201a, 201b, ...

[0055] Furthermore, the optical device 200 comprises a number of second optically effective surfaces 202a, 202b, each second optically effective surface 202a, 202b having an optical axis OA202a, OA202b and a respective focal point F202a, F202b, wherein each second optically effective surfaces 202a, 202b is configured to form light rays, which emanate from their respective focal point into a bundle of parallel (or essentially parallel) light rays.

[0056] Each first optically effective surface 201a, 201b is assigned in a one-to-one manner to precisely one second optically effective surface 202a, 202b, and the first optically effective surfaces 201a, 201b and second optically effective surfaces 202a, 202b assigned to each other are arranged relative to one another such that their focal points F202a, F202b coincide. Each focal point F202a, F202b thus is arranged between its first optically effective surface 201a, 201b and its second optically effective surface 202a, 202b.

[0057] The optical axes OA201a, OA201b, ..., OA202a, OA202b, ... of first optically effective surfaces 201a, 201b and second optically effective surfaces 202a, 202b assigned to each other run parallel to one another, and all optical axes of the first and second optically

surfaces are parallel to each other. Furthermore, the optical axes OA201a, OA201b, ..., OA202a, OA202b, ... of first optically effective surfaces 201a, 201b and second optically effective surfaces 202a, 202b assigned to each other coincide. The optical axes OA201a, OA201b, ..., OA202a, OA202b cut the respective focal point F201a, F201b; F202a, F202b, ...

[0058] The at least one lighting unit, in the example shown the four lighting units 100a - 100d is/are arranged such with respect to the optical device 200 that the first light emission direction X1 is parallel to the direction to the optical axes of the first and second optically surfaces.

[0059] Accordingly, the light rays S1 of the light beam B1 emitted by the lighting units 100a, 100b, 100c, 100d and propagating in the first light emission direction X1 emerge, after passing through the associated first optically effective surfaces 201a, 201b, and the second, optically effective surfaces 202a, 202b, ... as a modified light beam B2 in a second light emission direction X2, wherein the light rays S2 of the light beam B2 are parallel to the second light emission direction X2.

[0060] The second light emission direction X2 is identical to the first light emission direction X1, so that the light distribution produced by the modified light beam B2 is identical or essentially identical to the light distribution LV produced by the at least one light unit 101a, 101b, 101c, 101d for itself alone.

[0061] As indicated in Figure 2a, each first optically effective surface 201a, 201b, ... and its associated second optically effective surface 202a, 202b, ... defines an optically transparent optical body 1200a, 1200b, ..., 1200e, ...

[0062] In the case shown, these optically transparent bodies 1200a, 1200b, ... form so-called micro lenses, which are arranged directly adjacent to one another and are preferably integrally connected to one another, thus forming the optical device 200 in the form of a micro lens array.

[0063] The first optically effective surfaces 201a, 201b, ... and the second optically effective surfaces 202a, 202b, ... are curved, in particular convexly curved, in both the vertical and horizontal directions in the embodiment shown, see Figures 2b and 2c.

[0064] Accordingly, the beams are deflected in a qualitatively analogue manner in both the vertical and horizontal directions, as shown in Figure 2b and Figure 2c.

[0065] As further can be seen from Figure 2b and Figure 2c, the focal points F201a, F201b, ... of the first optically effective surfaces 201a, 201b, ... and the focal points F202a, F202b of the second optically effective surfaces 202a, 202b, ... lie in a common plane E, and a normal vector nE to said common plane E is parallel to the first light emission direction X1 of the light beam B1 emitted from the at least one lighting unit 100a, 100b, 100c, 100d.

[0066] Figures 3, 3a, 3b and 3c show a second embodiment of the invention. Basically, this second embodiment is largely identical to the first embodiment shown in

Figure 2, so that only the differences are described here.

[0067] In this embodiment according to **Figure 3**, associated first and second optically effective surfaces 201a, 202a, 201b, 202b delimit transversely lying optical bodies 1200a, 1200b made of an optically transparent material, so-called cylindrical lenses. Again, these bodies 1200a, 1200b are directly adjacent to one another and are formed in one piece to form the optical device 200 with a light entry surface 201 and a light exit surface 202.

[0068] The first and second optically effective surfaces 201a, 202a, 201b, 202b are curved in the vertical direction, in particular convexly curved. Instead of focal points, each first and second optically effective surface 201a, 202a, 201b, 202b has a focal line FL201a, FL201b, FL202a, FL202b, which lies between the first and second optically effective surfaces 201a, 202a, 201b, 202b, whereby the focal lines of associated first and second optically effective surfaces 201a, 202a, 201b, 202b coincide.

[0069] As in the first embodiment shown in **Figure 2**, the focal lines lie in a common plane E with a normal vector nE (**Figure 3b**, **Figure 3c**); the relationships with regard to the direction X1 are analogous to those in the embodiment shown in **Figure 2**.

[0070] Again, the optical axes OA201a, OA202a; OA201b, OA202b are parallel to each other and coincide, and cut the respective focal line FL201a, FL201b; FL202a, FL202b.

[0071] If one looks at **Figure 3b**, which shows a vertical section parallel to the direction X1, one can see that the light beams/light rays behave in the same way as described in **Figures 2b and 2c** and are parallel (in this vertical section) to the direction X1. In vertical sections, the light rays S1 of light beam B1 are thus deflected twice, resulting in a light beam B2 with a light emission direction X2 after the optical device 200, which second light emission direction X2 is parallel to the first light emission direction X1.

[0072] In the horizontal direction, however, as shown in the horizontal section of **Figure 3c**, the light rays S1 of the light beam B1 are not deflected.

[0073] **Figure 4** shows a sub-variant of the second embodiment shown in **Figure 3**. Here, in addition, a cylindrical lens 300, a so-called macro cylindrical lens, is provided between the one or more lighting units 100a - 100d and the optical device 200 in the beam path after the lighting units 100a - 100d. The cylinder axes FL300 of said macro cylindrical lens 300 runs vertically and in particular perpendicular to the first light emission direction X1 of the light beam(s) B1 emitted by the lighting units 100a - 100d.

[0074] **Figure 4a** shows the behavior of light rays passing through a (macro) cylindrical lenses before passing through the optical device in a horizontal section through the lighting device. In the horizontal section shown in **Figure 4a** the light rays emitted by the lighting unit 1 are not parallel to direction X1, but are parallelized by the macro cylindrical lens 300.

[0075] An optical device 200 as described in **Figure 3** can only influence light beams in the vertical direction.

[0076] For example, an asymmetry can generally be realized with a cylindrical lens in such a way that - depending on the orientation of the cylindrical lens - only vertical edges or only horizontal edges are in focus (which corresponds to parallel light beams), in the other direction the light distribution remains defocused/blurred.

[0077] Finally, **Figures 5 and 6** show, in purely schematic form, the influence of the invention on non-parallel light beams. **Figure 5** shows an arrangement in which light beams S1000 emanating from a light source 1000 are parallelized by an optical system 1001 in a direction X1. Light rays S2000, which are not emitted by the light source 1000, for example from an assembly level 1002, such as a carrier plate on which the light source 1000 is arranged, usually strike the optics 1001 in such a way that they are not parallelized by the optical system 1001. For example, ambient light that enters a lighting device is reflected in it and the reflected light can then be detected by an observer 3000. Two such (reflected) light beams S2000 emanating from a point on the plane 1002 in different directions are directed by the optics 1001 into the eye of the observer 3000.

[0078] The optical device 200 - see **Figure 6** - does not affect the direction of parallel light beams, as described in detail above. On the other hand, light rays S2000, which are not parallelized by the optical system 1001, are scattered in this case and, for example, reach the observer 3000 as light rays S2000a, S2000b in the same direction, although they originate from different points on the plane 1002.

[0079] It is therefore no longer possible to look at the plane 1002 through the optical device 200 or at a lighting unit behind the optical device 200.

Claims

1. Lighting device (1) for a vehicle, in particular a motor vehicle, wherein the lighting device (1) comprises at least one lighting unit (100a, 100b, 100c, 100d) which is configured to emit a light beam (B1) in a first light emission direction (X1), wherein the light rays (S1) of said light beam (B1) are parallel or essentially parallel to the first light emission direction (X1)

- in cutting planes parallel to a vertical plane containing the first light emission direction (X1), or
- in cutting planes parallel to a horizontal plane containing the first light emission direction (X1), or
- in cutting planes parallel to the vertical plane containing the first light emission direction (X1) and in cutting planes parallel to a horizontal plane containing the first light emission direction

(X1), wherein

the at least one lighting unit (100a, 100b, 100c, 100d) is configured to produce for itself alone a light distribution with said light beam (B1) emitted by it in an area in front of the lighting unit (100a, 100b, 100c, 100d), in particular in a traffic area, e.g. on a road,

characterized in that

an optical device (200) is provided after the at least one lighting unit (100a, 100b, 100c, 100d) seen in the direction of light propagation, wherein the optical device (200) comprises

- a number of first optically effective surfaces (201a, 201b, ..., 201e, ...), wherein each first optically effective surface (201a, 201b, ..., 201e, ...) has a first optical axis (OA201a, OA201b, ..., OA201e, ...), wherein light rays (S1) of the light bundle (B1) coming from the at least one lighting unit (100a, 100b, 100c, 100d) are focused by each first optically effective surface (201a, 201b, ..., 201e, ...) into a focus point (F201a, F201b, ..., F201e, ...) or a focal line (FL201a, FL201b, ...) of the respective first optically effective surface (201a, 201b, ...), and

- a number of second optically effective surfaces (202a, 202b, ...), each second optically effective surface (202a, 202b, ...) having an optical axis (OA202a, OA202b, ..., OA202e, ...) and a respective focal point or focal line (F202a, F202b, ..., FL202a, FL202b, ...), wherein each second optically effective surfaces (202a, 202b, ...) is configured to form light rays, which emanate from their respective focal point or their respective focal line (F202a, F202b, ..., FL202a, FL202b, ...), into a bundle of parallel or essentially parallel light rays,

wherein each first optically effective surface (201a, 201b, ...) is assigned in a one-to-one manner to precisely one second optically effective surface (202a, 202b, ...),

and wherein the first optically effective surfaces (201a, 201b, ...) and second optically effective surfaces (202a, 202b, ...) assigned to each other are arranged relative to one another such that their focal points or focal lines (F202a, F202b, ..., FL202a, FL202b, ...) coincide and wherein each focal point or focal line (F202a, F202b, ..., FL202a, FL202b, ...) is arranged between its first optically effective surface (201a, 201b, ...) and its second optically effective surface (202a, 202b, ...),

and wherein the optical axes (OA201a, OA201b, ..., OA202a, OA202b, ...) of first opti-

cally effective surfaces (201a, 201b, ...) and second optically effective surfaces (202a, 202b, ...) assigned to each other run parallel to one another,

and wherein all optical axes of the first and second optically surfaces are parallel to each other,

and wherein the first light emission direction (X1) is parallel to the direction to the optical axes of the first and second optically surfaces, so that the light rays (S1) of the light beam (B1) emitted by the at least one lighting unit (100a, 100b, 100c, 100d) and propagating in the first light emission direction (X1) emerge, after passing through the associated first optically effective surfaces (201 a, 201b, ...) and the second, optically effective surfaces (202a, 202b, ...) as a modified light beam (B2) propagating in a second light emission direction (X2), wherein the light rays (S2) of said modified light beam (B2) are parallel or essentially parallel to the second light emission direction (X2)

• in cutting planes parallel to a vertical plane containing the second light emission direction (X2), or

• in cutting planes parallel to a horizontal plane containing the second light emission direction (X2), or

• in cutting planes parallel to the vertical plane containing the second light emission direction (X2) and in cutting planes parallel to a horizontal plane containing the second light emission direction (X2), wherein

the second light emission direction (X2) is identical to the first light emission direction (X1).

2. Lighting device according to claim 1, wherein the optical axes (OA201a, OA201b, ..., OA202a, OA202b, ...) of first optically effective surfaces (201a, 201b, ...) and second optically effective surfaces (202a, 202b, ...) assigned to each other coincide.

3. Lighting device according to anyone of the preceding claims, wherein each first optically effective surface (201a, 201b, ...) and its associated second optically effective surface (202a, 202b, ...) define an optically transparent optical body (1200a, 1200b, ..., 1200e).

4. Lighting device according to anyone of the preceding claims, wherein the optical bodies (1200a, 1200b, ..., 1200e) are directly adjacent to one another, wherein, for example,

• the individual optical bodies are extending transversely, in particular horizontally, and are

arranged one above the other, or

- the individual optical bodies are arranged in an $m \times n$ array of columns and rows, where $m \geq 2$ and $n \geq 2$.

5. Lighting device according to anyone of the preceding claims, wherein the first optically effective surfaces (201a, 201b, ...) are directly adjacent to one another and form a continuous light-inlet surface (201), and wherein the second optically effective surfaces (202a, 202b, ...) are directly adjacent to one another and form a continuous light-emitting surface (202). 5 10
6. Lighting device according to anyone of the claims 3 to 5, wherein the optical bodies (200a', 200b', ...) are connected to one another in one piece and form the optical device (200). 15
7. Lighting device according to one of the preceding claims, wherein the first optically effective surfaces (201a, 201b, ...) and/or the second optically effective surfaces (202a, 202b, ...) are curved, in particular convexly curved. 20
8. Lighting device according to one of the preceding claims, wherein the focal points (F202a, F202b, ...) or focal lines (FL202a, FL202b, ...) of the first optically effective surfaces (201a, 201b, ...) and the second optically effective surfaces (202a, 202b, ...) lie in a common plane (E). 25 30
9. Lighting device according to claim 8, wherein a normal vector (n_E) to the common plane (E) is parallel to the first light emission direction (X_1) of the light beam (B1) emitted from the at least one lighting unit (100a, 100b, 100c, 100d). 35
10. Lighting device according to one of the preceding claims, wherein the focal lines (FL202a, FL202b, ...) run horizontally and transversely to the first light emission direction (X_1) of the light beam (B1) emitted by the at least one lighting unit (100a, 100b, 100c, 100d), in particular perpendicular to said first light emission direction (X_1). 40 45
11. Lighting device according to anyone of the preceding claim, wherein a cylindrical lens (300) is provided in the beam path after the at least one lighting unit (100a, 100b, 100c, 100d), the cylinder axis (FL300) of which cylindrical lens (300) runs vertically and in particular perpendicular to the first light emission direction (X_1) of the light beam (B1) emitted by the at least one lighting unit (100a, 100b, 100c, 100d). 50 55
12. Lighting device according to claim 10, wherein the cylindrical lens (300) is arranged between the at least one lighting unit (100a, 100b, 100c, 100d)

and the optical device (200).

13. Lighting device according to one of the preceding claims, wherein the lighting unit is configured to generate at least one of the following light functions and its corresponding light distribution: 5
 - a light function producing a light distribution with a cut-off line, in particular an essentially horizontally cut-off line;
 - a low-beam (light distribution);
 - a high beam (light distribution) or a light function producing a part of a high beam light distribution;
 - a cornering light (light distribution);
 - an adaptive driving beam (ADB) (light distribution);
 - a part of a driving beam light (a light function producing a part of a driving beam light distribution);
 - a daytime running light (light distribution),
 - a turn-indicator (light distribution).
14. Vehicle headlight comprising at least one lighting device (1) according to anyone of the claims 1 to 13. 25
15. Vehicle, in particular a motor vehicle comprising at least one lighting device (1) according to any one of claims 1 to 13 or at least one vehicle headlight according to claim 14. 30

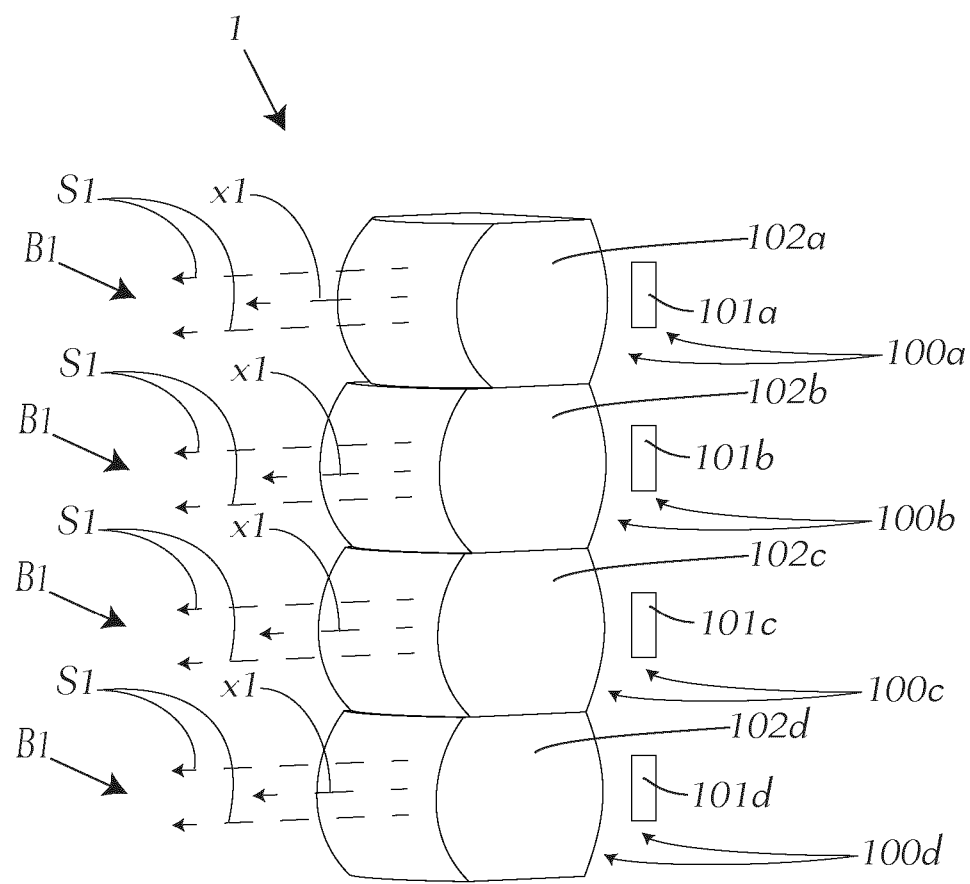


Fig.1 (state of the art)

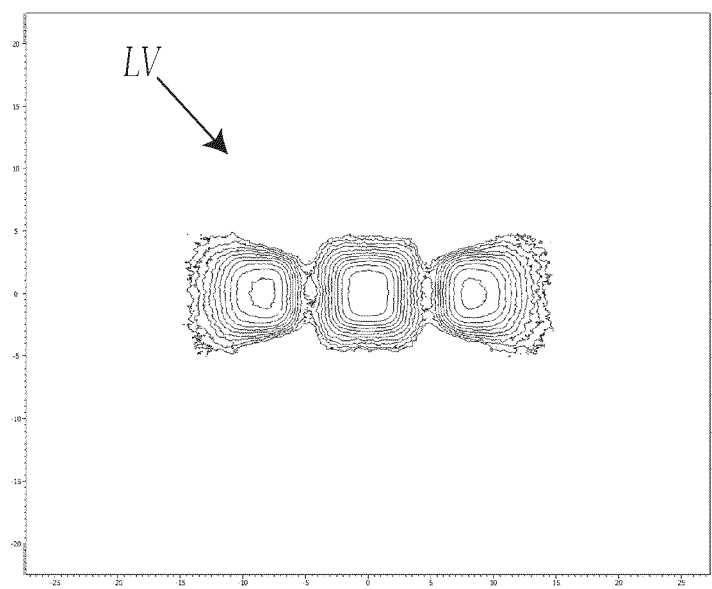
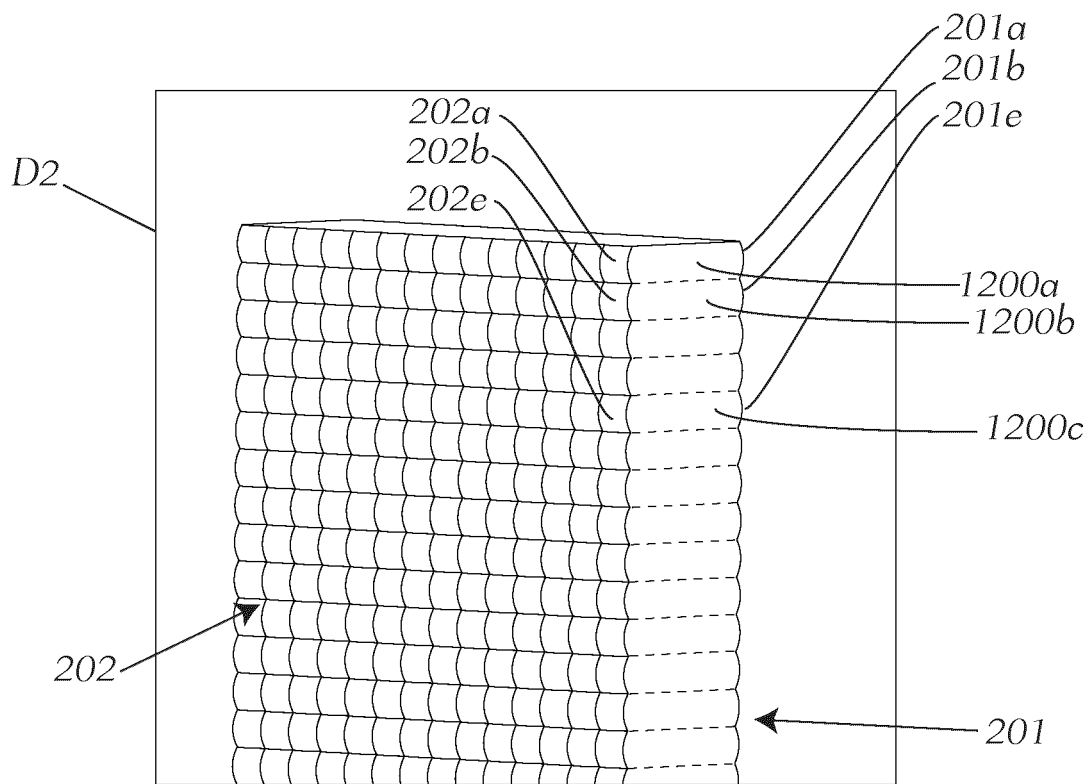
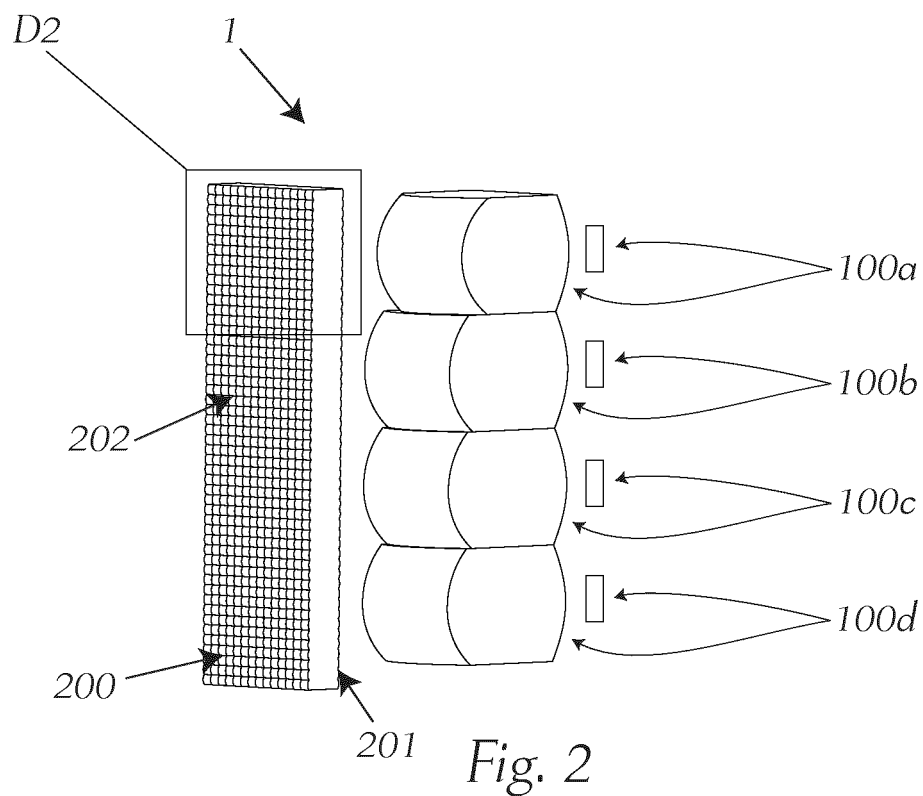
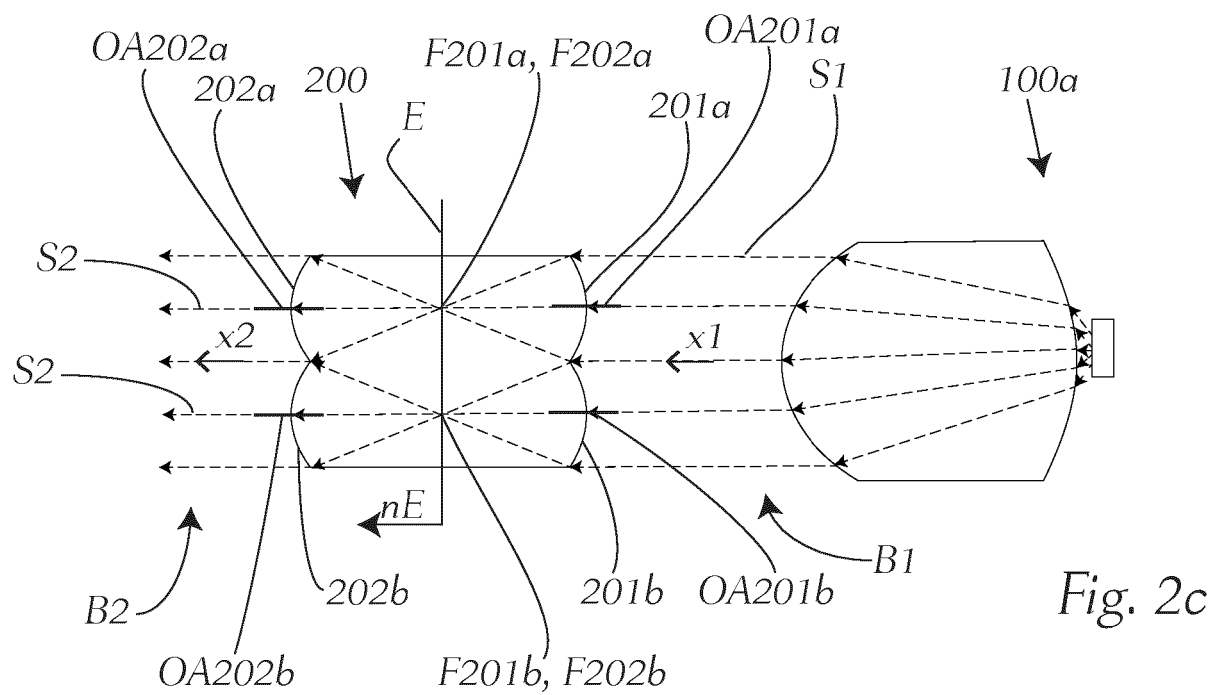
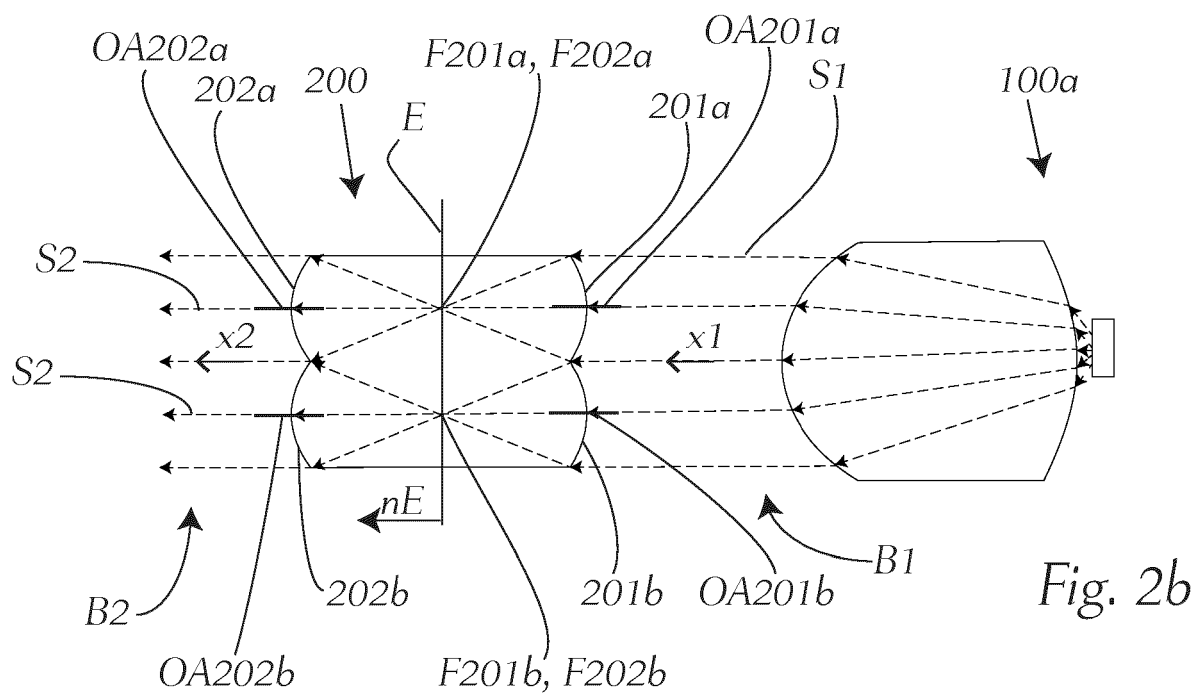


Fig.1a





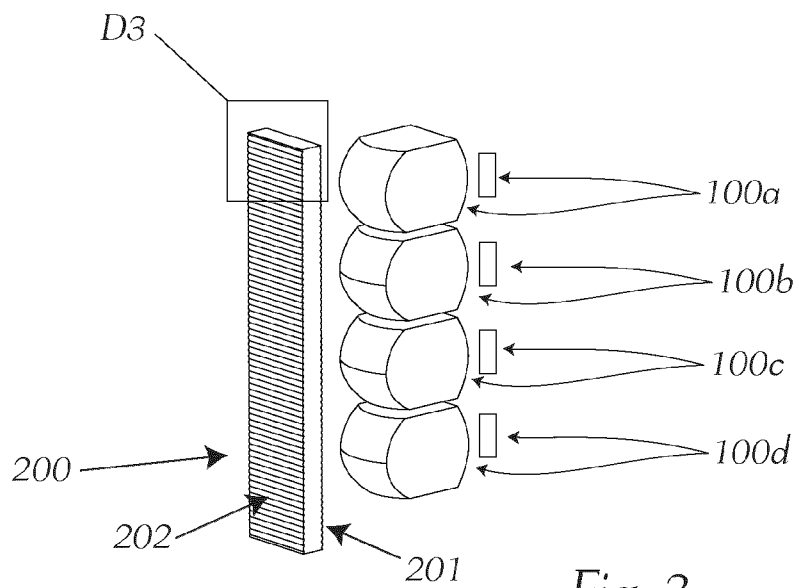


Fig. 3

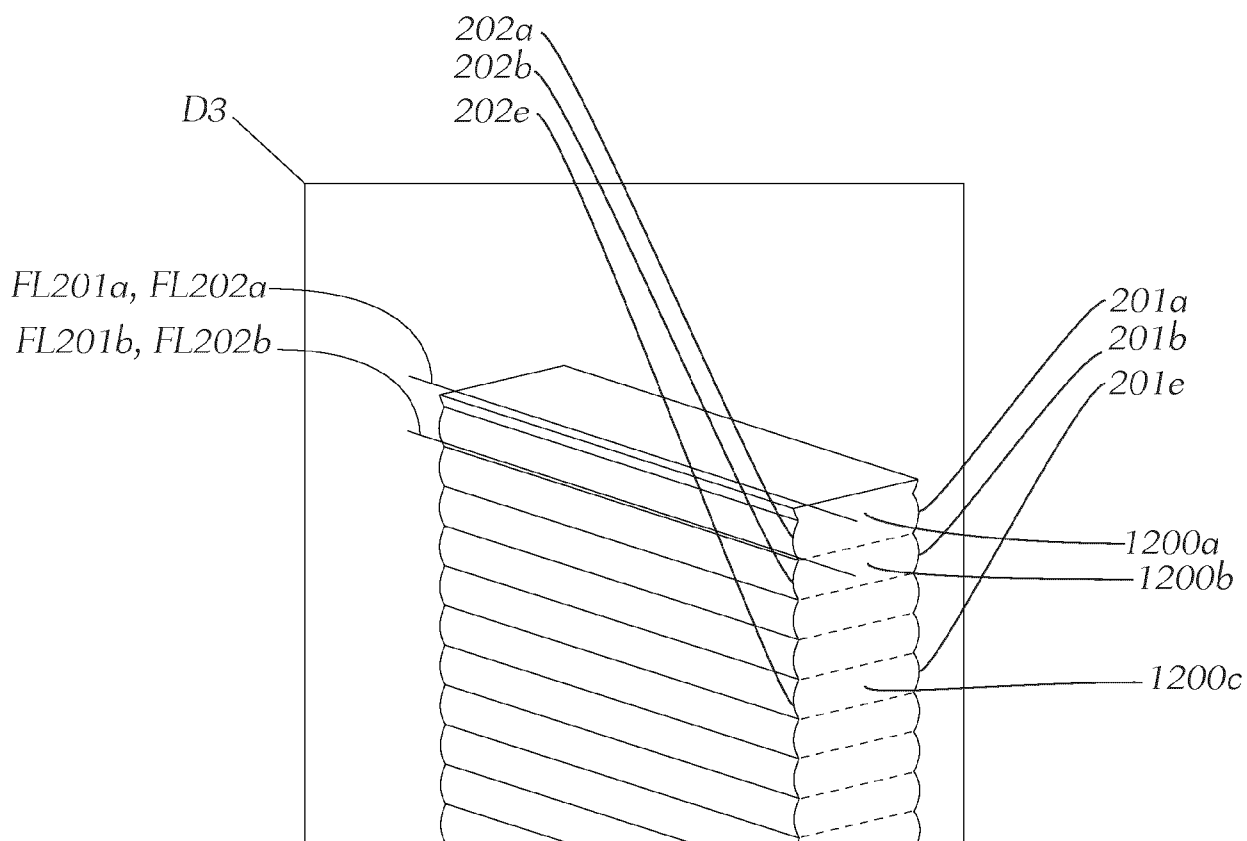
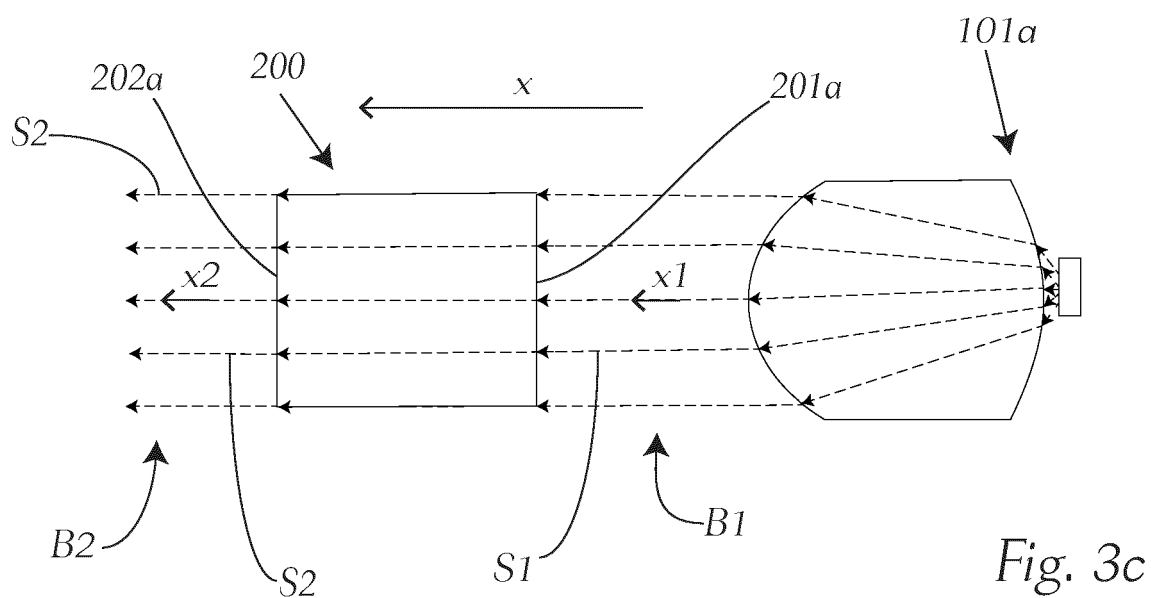
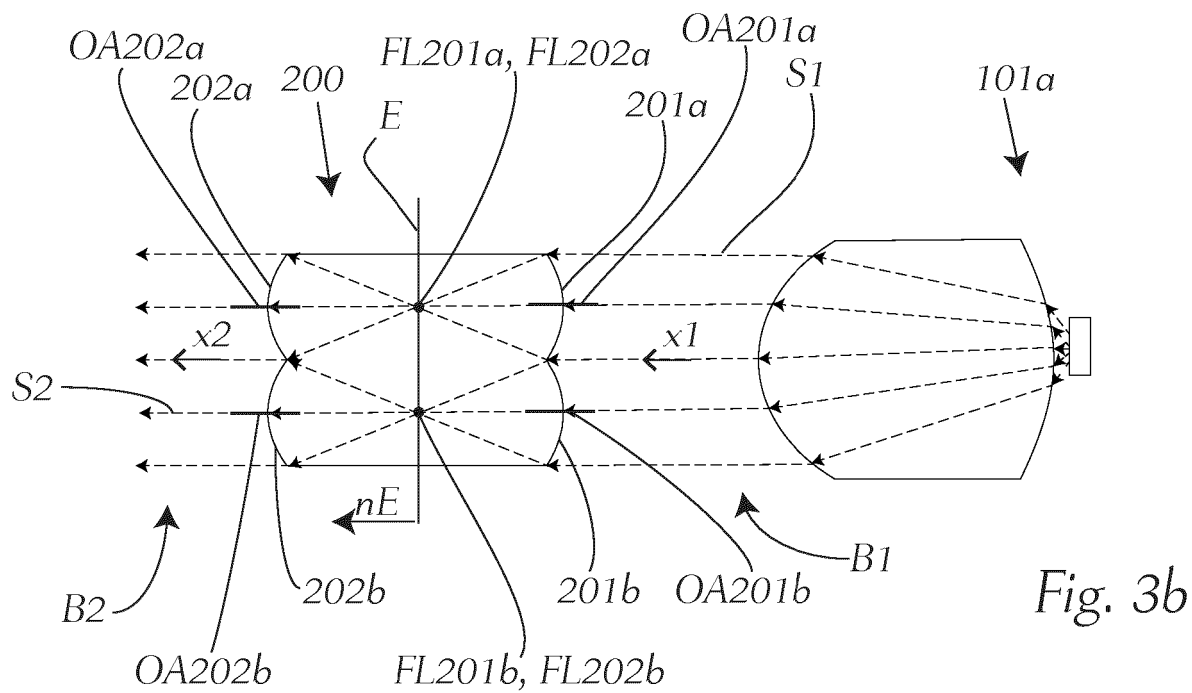


Fig. 3a



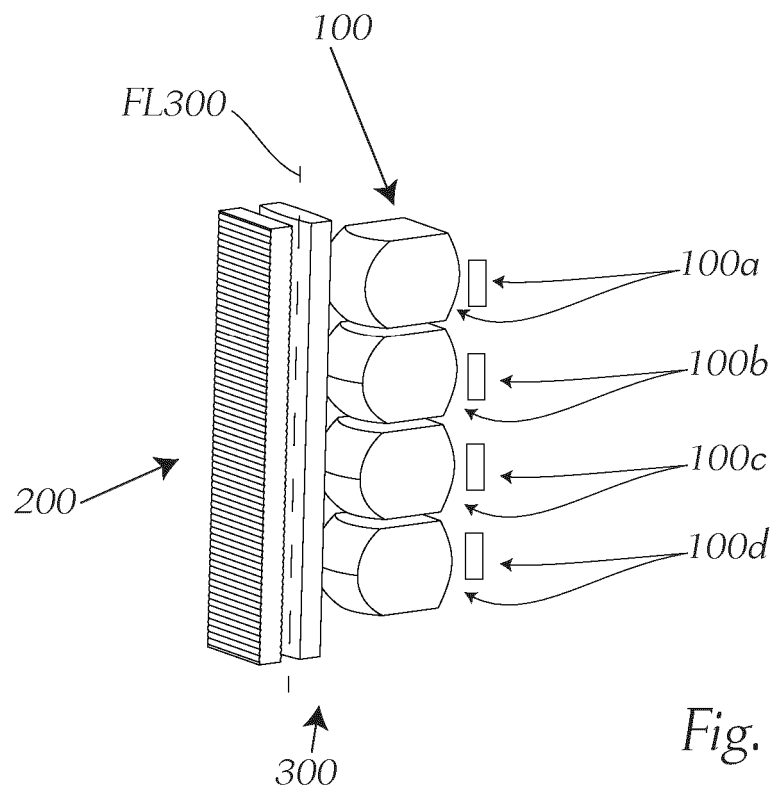


Fig. 4

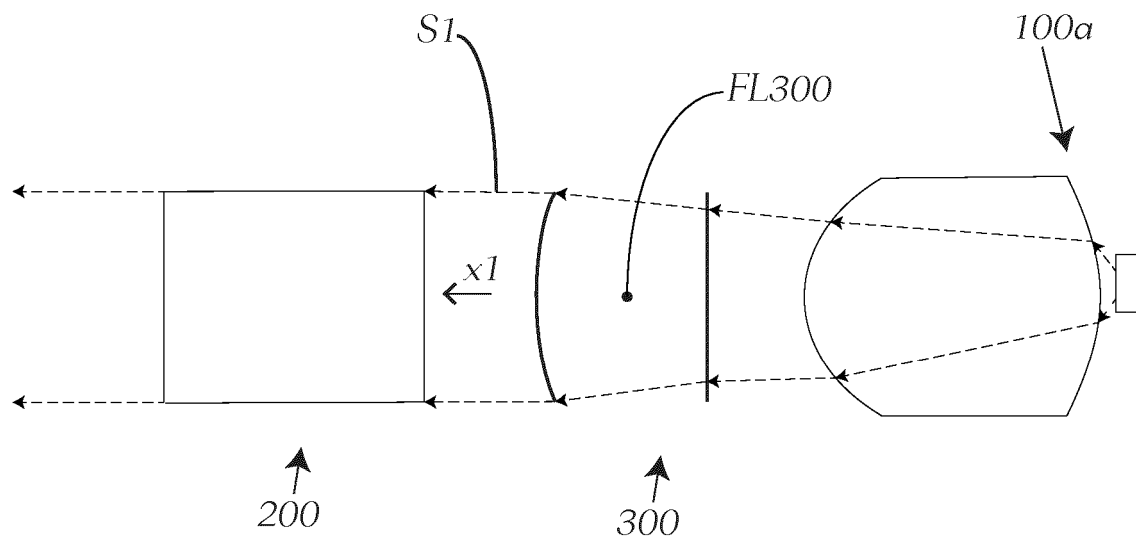


Fig. 4a

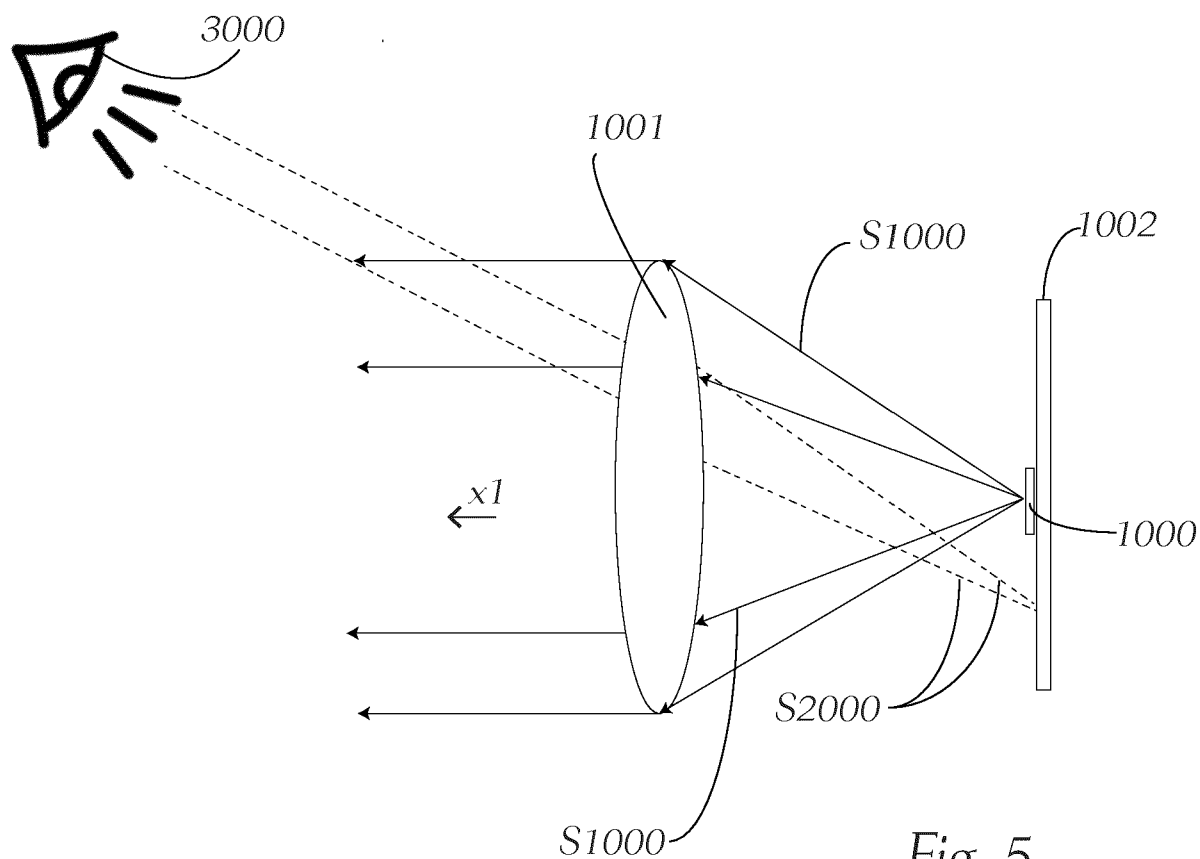


Fig. 5

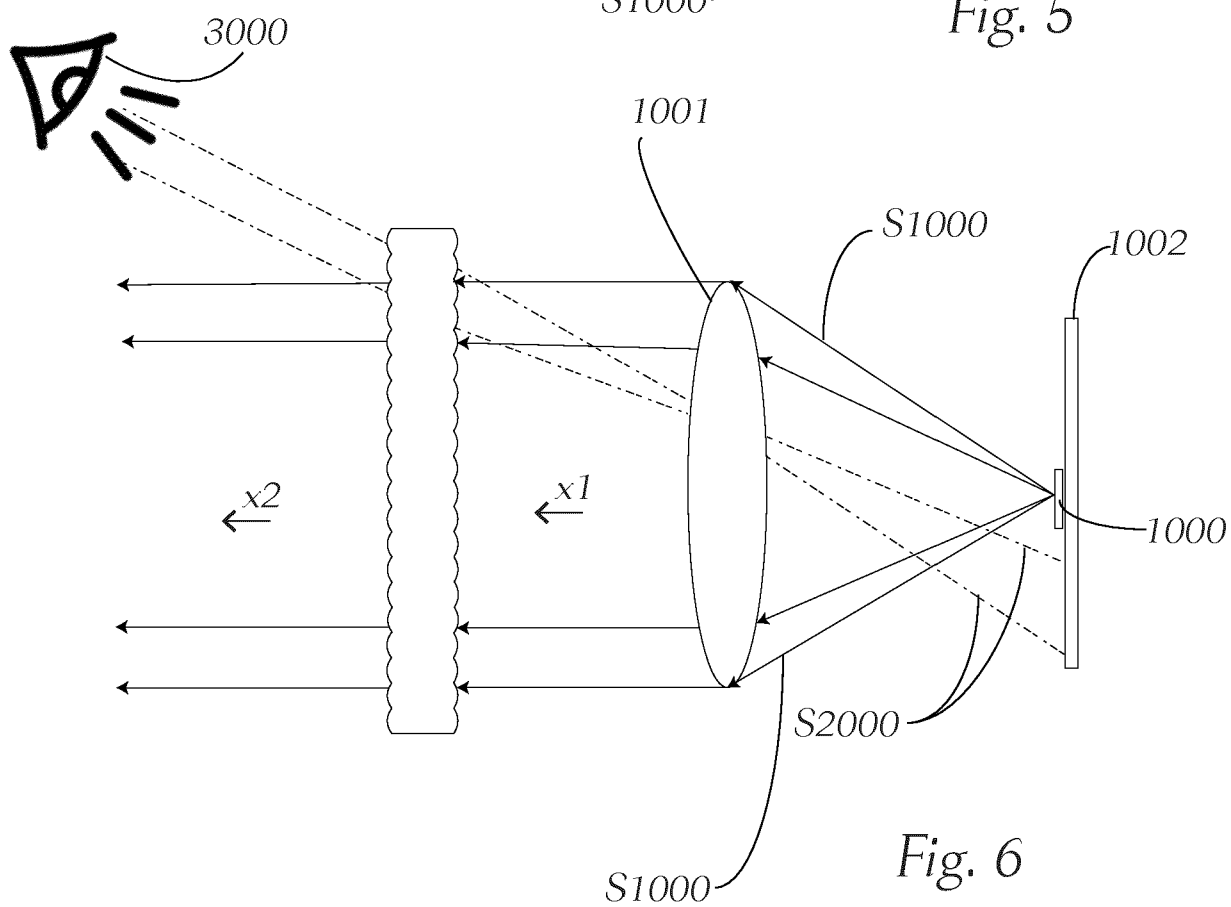


Fig. 6



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Application Number

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			F21S
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		24 June 2025	Sarantopoulos, A
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