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(72) Inventors:
• **Hradil, Milan**
779 00 Olomouc (CZ)
• **Hasek, Michal**
789 85 Mohelnice (CZ)

(74) Representative: **Bringemeier, Ulrich Heinz**
Hella Corporate Center GmbH
Rixbecker Straße 75
59552 Lippstadt (DE)

(71) Applicant: **Hella Autotechnik Nova, s.r.o.**
78985 Mohelnice (CZ)

(54) **AUTOMOBILE HEADLIGHT**

(57) The invention is directed to an automobile headlight comprising light sources (1), a primary optical element (2) for collimating light from the light sources (1), and a secondary optical element (3) for directing light collimated by the primary optical element (2). The primary optical element (2) comprises a body (4) comprising an exit surface (5) for letting light out of the element and comprising a collimating protrusion (6) for each light source (1). Each collimating protrusion (6) is connected

to the body (4) and comprises a protrusion entry surface (7) for letting light from corresponding light source (1) in. The exit surface (5) is divided into segments (8), each corresponding to at least one collimating protrusion (6) divided into multiple subsegments. The subsegments are adapted to direct light rays passing through the corresponding collimating protrusion (6) towards the secondary optical element (3) and to decrease divergence of light rays exiting through the exit surface (5).

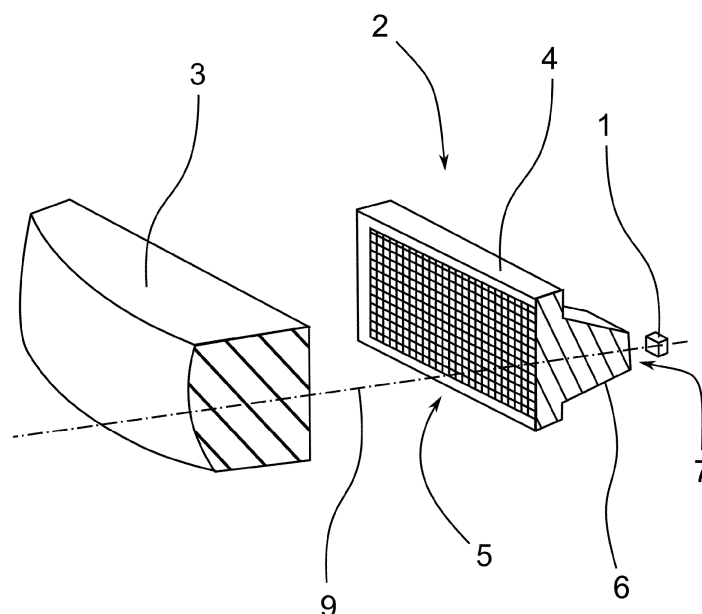


Fig. 1

Description

Technical field

[0001] The present invention relates to lighting device for automobiles, specifically to headlights having lens with micro-optical elements.

Background of the Invention

[0002] Headlights typically comprise at least two optical elements for shaping the light beams outputted by light sources into a single beam having desirable properties, e.g., an appropriately homogenous light beam for illuminating the road and traffic signs without blinding other drivers. A primary optical element is closer to the light sources and its main purpose is to direct as much light as possible as homogeneously as possible towards a secondary optical element. The secondary optical element then provides the desired output light beam, e.g., illuminates the road a certain distance ahead and sends a part of the light to the right side for illuminating traffic signs. These optical elements in the state of the art are quite bulky in order to provide them with necessary optical properties, which means they are also heavy and need to be carried by relatively large support elements. As a result, headlights are large and heavy and need a large space to be mounted into.

[0003] It would therefore be advantageous to provide a headlight having an optical element which would provide the desired optical function, while being lighter and/or smaller. It would also be desirable to simplify design of such optical elements, i.e., simplify the calculations needed to provide a shape for an optical element such that this element fulfills the desired optical function.

Summary of the Invention

[0004] The shortcomings of the solutions known in the prior art are to some extent eliminated by an automobile headlight comprising a set of multiple light sources arranged in at least one row, a primary optical element for collimating light from the light sources, and a secondary optical element for directing light collimated by the primary optical element towards the area in front of the headlight, i.e., in front of the vehicle. The headlight also has a main optical axis, wherein a center of the first optical element and a center of the second optical element are both located on the main optical axis. The primary optical element comprises a body comprising an exit surface for letting light out of the element, and comprising, opposite to the exit surface, a collimating protrusion for each light source from the set of light sources. Collimating protrusions are basically lightguides for incoupling light from each light source and transmitting it to the body of the optical element, preferably more homogenous and/or less diverging when compared to the light outputted by given light source.

[0005] Each collimating protrusion is connected to the body and comprises a protrusion entry surface for letting light into the primary optical element, wherein the corresponding light source is directed to the protrusion entry surface. The exit surface is divided into segments, each corresponding to at least one collimating protrusion and each further divided into multiple subsegments. Each subsegment has its length and width, both being less than 0.05 mm, preferably less than 0.04 mm, for example it can be 0.01 mm. The subsegments in each segment are adapted, by their shape and inclination, to direct light rays passing through the corresponding collimating protrusion and then passing through given segment and subsegment, towards the secondary optical element. All the subsegments are further adapted, also by their shape and inclination, to decrease divergence of light rays exiting through the exit surface. The light beam exiting the primary optical element is thus collimated and the amount of light not passing through the secondary optical element and out of the headlight is limited.

[0006] The primary and secondary optical elements can for example be a part of a high beam module or a low beam module of the headlight. The main advantage of headlight having primary optical element with the above-described micro-optics is in significantly decreasing the size of the optical element, which in turn decreases the size of a frame of the optical element holding it in place and also the size of the headlight as a whole. The headlight thus requires less space for mounting to the automobile, is lighter and cheaper to manufacture. Another advantage is in easier designing or modeling of the primary optical element. Optical elements used in the state of the art, having continuous and smooth exit surface, need to be designed, i.e., the shape of the exit surface needs to be modeled, as a whole, which makes the computations required for obtaining a shape providing a desired optical and illumination function complicated. The continuous shape also limits the variability of the surface, so the desired optical and illumination function is generally only approximated by the resulting optical element.

[0007] In the present headlight, each microlens, i.e., each subsegment, can be designed individually, independently of other subsegments. For example, a specific subsegment receives light from the body of the primary optical element at a certain known angle, with a certain divergence and homogeneity, etc., and its shape and inclination is then designed, e.g., by a computer simulating or modeling software, such that it bends or reflects the light in a desired manner, sending in towards a desired part of the secondary optical element with a desired divergence etc. Shape, inclination, and position of other subsegments does not have to be taken into account. As a result, the computations are simplified, and the desired optical and illumination function can be obtained much more precisely.

[0008] Inclination of a subsegment can be, for example, described by two angles - an angle between the sub-

segment and a vertical plane, preferably perpendicular to the main optical axis, and an angle between the subsegment and a horizontal plane. For a planar subsegments, these angles can be measured anywhere on the subsegment. For nonplanar subsegment, the angles can, for example, be measured at the center of the subsegment, i.e., as angle between the given vertical/horizontal plane and a tangent plane constructed at the center of the subsegment, or can be measured at a different specific point of the subsegment, e.g., one of its corners. The inclination angle(s) can also be measured as an average over angle between the horizontal/vertical plane and the subsegment at several different points, e.g., all four of its corners. The shape of each subsegment can for example be planar, spherical, convex or concave, but generally a subsegment can be of any shape.

[0009] In use, the light from each light source is thus transmitted through the corresponding collimating protrusion, into the body and out of the primary optical element through the corresponding segment, and, in part, possibly also through other neighboring segments. The light from all the segments is directed towards entry surface of the secondary optical element and then, optionally through some other optical elements, it is directed to the area in front of the automobile.

[0010] In each segment, the subsegments are preferably arranged in multiple rows and multiple columns. Rows are preferably horizontally oriented, columns vertically oriented. Having the subsegments arranged in such a grid simplifies design and manufacture.

[0011] Preferably, in a projection onto a vertical plane parallel to the main optical axis, at least on a lower half of each segment, the subsegments in each row deviate from the main optical axis more than or equally to the subsegments in lower-located rows. In other words, lower located subsegments have smaller angle between given subsegment and the main optical axis. This angle can be measured at some specific point or as an average over several points, as described above. As a result, the light passing through the lower segments is bent more and directed towards the secondary optical element, especially when the centers of both the optical elements are at the same height.

[0012] Lower, in the context of the present headlight, means closer to the ground or to the road, on which an automobil provided with this headlight is located, i.e., it means lower with respect to the standard and expected orientation of the headlight, in which it is to be mounted to an automobile standing on its wheels on a substantially flat surface.

[0013] Preferably, in a projection onto a horizontal plane, for each segment, the angle between individual subsegments and the main optical axis is at least partially dependent on the distance of the segment from the main optical axis. This arrangement improves homogeneity and decreases divergence of the light passing between the primary and secondary optical elements. In the bulky primary optical elements known from the state of the art,

the exit surface can be curved in order to approximate a focal plane of the secondary optical element. The curved shape further increases the size of the primary optical element. In the present invention, similar function can be achieved by the described arrangement of the subsegments, without increasing the size or weight of the primary optical element.

[0014] For example, in such an arrangement, for each segment, in the projection onto a horizontal plane, there is an average angle between subsegments and the main optical axis (i.e., sum of all the angles between a subsegment and the axis, divided by the number of subsegments in given segment), wherein for segments farther from the main optical axis the average angle is smaller than or equal to the average angle for segments located closer to the main optical axis (which are thus more perpendicular to the axis).

[0015] Preferably there is a plane, i.e., an imaginary plane, such that majority of the subsegments of the primary optical element exit surface, preferably at least 75 %, preferably at least 90 % and most preferably all of them, are intersected by this plane. In other words, the exit surface is substantially planar. For example, it is manufactured as a planar surface with the segments and subsegments stamped or otherwise provided on the surface. Other possible method for manufacture of the subsegments is for example Single Point Diamond Turning.

[0016] Each collimating protrusion can have its own optical axis intersecting the corresponding light source and the corresponding segment, wherein for each segment the inclination of individual subsegments is at least partially dependent on the position of given subsegment with respect to the optical axis of the corresponding collimating protrusion. This dependence can be in the form, e.g., of the angle between the axis and a subsegment being directly or inversely proportionate to the distance between the subsegment and the protrusion optical axis. This dependence can be present when viewed from above (i.e., in a projection onto a horizontal plane) and/or when viewed from the side (i.e., in a projection onto a vertical plane parallel to the main optical axis). For example, there can be a hundred rows and columns of subsegments in a segment, and the four central segments, directly touching the axis with one of their corners, might be perpendicular to the protrusion optical axis, subsegments one row/column farther might have the angle, both when viewed from the side and from the above, 89.75° , subsegments another row/column farther can have the angle 89.5° , and so on. This dependence might be linear, but it can also be nonlinear, e.g., polynomial or exponential. In general, the angle might increase or decrease with the distance of each given subsegment from the axis such that for each given subsegment, other subsegments in the same segment closer to the protrusion optical axis have the angle with respect to the axis smaller than or equal to, or larger than or equal to, than this given subsegment.

[0017] Similarly to the dependence on the protrusion

optical axis, there can be an imaginary line connecting the center of each segment with a predetermined point on the entry surface of the secondary optical element. Center of a segment can be a point on the surface of the segment lying on the intersection of lines connecting opposite corners when projected onto a plane perpendicular to the main optical axis. For each segment the inclination of individual subsegments can then be at least partially dependent on the position of given subsegment with respect to this line.

[0018] In embodiments with the inclination dependent on the distance from the protrusion optical axis or the line described above, the subsegments on the entire exit surface are, at least to some extent, oriented in a periodical arrangement. For example, in direction from left to right, i.e., horizontally and perpendicularly to the main optical axis, the angle of subsegments repeatedly increases and decreases. This arrangement improves homogeneity of the light beam exiting the primary optical element.

[0019] The focal plane of the secondary optical element can be in front of the primary optical element (with respect to direction of light passing from the primary optical element towards the secondary one). This arrangement might be simpler to design or manufacture. However, the focal plane can also be behind the exit surface of the primary optical element, e.g., it can intersect the primary optical element, or it can pass behind its protrusion entry surfaces or even behind the light sources when viewed from the side. The optical assembly and thus also the whole headlight can then be smaller, since the optical elements might be closer together. The subsegments of the exit surface can then have different shape or orientation depending on the position of the focal plane.

Description of drawings

[0020] A summary of the invention is further described by means of exemplary embodiments thereof, which are described with reference to the accompanying drawings, in which:

Fig 1. Shows a simplified sectional drawing of arrangement of the optical elements from the automobile headlight according to the invention, wherein the section plane is vertical, and the main optical axis of the headlight lies within the section plane.

Fig 2. Shows a simplified side drawing of the arrangement from fig. 1 wherein the collimated beam of light exiting the primary optical elements is indicated by dashed lines.

Fig 3. Shows a schematical top view of the primary optical element from the headlight according to the invention, wherein the segments forming the exit surface are indicated by vertical lines.

Fig 4. Shows a detailed view of a part of the exit surface and several collimating protrusions from fig. 3, wherein for each of the protrusions an area on the exit surface through which light entering through the given protrusion exits the primary optical element is indicated by dotted and dash-and-dot lines.

Fig 5. Shows a simplified sectional drawing of arrangement of the optical elements from the automobile headlight, wherein the focus and focal plane of the secondary optical element are located in front of the primary optical element. And

Fig 6. Shows a simplified sectional drawing of arrangement of the optical elements from the automobile headlight, wherein the focus and focal plane of the secondary optical element are located behind the primary optical element.

Exemplary Embodiments of the Invention

[0021] The invention will be further described by means of exemplary embodiments with reference to the respective drawings.

[0022] The subject of the present invention is an automobile headlight. The headlight comprises a set of multiple light sources 1, preferably LEDs, arranged in one or more rows, and further comprises a primary optical element 2 and secondary optical element 3. The primary optical element 2 is adapted for collimating light from the light sources 1, i.e., adapted at least to decrease the divergence of the light, and sending it towards the secondary optical element 3. The secondary optical element 3 is adapted to direct the collimated light in accordance with the purpose of the headlight or of a headlight module comprising these optical elements. The headlight can have a main optical axis 9 such that a center of the first optical element and a center of the second optical element 3 are both located on the main optical axis 9. The main optical axis 9 can also be a line connecting centers of mass of both optical elements, or their focal points.

[0023] For example, if the primary optical element 2 and the secondary optical element 3 are parts of a low beam module, the secondary optical element 3, optionally together with other parts of the module, shapes the output light beam such that it illuminates the corresponding traffic lane farther than the opposite lane. For a high beam module, an appropriate illumination for several locations at different distances in front of the automobile might be given by law and the secondary optical element 3 is then adapted to output a light beam providing such an illumination.

[0024] The primary optical element 2 comprises a body 4, several collimating protrusions 6 on one side of the body 4 and an exit surface 5 for the light passing through the element on the opposite side of the body 4. Each

collimating protrusion 6 comprises a protrusion entry surface 7 and is arranged in front of one of the light sources 1, and its purpose is incoupling light from the light source 1 and directing it towards the exit surface 5, preferably as homogeneously as possible. The layout of the collimating protrusions 6 is thus defined by the layout of the set of light sources 1 - if all the light sources 1 are in a single row, the collimating protrusions 6 are also in a single row; for two rows of light sources 1 there are two rows of collimating protrusions 6 etc. In some embodiments, each light source 1 can be formed by multiple smaller partial sources, e.g., by multiple LEDs. The exit surface 5 is divided into multiple segments 8, preferably at least as many segments 8 as there are collimating protrusions 6, and each segment 8 is further divided into subsegments. Subsegments have sizes at most 50x50 μm and each subsegment has to some extent a shape (e.g., planar, convex, concave, further divided into several smaller facets, etc.) and inclination (e.g., an angle with respect to a vertical plane and a second angle with respect to a horizontal plane) independent of other subsegments. The shape and inclination of all the subsegments of each of the segments 8 are adapted to direct light rays, originating in the corresponding light source 1 and passing through the corresponding collimating protrusion 6, towards the secondary optical element, and are adapted to decrease the divergence of the light rays exiting through the exit surface 5.

[0025] The directing of the light, as well as the decrease in the divergence, ensures that as much light as possible is transferred from the light sources 1 through the primary optical element 2 towards and into the secondary optical element 3. Therefore, the divergence can be larger if the secondary optical element 3 is larger or is closer to the primary optical element 2, and the divergence is preferably smaller if the secondary optical element 3 is smaller or is farther from the primary optical element 2. The light from each segment 8 can be directed towards the whole entry surface of the secondary optical element 3 or it can be directed towards only a part of this entry surface, with other parts of the surface being illuminated by light directed by other segments 8.

[0026] The shape and inclination of each subsegment can be computed individually, i.e., independently from other subsegments, preferably by a computer simulation/modeling. The subsegments are preferably arranged in rows and columns, i.e., they form a grid and the exit surface 5 as well as each segment 8 has a rectangular shape. Such a grid is depicted in fig. 1. Individual subsegments can have virtually any shape as long as such a shape provides for some desired optical or illuminating function. Planar subsegments might be defined by their inclination only, convex or concave, e.g., spherical, subsegments might be defined by their inclination, radius of curvature, focal points, etc. Other subsegments might have even more complex shapes, e.g., they can comprise protrusions or depression formed by one or more planar or nonplanar facets (i.e., even smaller con-

tinuous parts of the exit surface 5) etc.

[0027] The resulting light beam passing between the primary optical element 2 and the secondary optical element 3 can in some embodiments provide as homogeneous illumination of the secondary optical element 3 entry surface as possible, with minimal amount of light being directed towards any other part of the headlight. In other embodiments, some parts of the entry surface of the secondary optical element 3 might be illuminated brighter than others, and the secondary optical element 3 then processes this light in order to achieve the desired output light beam. For example for high beam light, the light intensity on the road closer to the automobile should be higher than farther from the automobile. Thus, a part of the light entry surface of the secondary optical element 3 from which light is directed closer to the automobile might be illuminated more brightly than some other part of the surface from which the light is directed farther in front of the vehicle, towards traffic signs etc. The shape, inclination, and arrangement of the individual segments 8 and subsegments can thus be influenced by the shape of the secondary optical element 3, by the kind of light module being formed by these optical elements, by desired illumination properties of the headlight or the module etc.

[0028] In order to make the light beam exiting the primary optical element 2 less divergent, the subsegments are preferably arranged, at least on a lower half of each segment 8, such that the lower a row of subsegments is, the lower its inclination when viewed from the side (e.g., as in fig. 2). As a result, the lower located rows send rays of light towards the secondary optical element 3 at a higher angle with respect to a horizontal plane. In other words, for each row of subsegments at the at least lower half of each segment 8, in a projection onto a vertical plane parallel to the main optical axis 9, the subsegments in the row deviate from the main optical axis 9 (have a larger angle with respect to the axis) more than or equally to the subsegments in any lower placed row. For planar subsegments, the angle can be measured at any part of the subsegments. For convex/concave subsegments, the angle can be measured at the center of the subsegment. For more complexly shaped subsegment the inclination of a subsegments can for example be average inclination over all four corners of the subsegment.

[0029] Preferably, for each row of subsegments located lower than or at the same height as the main optical axis 9, when viewed from the side, the subsegments in the row have an angle between the subsegments and the main optical axis 9 larger than or equal to the subsegments in any lower placed row. In other words, the vertical distance between the main optical axis 9 and a subsegment has impact on inclination of this subsegment at least for all the subsegments which are not placed higher than the main optical axis 9 of the headlight.

[0030] Preferably, the inclination of each subsegment is also affected by the distance between the main optical axis 9 and the segment 8 comprising this subsegment.

This distance can be measured as a horizontal distance, especially in embodiments where the segments 8 are all placed at the same height, but also if some segments 8 are located at different heights, i.e., if they are arranged in multiple rows. For example, a parameter computed as an average (i.e., mean) angle of deviation of a subsegment from the main optical axis 9 over all subsegments in each segment 8 when viewed from the top can be used to describe the arrangement of subsegments and segments 8 with respect to the main optical axis 9. For segments 8 closer to the main optical axis 9, the value of this parameter, i.e., the average angle of deviation in a projection onto a horizontal plane, can be larger than or equal to the value of this parameter for segments 8 further away from the optical axis. In other words, in segments 8 closer to the main optical axis 9, the average subsegments is closer to being perpendicular to the axis than in segments 8 farther away from the axis.

[0031] If there are multiple rows of segments 8, e.g., if the light sources 1 are arranged in multiple rows, the inclination of subsegments can also be affected by placement of given segment 8 in lower or higher row of segments 8. For example, subsegments from segments 8 from a lower-located row can on average have a lower deviation from the main optical axis 9 when viewed from the side than subsegments from a higher-located row of segments 8.

[0032] Apart from the main optical axis 9, each collimating protrusion 6 can have its own optical axis, e.g., a line parallel to the main optical axis 9 and intersecting the light source 1 corresponding to given collimating protrusion 6. The protrusion optical axis can further intersect the center of the entry surface of this protrusion, and it also intersects the segment 8 corresponding to this protrusion. The position of a subsegment relative to the optical axis of the protrusion corresponding to the segment 8 comprising this subsegment can then also have impact on the inclination of the subsegment. For example, the normal of each subsegment at the center of this subsegment can have a larger angle with respect to the protrusion optical axis if the subsegment is farther from the protrusion optical axis.

[0033] When viewed in a projection onto a vertical plane parallel to the main optical axis 9 (i.e., side view), the angle between a subsegment and the corresponding protrusion optical axis can be larger for subsegments closer to the protrusion optical axis than for subsegments farther away. Alternatively or additionally, when viewed in a projection onto a horizontal plane parallel to the main optical axis 9 (i.e., top view), the angle between a subsegment and the corresponding protrusion optical axis can be larger for subsegments closer to the protrusion optical axis than for subsegments farther away.

[0034] Instead of the protrusion optical axis, a different line can be used for describing the inclination of subsegments analogically to the previous two paragraphs. For example, a line connecting the center of each segment 8 with a predetermined point on the secondary optical

element 3 entry surface can be used and the relative position between each subsegment in given segment 8 and this line can have impact on the inclination. For example, the angle between a subsegment (e.g., a between a tangent plane constructed at the center of this subsegment) and this line can increase, or decrease, with increasing the distance between given subsegment and the line (i.e., the center of given segment), for example the angle can be proportionate, or inversely proportionate, to this distance. This predetermined point can be the same for all the segments 8, e.g., it can be the center of the entry surface, but it can also be different for each segment 8 or common for some segments 8 and different for others.

[0035] This can, for example, result into focusing the light passing through each subsegment in a segment 8 more or less towards the point on the entry surface of the secondary optical element 3 by adjusting the dependence of subsegment-line angle on the subsegment-line distance. Brightness of illumination can thus be adjusted locally on the entry surface, and that in turn can impact the illumination of the area in front of the vehicle, e.g., illuminate some parts of the road brighter than others. The distance between a segment 8 and the main optical axis 9 can analogically affect inclination of subsegments in each given segment 8, for example in order to focus the light beam exiting the primary optical element 2 as much as possible onto the entry surface of the secondary optical element 3.

[0036] Preferably, both the position of segment 8 relative to the main optical axis 9 and the position of subsegment relative to the protrusion optical axis or some other line specific for the given segment 8, have impact on inclination of subsegments.

[0037] Preferably the exit surface 5 of the primary optical element 2 is substantially planar. For example, a plane perpendicular to the main optical axis 9 can be constructed or imagined, such that a majority of subsegments is intersected by this plane, preferably at least three quarters of subsegments. In other words, the only deviations from the planar shape of the exit surface 5 are caused by the shape and inclination of the individual subsegments. For a naked eye, the exit surface 5 can then seem to be completely planar, and even smooth since the size of the subsegments might be smaller than what the human eye can distinguish or notice.

[0038] The substantially planar shape can be seen in the embodiment depicted in fig. 1. In this embodiment, the subsegments are arranged in a grid, there is a single row of light sources 1, collimating protrusions 6 and segments 8, and the main optical axis 9 coincides with the protrusion optical axis of a middle collimating protrusion 6 (i.e., the protrusion which is cut in half in fig. 1). The subsegments are preferably arranged as described above, with their inclination affected by their position in a segment 8 (i.e., relative to the given line or the protrusion optical axis), as well as by the position of the segment 8 on the exit surface 5 (i.e., relative to the main optical

axis 9).

[0039] In fig. 2, depicting a side view of the optical elements, or a projection onto a vertical plane, the main optical axis 9 also coincides with all the protrusion optical axes. The collimated beam of light exiting the primary optical element 2 is indicated by the dashed lines. The entry surface of the secondary optical element 3 is depicted as planar, but in other embodiments, it can be convex or concave, spherical or aspherical, freeform etc., according to its desired optical and illumination functions. The focus / focal point 10 of the secondary optical element 3 and its focal plane 11 can be situated in front of the primary optical element 2, i.e., between the optical elements, as shown in fig. 5. However, they can also be situated behind the primary optical element 2 or they can pass through it, as shown in fig. 6. This shifting of the focal plane 11 can be a result of different construction, e.g., shape, of the secondary optical element 3 and/or can result from shifting the secondary optical element 3 with respect to the primary optical element 2 (compare figs. 5 and 6). The exit surface 5 of the primary optical element 2, e.g., its segments 8 and subsegments, their shape, orientation etc., can then also reflect the change in shape/position of the secondary optical element 3, e.g., the beam of light can be wider, i.e., have larger beam angle, to illuminate the secondary optical element 3 as needed.

[0040] Fig. 3 shows an exemplary embodiment of the primary optical element 2 with its collimating protrusions 6 and their respective protrusion entry surfaces 7. Segments 8 of the exit surface 5 are aligned with the collimating protrusions 6. As indicated in the detailed view in fig. 4, each segment 8 receives light not only from the corresponding collimating protrusion 6, but also from the adjacent collimating protrusions 6. For example, the light beam originating in the middle collimating protrusion 6 indicated by the dash-and-dot lines illuminates the middle segment 8 but also the segments 8 to the right and to the left. This middle segment 8 is also illuminated by those adjacent light beams indicated by dotted lines, but to a lesser extent than by the corresponding light beam from the corresponding protrusion. The subsegments illuminated by light from two different collimating protrusions 6, i.e., from two different light sources 1 and directions, can have a shape and/or an inclination adapted to these multiple illuminations, so that light from both collimating protrusions 6 is directed towards the secondary optical element 3, with its divergence lowered, as desired.

[0041] In some embodiments, each subsegment can be planar, or each subsegment can be spherical etc. In other embodiments, which might be preferable as they provide the highest variability and precision in providing the desired optical function, some subsegments might be planar, others spherical, others might comprise multiple smaller mutually angled surfaces or facets or might be shaped as a complex continuous surface having several protruding and recessed areas, etc.

List of reference numbers

[0042]

- | | | |
|----|------|---------------------------|
| 5 | 1 - | Light source |
| | 2 - | Primary optical element |
| | 3 - | Secondary optical element |
| | 4 - | - Body |
| | 5 - | Exit surface |
| 10 | 6 - | Collimating protrusion |
| | 7 - | Protrusion entry surface |
| | 8 - | Segment |
| | 9 - | Main optical axis |
| | 10 - | Focus |
| 15 | 11 - | Focal plane |

Claims

- | | | |
|----|----|---|
| 20 | 1. | Automobile headlight comprising a set of multiple light sources (1) arranged in at least one row, a primary optical element (2) for collimating light from the light sources (1), a secondary optical element (3) for directing light collimated by the primary optical element (2), and a main optical axis (9), wherein a center of the first optical element and a center of the secondary optical element (3) are both located on the main optical axis (9), wherein the primary optical element (2) comprises a body (4) comprising an exit surface (5) for letting light out of the element and comprising, opposite to the exit surface (5), a collimating protrusion (6) for each light source (1) from the set of light sources (1), each collimating protrusion (6) connected to the body (4) and comprising a protrusion entry surface (7) for letting light into the primary optical element (2), wherein the corresponding light source (1) is directed to the protrusion entry surface (7), characterized in that the exit surface (5) is divided into segments (8), each corresponding to at least one collimating protrusion (6) and each further divided into multiple subsegments, wherein each subsegment has its length and width, both being less than 0.05 mm, wherein the subsegments in each segment (8) are adapted, by their shape and inclination, to direct light rays passing through the corresponding collimating protrusion (6) towards the secondary optical element (3) and to decrease divergence of light rays exiting through the exit surface (5). |
| 25 | | |
| 30 | | |
| 35 | | |
| 40 | | |
| 45 | | |
| 50 | 2. | The automobile headlight according to claim 1 characterized in that in each segment (8) the subsegments are arranged in multiple rows and multiple columns. |
| 55 | 3. | The automobile headlight according to claim 2 characterized in that in a projection onto a vertical plane parallel to the main optical axis (9), at least on a lower |

half of each segment (8), the subsegments in each row deviate from the main optical axis (9) more than or equally to the subsegments in lower-located rows.

4. The automobile headlight according to any one of the preceding claims **characterized in that** in a projection onto a horizontal plane, for each segment (8), the angle between individual subsegments and the main optical axis (9) is at least partially dependent on the distance of the segment (8) from the main optical axis (9). 5
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5. The automobile headlight according to claim 4 **characterized in that** wherein for each segment (8), in the projection onto a horizontal plane, there is an average angle between subsegments and the main optical axis (9), wherein for each segment (8), the average angle is smaller than or equal to the average angle for segments (8) located closer to the main optical axis (9). 15
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6. The automobile headlight according to any one of the preceding claims **characterized in that** there is a plane such that majority of the subsegments of the primary optical element (2) exit surface (5) are intersected by this plane. 25

7. The automobile headlight according to any one of the preceding claims **characterized in that** each collimating protrusion (6) has its optical axis intersecting the corresponding light source (1) and the corresponding segment (8), wherein for each segment (8) the inclination of individual subsegments is at least partially dependent on the position of given subsegment with respect to the optical axis of the corresponding collimating protrusion (6). 30
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8. The automobile headlight according to any one of the preceding claims **characterized in that** for each segment (8), there is a line connecting the center of the segment (8) with a predetermined point on the entry surface of the secondary optical element (3), wherein for each segment (8) the inclination of individual subsegments is at least partially dependent on the position of given subsegment with respect to this line. 40
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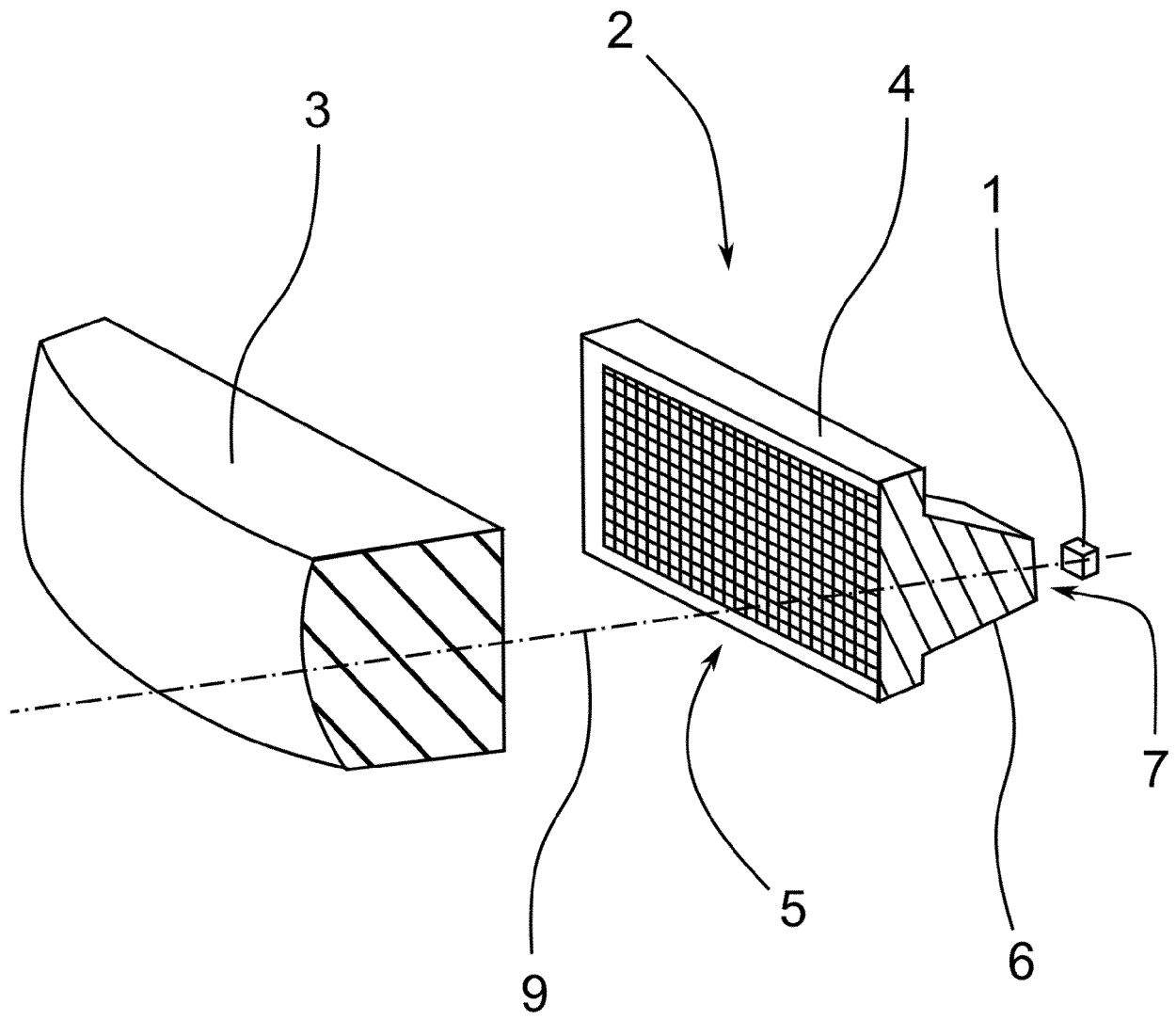


Fig. 1

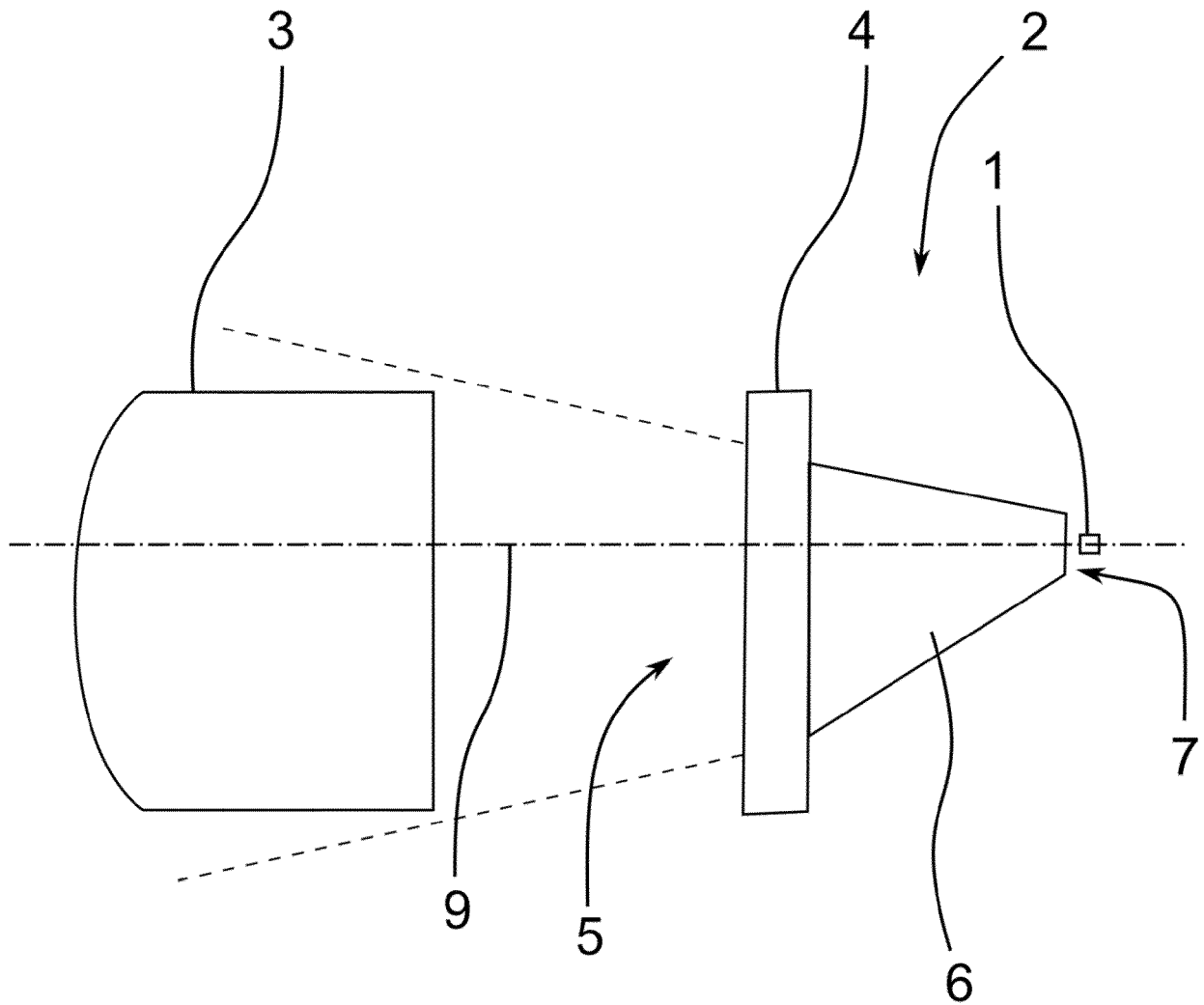


Fig. 2

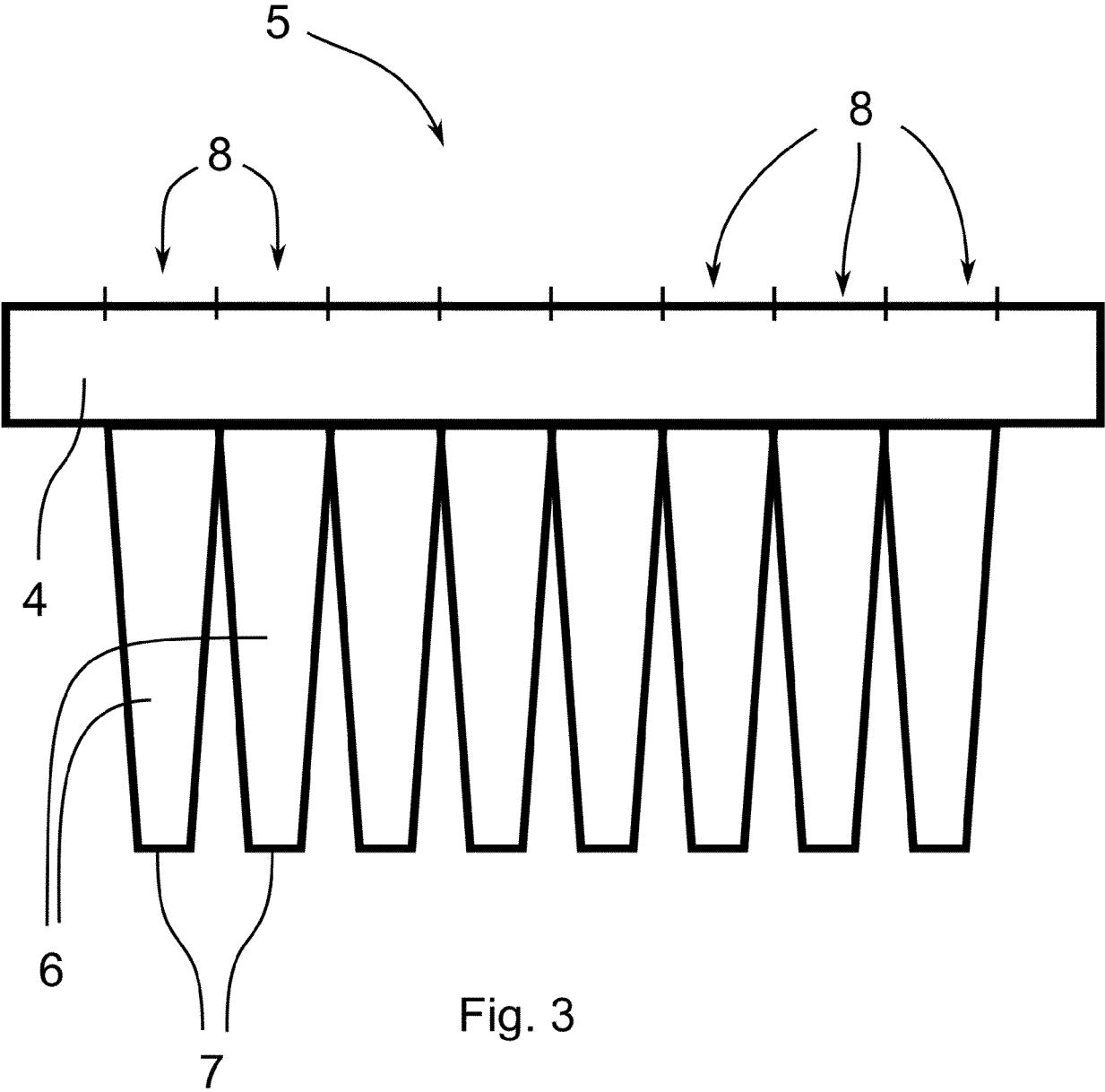


Fig. 3

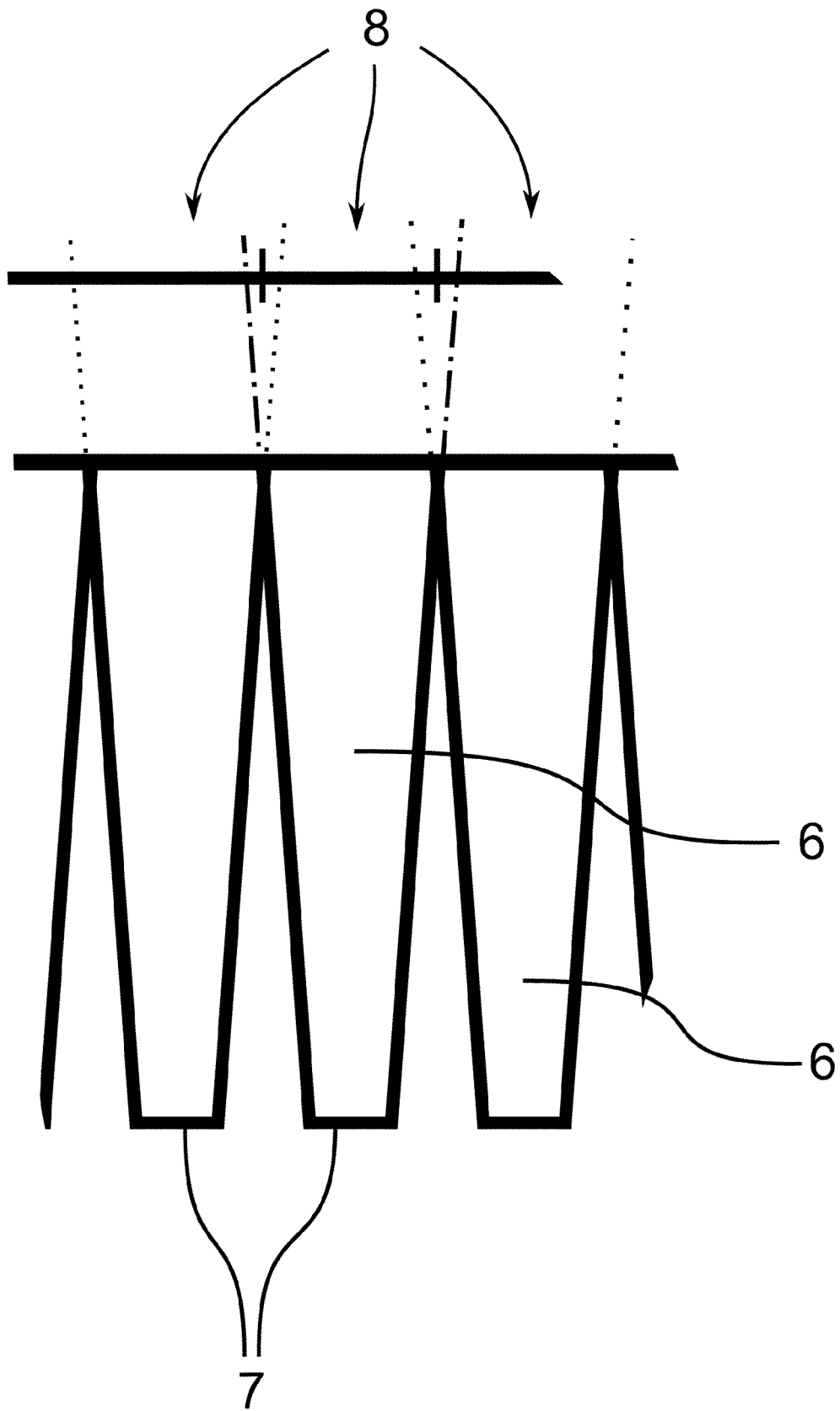
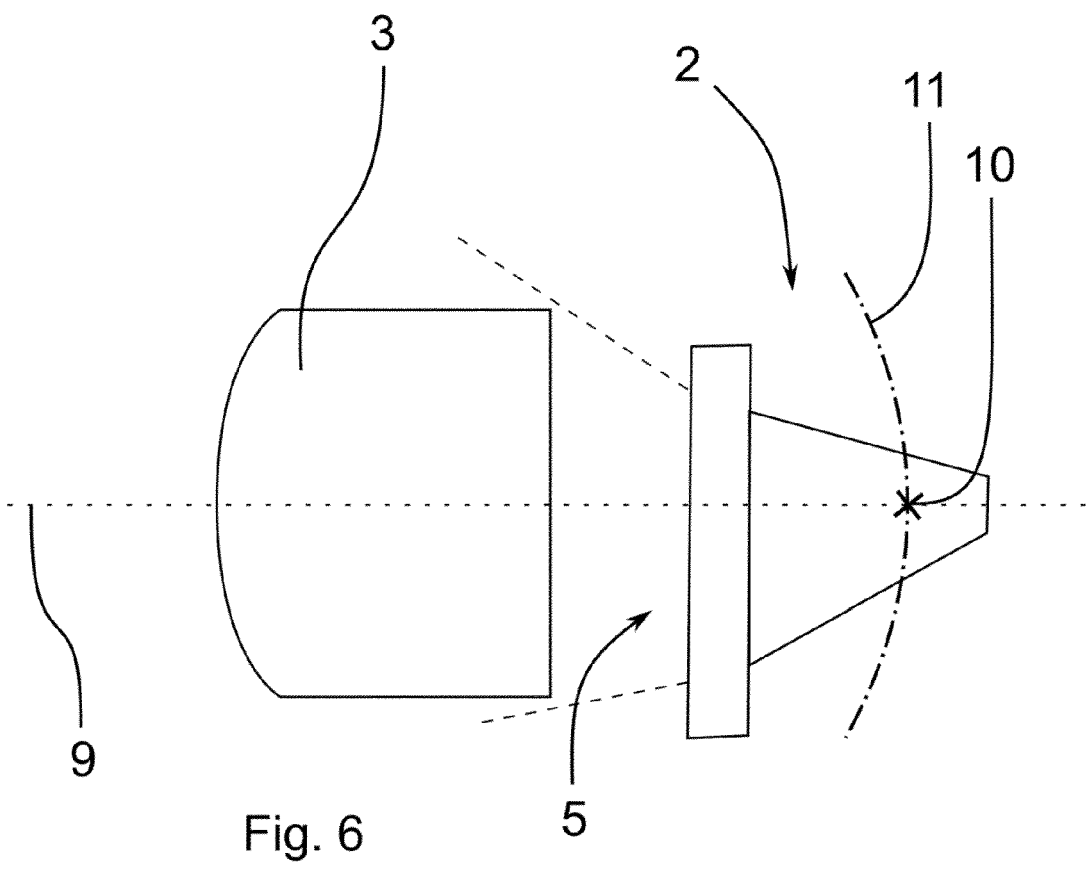
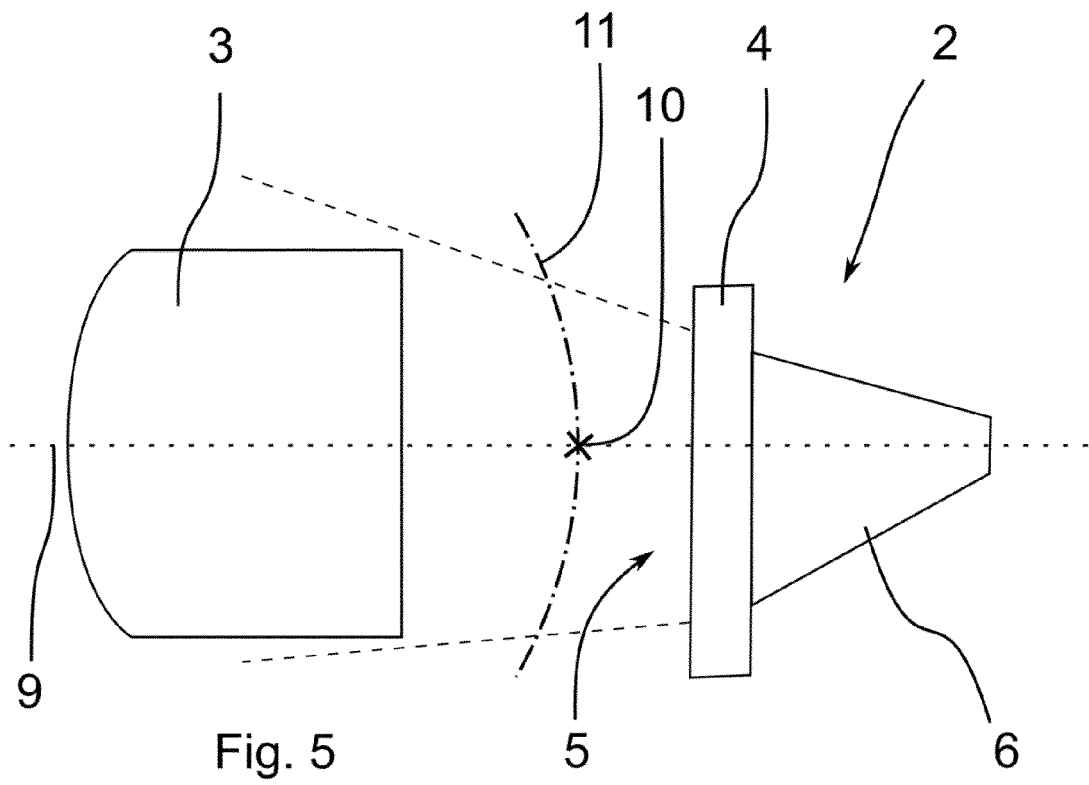


Fig. 4





EUROPEAN SEARCH REPORT

Application Number

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2018 207063 A1 (OSRAM GMBH [DE]) 7 November 2019 (2019-11-07) * the whole document *	1-8	INV. F21S41/24 F21S41/143
X	EP 3 301 350 A1 (AUTOMOTIVE LIGHTING REUTLINGEN GMBH [DE]) 4 April 2018 (2018-04-04) * the whole document *	1-8	
X	WO 2017/198516 A1 (HELLA KGAA HUECK & CO [DE]) 23 November 2017 (2017-11-23) * pages 6-11; figures 1-12 *	1-8	
X	DE 10 2010 046021 A1 (AUTOMOTIVE LIGHTING REUTLINGEN [DE]) 22 March 2012 (2012-03-22) * paragraphs [0035] - [0084]; figures 1-8 *	1, 2, 6, 8	
A	US 2022/146069 A1 (LEE CHAO PAI [TW] ET AL) 12 May 2022 (2022-05-12) * paragraphs [0028] - [0040]; figures 1-17 *	1-8	TECHNICAL FIELDS SEARCHED (IPC) F21S
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 March 2023	Examiner Sarantopoulos, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 22 20 6194

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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21-03-2023

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102018207063 A1	07-11-2019	NONE	

EP 3301350 A1	04-04-2018	DE 102016118152 A1	29-03-2018
		EP 3301350 A1	04-04-2018

WO 2017198516 A1	23-11-2017	CN 108139059 A	08-06-2018
		DE 102016109132 A1	23-11-2017
		US 2019086050 A1	21-03-2019
		WO 2017198516 A1	23-11-2017

DE 102010046021 A1	22-03-2012	DE 102010046021 A1	22-03-2012
		EP 2616738 A1	24-07-2013
		WO 2012034936 A1	22-03-2012

US 2022146069 A1	12-05-2022	TW 202221254 A	01-06-2022
		US 2022146069 A1	12-05-2022

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