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(54) **AUTOMOTIVE LIGHTING APPARATUS**

(57) Automotive lighting apparatus (1) provided with a lighting assembly (4) comprising: an optical fibre (6) of given length; an electrically-powered light source (5), which is placed in front of a proximal end (6a) of the optical fibre (6), and is selectively adapted to direct, towards the same proximal end (6a), a light beam that enters and travels inside the optical fibre (6); and an intermediate lens (7), which is interposed between the proximal end (6a) of the optical fibre (6) and the light source (5), and is adapted to focus the light exiting from the light source

(5) towards the behind-located proximal end of the optical fibre (6); and at least one proximal photometric sensor (9) which is arranged beside the collimated light source (5) and/or the intermediate lens (7), so as to capture/detect the light reflected/dispersed by said intermediate lens (7); the intermediate lens (7) having, on its front face, one surface chamfer or notch (7a) which is adapted to direct/reflect the incident light at least partly towards said proximal photometric sensor (9).

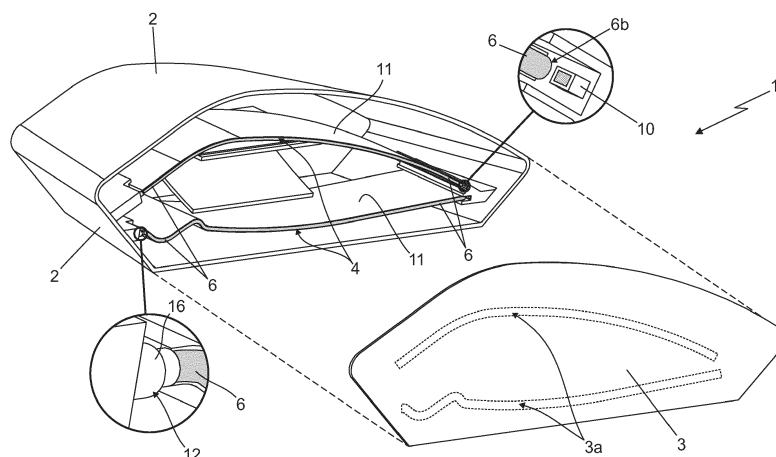


Fig. 1

Description

[0001] The present invention relates to an automotive lighting apparatus.

[0002] In more detail, the present invention relates to a headlight or taillight for cars and similar vehicles, i.e. a lighting apparatus adapted to be incorporated into a motor vehicle with the function of signalling the position, the sudden deceleration and/or the turning direction, and/or with the function of lighting the area surrounding the vehicle. Use to which the following disclosure will make explicit reference without however losing in generality.

[0003] As is known, the taillights for cars and similar vehicles generally comprise: a rigid and substantially basin-shaped rear body, which is structured so as to be stably recessed into a compartment specially realized in the rear part of the bodywork of the vehicle; a front half-shell which is arranged to close the mouth of the rear body so as to surface outside the bodywork of the vehicle, and is generally provided with a plurality of transparent or semitransparent sectors, usually with a colour different from one another; and a series of lighting assemblies that are located inside the rear body, each immediately beneath a respective transparent or semitransparent sector of the front half-shell, so as to be able to selectively backlight the overlying transparent or semitransparent sector of the front half-shell.

[0004] Usually, each transparent or semitransparent sector of the front half-shell is moreover uniquely associated with a specific light signal adapted to signal the position of the vehicle, the sudden deceleration of the vehicle or the turning direction of the vehicle during travel. Each lighting assembly, therefore, is specifically structured to emit, on command, a light beam that, once coming out from the taillight through the corresponding transparent or semitransparent sector of the half-shell, meets the type-approval specifications (colour and light distribution) required for the corresponding light signal.

[0005] In most of the taillights for cars currently on the market, at least one of the lighting assemblies comprises: a light-guide bar which is made of polymethylmethacrylate (PMMA) or other photoconductive material and extends inside the rear body skimming over the transparent or semitransparent sector to be backlit, substantially for the entire length of the same sector; and one or more high-power LEDs (acronym for Light Emitting Diode) that are fixed on a small printed circuit board which, in turn, is placed inside the rear body, close to at least one of the two ends of the light-guide bar, so that the LED(s) can direct the light directly into the light-guide bar through said end.

[0006] Light that then travels inside the body of the light-guide bar by total internal reflection, and usually exits progressively from the lateral side of the light-guide bar directly facing the front half-shell, so as to be able to backlight the overlying transparent or semitransparent sector of the half-shell.

[0007] Despite working very well, the backlighting sys-

tem with the light-guide bar makes the assembly of the taillight relatively laborious.

[0008] The light-guide bar, in fact, is notoriously a hard and rigid, but relatively fragile, monolithic body thus it must be inserted into the rear body with due care. In addition, the or both ends of the light-guide bar must be perfectly aligned with the LEDs to avoid light leaks, and this contributes in lengthening the assembly time of the headlight.

[0009] In order to obviate these drawbacks, in recent years some manufacturers of automotive headlights/tail-lights have started to use optical fibres to channel the light exiting from the LED(s) towards the corresponding transparent or semitransparent sectors to be backlit.

[0010] Optical fibres, in fact, are notoriously much more flexible than a light-guide bar made of polymethylmethacrylate (PMMA) and therefore considerably simplify the assembly of the headlight/taillight. In addition, the optical and mechanical coupling between each optical fibre and the corresponding LED can be performed rapidly by using a fixing connector which holds the end of the optical fibre firmly in place in front of the LED.

[0011] Since LEDs are point-type light sources and the optical fibres have a very small diameter, a small converging lens is usually placed between the LED and the end of the optical fibre, which lens concentrates the light rays exiting from the LED towards the facing end of the optical fibre.

[0012] More recently, the high-power LED(s) have been replaced by small laser emitters that guarantee a higher intensity of the emitted light.

[0013] Unfortunately, despite working very well, the new lighting assemblies have proved to be not very safe in the event of a breakage of the headlight/taillight following a car accident.

[0014] Experimental tests, in fact, have shown that, in the event of a breakage of the front half-shell of the light, the optical fibre can break up and move from its seat allowing the light to freely come out of the light, with all the problems that this entails.

[0015] The light emitted by the LEDs, in fact, generally has such an intensity that it can temporarily blind a person, and a broken and free-to-move optical fibre theoretically could accidentally direct the LED light outside of the headlight/taillight, towards the eye of a person stationary inside the vehicle or in the immediate nearby of the vehicle, with all the problems that this entails.

[0016] The criticality is even greater if the high-power LED(s) are replaced by laser emitters. In this case, the light emitted by the laser emitter can have such an intensity that it can irreparably damage the human eye.

[0017] Aim of the present invention is to increase the active safety of the new lighting assemblies that use optical fibres to backlight the front half-shell of the headlight/taillight.

[0018] In accordance with these aims, according to the present invention there is provided an automotive lighting apparatus as defined in Claim 1 and preferably, though

not necessarily, in any one of the claims depending on it.

[0019] The present invention will now be described with reference to the attached drawings, which illustrate a nonlimiting embodiment thereof, in which:

- Figure 1 is a partially exploded perspective view of an automotive light realized according to the teachings of the present invention, with parts removed for clarity's sake;
- Figure 2 is an exploded perspective view of the backlighting system of the automotive light shown in Figure 1, with parts removed for clarity's sake;
- Figure 3 is a sectional schematic view of the coupling system between the light source and the optical fibre of one of the lighting assemblies present in the automotive light shown in the preceding figures, with parts removed for clarity's sake;
- Figure 4 is a front view of the door of a car provided with a lighting apparatus realized according to the teachings of the present invention, with parts removed for clarity's sake; whereas
- Figure 5 is a partial side view of the door shown in Figure 4, sectioned along the section line V-V and with parts removed for clarity's sake.

[0020] With reference to Figures 1 and 2, number 1 denotes as a whole a lighting apparatus for automotive use, i.e. a lighting apparatus adapted to be mounted in a motor vehicle.

[0021] More in detail, the lighting apparatus 1 is preferably an automotive light, i.e. a lighting device particularly adapted to be placed on the front or rear part of the bodywork of a motor vehicle, with the function of emitting light signals adapted to signal the position of the vehicle and/or the sudden deceleration of the vehicle and/or the turning direction of the vehicle during travel.

[0022] In other words, the lighting apparatus 1 is adapted to be fixed to the front or rear part of the bodywork of a car, van, truck, motorcycle or other similar motor vehicle, to perform the function of a headlight or taillight.

[0023] Preferably, the lighting apparatus 1 is furthermore structured so as to surface outside the vehicle.

[0024] In the example shown, in particular, the lighting apparatus 1 is preferably structured to be stably recessed in the rear part of the bodywork of a car or other similar motor vehicle.

[0025] In other words, the lighting apparatus 1 is preferably a taillight for cars and the like.

[0026] Obviously, in a different embodiment the lighting apparatus 1 could also be structured so as to be simply fixed cantilevered on the front or rear part of the bodywork of the vehicle (not shown).

[0027] With reference to Figures 1 and 2, the lighting apparatus 1 preferably comprises: a substantially rigid and preferably made of plastic material, rear body 2 which is adapted to be firmly fixed to the vehicle, preferably outside of the vehicle; and a substantially rigid and preferably made of plastic material, front half-shell 3, tradi-

tionally called lens, which is arranged to close the mouth of rear body 2, preferably so as to surface outside of the bodywork of the vehicle, and is provided with at least one transparent or semitransparent sector.

[0028] More in detail, rear body 2 is preferably substantially basin-shaped, and is preferably structured so as to be at least partially recessed into a seat specially made in the rear part of the bodywork of the vehicle (not shown).

[0029] Obviously, in a different embodiment rear body 2 could also be structured so as to be simply fixed cantilevered on the rear part of the bodywork of the vehicle (not shown).

[0030] In addition, the lighting device 1 moreover comprises at least one electrically-powered lighting assembly that emits light on command and is located inside the rear body 2, beneath a corresponding transparent or semitransparent sector of front half-shell 3, so as to be able to selectively backlight said transparent or semitransparent sector of front half-shell 3.

[0031] In more detail, the front half-shell 3 is preferably provided with a plurality of transparent or semitransparent sectors. In addition, the lighting apparatus 1 is preferably provided with a plurality of electrically-powered lighting assemblies, each of which is located inside the rear body 2 in a position such as to backlight exclusively the overlying and corresponding transparent or semitransparent sector of front half-shell 3, preferably separately and independently from the other lighting assemblies of the lighting apparatus.

[0032] In the example shown, in particular, the rear body 2 is preferably made of an opaque plastic material, preferably via an injection moulding process.

[0033] The front half-shell 3, on the other hand, is preferably made of a transparent or semitransparent plastic material, such as for example polycarbonate (PC) or polymethylmethacrylate (PMMA), also in this case preferably via an injection moulding process.

[0034] With reference to Figures 1, 2 and 3, at least one of said lighting assemblies, hereafter denoted with number 4, in turn comprises: an electrically-powered light source 5 which is placed inside the rear body 2 and is capable of emitting light on command; and an optical fibre 6 of given length and preferably with a flexible filiform structure, which extends inside the rear body 2 and has one of its two ends, hereafter called proximal end, faced and optically coupled to the light source 5 so that the light emitted by the light source 5 can freely enter into the optical fibre 6 and travel inside it. The optical fibre 6 is adapted to channel the light emitted by the light source 5 towards the front half-shell 3.

[0035] In addition, the lighting assembly 4 moreover comprises a small intermediate lens 7, which is interposed between the proximal end of optical fibre 6 and the light source 5, and is adapted to channel the light exiting from the light source 5 towards the rearward proximal end of optical fibre 6.

[0036] Preferably, the intermediate lens 7 is addition-

ally a converging lens adapted to concentrate/focus the light exiting from the light source 5 towards the behind-located proximal end of optical fibre 6.

[0037] More in detail, the optical fibre 6 has a proximal end 6a and a distal end 6b, opposite to the proximal end 6a.

[0038] The light source 5 is arranged inside the rear body 2 facing the proximal end 6a of optical fibre 6, and is adapted to emit, on command and towards the proximal end 6a, a light beam that enters and travels inside the optical fibre 6, towards the distal end 6b. The intermediate lens 7 is placed between the light source 5 and the proximal end 6a of the optical fibre 6 spaced from the light source 5 and preferably abutting on the proximal end 6a of optical fibre 6.

[0039] The optical fibre 6, in addition, is preferably arranged inside the rear body 2 so as to extend, at least for an own portion/segment of given length, locally substantially skimmed over a corresponding transparent or semitransparent sector of front half-shell 3, and is preferably structured so as to gradually diffuse outwards the light that travels inside itself, preferably at least along said portion/ segment of given length.

[0040] More in detail, the optical fibre 6 is specifically structured to channel the entering light towards its own distal end 6b, simultaneously and progressively diffusing outside of the same optical fibre 6, substantially in a radial direction, a predetermined percentage of the light as the light travels inside the same optical fibre 6.

[0041] In other words, the optical fibre 6 is preferably a radially emitting optical fibre.

[0042] Preferably, the light source 5 is, in turn, a laser light source, i.e. a light source capable of emitting, on command, a laser beam *r* (namely an extremely-concentrated and collimated, coherent and monochromatic light beam) towards the intermediate lens 7 and the behind-located proximal end 6a of optical fibre 6.

[0043] With reference to Figures 2 and 3, the intermediate lens 7, on the other hand, is preferably a substantially plane-convex converging lens and is preferably arranged abutting on the proximal end 6a of optical fibre 6.

[0044] In other words, the front or light entry face of the intermediate lens 7 has a convex shape, while the rear or light exit face of intermediate lens 7 is substantially plane and preferably also rests on the proximal end 6a of optical fibre 6.

[0045] In addition, the intermediate lens 7 preferably has a diameter greater than that of the proximal end 6a of optical fibre 6, and is preferably rigidly fixed to the proximal end 6a of optical fibre 6.

[0046] In the example shown, moreover, the front face of intermediate lens 7 is preferably substantially spherical or aspherical.

[0047] The light source 5, on the other hand, is preferably arranged spaced in front of the intermediate lens 7, at a distance *d* from the light source 5, or rather from the emitter of laser light source, preferably lower than or equal to 0,5 mm (millimetres) and more conveniently

ranging between 0,1 and 0,3 mm (millimetres).

[0048] With reference to Figure 2, preferably the lighting assembly 4 moreover comprises an electronic control unit 8 that powers and/or commands the light source 5, and is preferably placed inside the rear body 2, optionally close to the bottom of the same rear body 2.

[0049] The electronic control unit 8 is adapted to activate and deactivate the light source 5 on the basis of an external command signal.

[0050] In other words, the external command signal commands the emission of the laser beam *r*.

[0051] With reference to Figures 1, 2 and 3, in addition the lighting assembly 4 moreover comprises: at least one proximal photometric sensor 9 which is arranged beside the light source 5, or rather beside the emitter of laser light source, and/or beside the intermediate lens 7, so as to capture/ detect the light which is reflected/dispersed by the intermediate lens 7 when the light, or rather the laser beam *r*, enters the lens 7; and preferably also at least one distal photometric sensor 10 which is placed in front of the distal end 6b of optical fibre 6, and is adapted to capture/detect the light exiting from the distal end 6b of optical fibre 6.

[0052] The intermediate lens 7 moreover has, on its front face or light entry face, a small surface notch or chamfer 7a, which is adapted to direct/reflect the incident light at least in part towards the proximal photometric sensor 9.

[0053] The electronic control unit 8, in turn, is preferably adapted to command the light source 5, or rather the laser light source, also on the basis of the signals coming from said at least one proximal photometric sensor 9, and optionally also on the basis of the signals coming from said at least one distal photometric sensor 10.

[0054] More in detail, the electronic control unit 8 is preferably programmed/configured so as to autonomously switch off/deactivate the light source 5 when the intensity of the light detected by the proximal photometric sensor 9 deviates from a corresponding predetermined first reference value.

[0055] Preferably, the electronic control unit 8 is moreover programmed/configured so as to autonomously switch off/ deactivate the light source 5 when the intensity of the light detected by the proximal photometric sensor 10 deviates from a corresponding predetermined second reference value.

[0056] In other words, the electronic control unit 8 is programmed/configured so as to activate and deactivate the light source 5 on the basis of the external command signal. In addition, the electronic control unit 8 is additionally programmed/configured so as to automatically deactivate the light source 5 when the intensity of the laser light detected by the proximal photometric sensor 9 deviates from said first reference value, and preferably also when the intensity of the light detected by the distal photometric sensor 10 deviates from said second reference value.

[0057] More in detail, the electronic control unit 8 is

preferably programmed/configured so as to automatically deactivate the light source 5 when the intensity of the light detected by the proximal photometric sensor 9 moves outside a given first tolerance interval which is astride of said first reference value, and is preferably also substantially centred on said first reference value.

[0058] In addition, the electronic control unit 8 is preferably also programmed/configured so as to automatically deactivate the light source 5 when the intensity of the light detected by the distal photometric sensor 10 moves outside a given second tolerance interval which is astride of said second reference value, and is preferably also substantially centred on said second reference value.

[0059] Preferably, said first reference value and/or said second reference value is/are also a function of the power/intensity of the light beam emitted by the light source 5.

[0060] In addition or alternatively, the electronic control unit 8 is preferably programmed/configured so as to autonomously deactivate the light source 5 to interrupt/prevent the emission of the light beam, or rather of the laser beam *r*, when the ratio between the intensity of the light detected by the proximal photometric sensor 9 and the intensity of the light detected by the distal photometric sensor 10 deviates from a predetermined third reference value.

[0061] In other words, the electronic control unit 8 is preferably also programmed/configured so as to automatically deactivate the light source 5 when the ratio between the intensity of the light detected by the proximal photometric sensor 9 and the intensity of the light detected by the distal photometric sensor 10 moves outside a given third tolerance interval, which is astride of said third reference value, and is preferably also substantially centred on said third reference value.

[0062] Clearly, said third reference value is a constructive parameter which is a function of the structural characteristics of the optical fibre 6, such as for example the length of the optical fibre and/or the radial emittance/dispersion coefficient of the optical fibre 6.

[0063] Preferably, the first reference value and/or the second reference value and/or the third reference value is/are moreover stored inside the electronic control unit 8.

[0064] In a less sophisticated embodiment, however, the electronic control unit 8 could be programmed/configured so as to autonomously switch off/deactivate the light source 5 only on the basis of the ratio between the light intensity detected by the proximal photometric sensor 9 and the light intensity detected by the distal photometric sensor 10.

[0065] With reference to Figures 1 and 2, in the example shown, in particular, at least one (two sectors in the example shown) of the transparent or semitransparent sectors of front half-shell 3, hereafter denoted with the reference numeral 3a, additionally has a narrow and elongated shape, i.e. it is substantially ribbon-like.

[0066] The lighting assembly 4 adapted selectively to backlight the/each transparent or semitransparent ribbon-like sector 3a of front half-shell 3, preferably comprises:

a radially-emitting optical fibre 6 that extends inside the rear body 2 so that at least a portion/segment of the optical fibre is locally substantially skimmed over the ribbon-like sector 3a to be backlighted, preferably substantially for the entire length of the ribbon-like sector 3a; and an electrically-powered light source 5 which is placed inside the rear body 2 directly facing and aligned to the intermediate lens 7, and is capable of emitting, on command and towards the intermediate lens 7, a light beam, or rather a laser beam *r*, which crosses the intermediate lens 7 and enters into the optical fibre 6 through the proximal end 6a of the fibre.

[0067] Preferably, the optical fibre 6 moreover has an external diameter lower than 5 mm (millimetres) and more conveniently lower than 1,2 mm (millimetres).

[0068] Moreover, with reference to Figures 1, 2 and 3, the optical fibre 6 is preferably also sustained/supported by a rigid bearing structure, which is integral with rear body 2 and is preferably made of plastic material.

[0069] More in detail, the optical fibre 6 is preferably fixed on the front sidewall of a rigid and preferably made of opaque plastic material, support plate 11 that is arranged inside the rear body 2 with its front sidewall directly facing the front half-shell 3, or rather the corresponding ribbon-like sector 3a preferably substantially for the entire length of the same ribbon-like sector 3a, and with its rear sidewall facing the bottom of rear body 2. Clearly, the support plate 11 could also protrude in cantilevered from the bottom of rear body 2.

[0070] With reference to Figures 1, 2 and 3, additionally the lighting assembly 4 preferably also comprises centring and fixing mechanical members 12, which are adapted to rigidly connect the proximal end 6a of optical fibre 6 to the light source 5, or rather to the emitter of laser light source, and which are structured so as to stably keep the proximal end 6a of optical fibre 6 centred and stationary in front of the light source 5, or rather of the emitter of the laser light source, and/or of the intermediate lens 7. Preferably, the intermediate lens 7 is moreover fixed to said centring and fixing mechanical members 12.

[0071] More in detail, the centring and fixing members 12 are preferably structured to directly support the intermediate lens 7 and to keep the proximal end 6a of optical fibre 6 stationary in front of the intermediate lens 7 and preferably in abutment on intermediate lens 7. In addition, the centring and fixing members 12 are preferably structured so as to keep the proximal end 6a of optical fibre 6 and the intermediate lens 7 stationary in front of the light source 5, or rather of the emitter of the laser light source, preferably at a distance *d* from the light source 5, or rather from the emitter of the laser light source, lower than 0,5 mm (millimetres) and more conveniently ranging between 0,1 and 0,3 mm (millimetres).

[0072] In the example shown, in particular, the centring and fixing members 12 are preferably structured so as to contain/accommodate the intermediate lens 7 and to stably keep the proximal end 6a of optical fibre 6 in abut-

ments against the rear face of intermediate lens 7. Preferably, the centring and fixing members 12 are moreover structured so as to stably keep the intermediate lens 7 at a distance d from the light source 5, or rather from the emitter of the laser light source, ranging between 0,2 and 0,25 mm (millimetres).

[0073] The electronic control unit 8, in turn, is preferably programmed/configured so as to activate and deactivate the light source 5 on the basis of the external command signal.

[0074] Moreover, the electronic control unit 8 is preferably also programmed/configured so as to automatically switch off /deactivate the light source 5 when the intensity of the light detected by the proximal photometric sensor 9 deviates/ varies at least by 3% with respect to said first reference value, and/or when the intensity of the light detected by the distal photometric sensor 10 deviates/varies by at least 3% with respect to said second reference value.

[0075] In other words, in the example shown, the first tolerance interval preferably has a width equal to 6% of said first reference value. Similarly, the second tolerance interval preferably has a width equal to 6% of said second reference value

[0076] In addition, the electronic control unit 8 is preferably also programmed/configured so as to automatically deactivate the light source 5 when the ratio between the intensity of the light detected by the proximal photometric sensor 9 and the intensity of the light detected by the distal photometric sensor 10 moves away/deviates by at least 10% from said third reference value.

[0077] In other words, in the example shown, the third tolerance interval preferably has a width equal to 20% of said third reference value.

[0078] With reference to Figures 2 and 3, preferably the proximal photometric sensor 9 and the light source 5, or rather the emitter of the laser light source, are moreover placed/fixed one next to the other, on a small printed circuit board 13 which, in turn, is placed/fixed inside the rear body 2 of lighting apparatus 1, close to the proximal end 6a of optical fibre 6.

[0079] In addition, the distance between the light source 5, or rather the emitter of the laser light source, and said at least one proximal photometric sensor 9 is preferably lower than or equal to 10 mm (millimetres), and more conveniently ranges between 1 and 8 mm (millimetres).

[0080] Preferably, the proximal photometric sensor 9 is also a photodiode. Similarly, the distal photometric sensor 10 is preferably a photodiode.

[0081] In the example shown, moreover, the lighting assembly 4 is preferably also provided with at least one temperature sensor 14 which is adapted to continuously detect the temperature of the light source 5, or rather of the emitter of the laser light source, and is preferably placed on the printed circuit board 13, in contact with or in any case close to the light source 5, or rather to the emitter of the laser light source.

[0082] In addition, the electronic control unit 8 is preferably also connected to the temperature sensor 14, and is preferably adapted to amplify the signals coming from the proximal photometric sensor 9 and/or the signals coming from the distal photometric sensor 10 as a function of the current temperature of the light source 5, or rather of the emitter of the laser light source.

[0083] Finally, with particular reference to Figure 3, in the example shown the centring and fixing mechanical members 12 preferably comprise: a rigid and preferably made of plastic or metallic material, support socket 15 which is stably fixed on the printed circuit board 13 so as to extend as a bridge over the light source 5, or rather over the emitter of the laser light source, and over the proximal photometric sensor 9; and a ferrule connector 16 preferably made of metallic material, which is adapted to be fitted and firmly locked onto the proximal end 6a of optical fibre 6, and is also adapted to be screwed onto a corresponding threaded portion of support socket 15, so as to firmly fix the proximal end 6a of optical fibre 6 to the support socket 15.

[0084] The threaded portion of the support socket 15 is preferably placed immediately over the light source 5, or rather immediately over the emitter of the laser light source.

[0085] The ferrule connector 16, on the other hand, is preferably structured so as to be screwed onto the threaded portion of support socket 15 in order to arrange and lock the proximal end 6a of optical fibre 6 spaced over the light source 5, or rather over the emitter of the laser light source.

[0086] Preferably, the ferrule connector 16 is moreover structured to directly support the intermediate lens 7, and to interpose the intermediate lens 7 between the proximal end 6a of optical fibre 6 and the light source 5, or rather the emitter of the laser light source.

[0087] Clearly in a different embodiment, the intermediate lens 7 could be fixed firmly on the support socket 15 spaced over the light source 5, or rather over the emitter of the laser light source, and beneath the threaded portion of - support socket 15. In this case, the ferrule connector 16 is preferably structured so as to be screwed onto the threaded portion of support socket 15 in order to arrange and stably lock the proximal end 6a of optical fibre 6 behind the intermediate lens 7, preferably in abutment on the rear face of the intermediate lens 7.

[0088] General operation of lighting apparatus 1 is easy inferable from what written above.

[0089] As regards instead the operation of lighting assembly 4, the electronic control unit 8 activates and deactivates the light source 5 on the basis of the external command signal.

[0090] Due to the air/glass interface, when the light, or rather the laser beam, enters the intermediate lens 7 to reach the proximal end 6a of optical fibre 6, a very small amount of light is reflected back (Fresnel reflections), towards the light source 5 and towards the proximal photometric sensor 9.

[0091] Thanks to its geometry, the intermediate lens 7 is capable of minimizing and bringing almost to zero the amount of light that is reflected back towards the light source 5 and towards the proximal photometric sensor 9. However, the presence of the surface notch or chamfer 7a allows to deviate /reflect in any case a very small part of the incident light towards the proximal photometric sensor 9, allowing to the latter to detect something.

[0092] Clearly, the intensity of the light reflected back towards the proximal photometric sensor 9 has a value proportional to the power of the light beam, or rather of the laser beam *r*, emitted by the light source 5.

[0093] In addition, if the power of the light beam does not vary, the intensity of the light reflected back towards the proximal photometric sensor 9 remains substantially constant as long as the intermediate lens 7 and the rearward proximal end 6a of optical fibre 6 are perfectly aligned and coupled to the light source 5.

[0094] Clearly, any variation in the position of the intermediate lens 7 and/or of the proximal end 6a of optical fibre 6 with respect to the ideal position causes a variation in the intensity of the light directed towards the proximal photometric sensor 9.

[0095] Consequently, if the power of the light beam, or rather of the laser beam *r*, remains constant, any variation in the light energy detected by the proximal photometric sensor 9 is indicative of the breakage of optical fibre 6, of the incorrect positioning of intermediate lens 7 and/or of the optical fibre 6 with respect to the light source 5, perhaps due to the occurred breakage of the lighting apparatus 1, or to the incorrect assembly/optical coupling of intermediate lens 7 and of optical fibre 6 with respect to the light source 5.

[0096] The distal photometric sensor 10, on the other hand, detects the intensity of the light exiting from the distal end 6b of optical fibre 6. If the optical fibre 5, the intermediate lens 7 and the optical fibre 6 are correctly dimensioned, the amount of light that reaches the distal end 6b of the optical fibre 6 and is dispersed outside the optical fibre is minimal, but is still present.

[0097] Clearly, the intensity of the light coming out from the distal end 6b of the optical fibre is in any case proportional to the power of the light beam, or rather of the laser beam *r*, emitted by the light source 5.

[0098] Also in this case, if the power of the light beam, or rather of the laser beam *r*, remains constant, any variation of the light energy detected by the distal photometric sensor 10 is indicative of the breakage of the optical fibre 6, or of the incorrect positioning of optical fibre 6 on the relative supporting structure, or rather on the sidewall of support plate 11, probably due to the occurred breakage of the lighting apparatus 1.

[0099] The electronic control unit 8 is programmed/configured so as to activate and deactivate the light source 5 on the basis of the external command signal.

[0100] In addition, the electronic control unit 8 is programmed /configured so as to autonomously switch

off/deactivate the light source 5 when the intensity of the light detected by the proximal photometric sensor 9 deviates from said first predetermined reference value; and/or when the intensity of the light detected by the distal photometric sensor 10 deviates from said second predetermined reference value; and/or when the ratio between the intensity of the light detected by the proximal photometric sensor 9 and the intensity of the light detected by the distal photometric sensor 10 deviates from said third predetermined reference value.

[0101] The lighting assembly 4 thus configured prevents the light beam emitted by the light source 5 from being accidentally directed outside of the lighting apparatus 1 in the event of a broken or badly arranged optical fibre 6.

[0102] The advantages connected to the particular structure of the lighting assembly 4 are noteworthy.

[0103] Firstly, the presence of the intermediate lens 7 allows to channel almost all of the light emitted by the light source 5 towards the proximal end 6a of the optical fibre 6. In addition, the presence of the surface notch or chamfer 7a on the front face of lens 7 allows to divert a very small amount of light towards the proximal photometric sensor 9, thus allowing the electronic control unit 8 to deactivate the light source 5 promptly in the event of breakage of the lighting apparatus 1.

[0104] In other words, the intermediate lens 7 minimizes the leaks of light on entering into the optical fibre 6, while the surface notch or chamfer 7a suitably directs the few light leaks towards the proximal photometric sensor 9 allowing the operation of the electronic control unit 8.

[0105] In addition, the use of the ratio between the intensity of the light detected by the proximal photometric sensor 9 and the intensity of the light detected by the distal photometric sensor 10, as a reference parameter for the automatic deactivation of the light source 5, makes the lighting assembly 4 very reliable and safe.

[0106] By using this reference parameter, in fact, the automatic deactivation of the light source 5 becomes independent of the intensity of the light beam, or rather of the laser beam *r*, momentarily emitted by the light source 5, allowing to eliminate the operating problems resulting from the considerable performance differences found in laser light sources currently on the market.

[0107] The power of the laser beam *r* emitted by the laser light sources currently on the market, in fact, can vary significantly and suddenly depending on the production batch of the laser light source, on the age of the laser light source, on the temperature reached by the emitter of the laser light source, and/or on the intensity of the electric current circulating at that moment in the emitter of the laser light source.

[0108] It is finally clear that modifications and variations can be made to the lighting apparatus 1 and to the lighting assembly 4 described above without however departing from the scope of the present invention.

[0109] For example, the optical fibre 6 could be structured so as to channel light from the proximal end 6a to

the distal end 6b for total internal reflection, substantially without leaks along its entire length.

[0110] In other words, the optical fibre 6 could be a conventional optical fibre.

[0111] In a less sophisticated and not-shown embodiment, in addition, the light source 5 of lighting assembly 4 could be a LED (acronym for Light Emitting Diode) possibly surmounted by an optical collimator capable of collimating the light rays emitted by the LED towards the intermediate lens 7.

[0112] In a more sophisticated not-shown embodiment, moreover, the lighting assembly 4 could be provided with two proximal photometric sensors 9 arranged on opposite sides of the light source 5, or rather of the emitter of the laser light source. The front face of intermediate lens 7, in turn, could be provided with two different surface notches or chamfers 7a, which are adapted to direct/reflect the incident light each towards a respective proximal photometric sensor 9.

[0113] Finally, the lighting apparatus 1 can be also located inside the motor vehicle, for example to illuminate all or part of the passenger compartment of the vehicle.

[0114] With reference to Figures 4 and 5, in particular, the lighting apparatus 1 can be advantageously placed/incorporated within the door 100 of the vehicle, in order to illuminate the surrounding space.

[0115] In other words, the rear body 2 is adapted to be firmly fixed to the vehicle, inside the same vehicle.

[0116] In the example shown, in particular, the lighting apparatus 1 is preferably oblong in shape, and is preferably recessed into the inner coating panel 101 of the door 100 so as to form a light strip that illuminates the armrest area.

[0117] More in detail, in the example shown, the rear body 2 is preferably oblong in shape and is firmly fixed or incorporated into the panel 101 of door 100. The front half-shell 3, on the other hand, preferably has a ribbon-like structure and is arranged to close the mouth of the rear body 2, preferably substantially along the entire length of the rear body 2.

[0118] The optical fibre 6 extends inside the rear body 2, preferably substantially along the entire length of the latter.

[0119] Preferably, the optical fibre 6 is moreover fixed to the crest of a longitudinal rib 110 protruding inside the rear body 2, preferably substantially along the entire length of the latter or of the optical fibre 6.

[0120] In addition, the inner surface of rear body 2 preferably also has a metallic mirror finishing so as to reflect the incident light towards the front half-shell 3.

[0121] In other words, in this embodiment the lighting apparatus 1 is preferably provided with a single lighting assembly 4 which is adapted to backlight the entire front half-shell 3.

[0122] In addition, in this embodiment, the light source 5 can also be arranged outside of the rear body 2, preferably on the back of panel 101, i.e. inside the door 100.

[0123] Clearly, the lighting apparatus 1 can be incor-

porated also in the dashboard of the vehicle, for example for illuminating or backlighting the perimeter of the instrument panel, or inside the central console, for example for illuminating or backlighting a control panel placed therein.

Claims

1. An automotive lighting apparatus (1) provided with a lighting assembly (4) comprising: an optical fibre (6) of predetermined length; an electrically-powered light source (5), which is placed in front of a proximal end (6a) of the optical fibre (6), and is selectively adapted to direct, towards the same proximal end (6a), a light beam that enters and travels inside the optical fibre (6); and an intermediate lens (7) which is interposed between the proximal end (6a) of the optical fibre (6) and the light source (5), and is adapted to direct the light exiting from the light source (5) towards the behind-located proximal end of the optical fibre (6);
said lighting apparatus being **characterized in that** the lighting assembly (4) additionally comprises at least one proximal photometric sensor (9) which is arranged beside the collimated light source (5) and/or the intermediate lens (7), so as to capture/detect the light that is reflected/ dispersed by said intermediate lens (7); **and in that** the intermediate lens (7) has, on its front face, at least one surface chamfer or notch (7a) which is adapted to direct/ reflect the incident light at least partly towards said at least one proximal photometric sensor (9).
2. Lighting apparatus according to Claim 1, wherein the intermediate lens (7) is spaced from said light source (5) and/or abutts on the proximal end (6a) of said optical fibre (6).
3. Lighting apparatus according to Claim 1 or 2, wherein the intermediate lens (7) is rigidly fixed to said optical fibre (6).
4. Lighting apparatus according to Claim 1, 2 or 3, wherein the intermediate lens (7) is a converging lens and is adapted to focus the light exiting from said light source (5) towards the behind-located proximal end of the optical fibre (6).
5. Lighting apparatus according to Claim 4, wherein the intermediate lens (7) is a substantially plane-convex lens.
6. Lighting apparatus according to any one of the preceding claims, wherein the front face of the intermediate lens (7) is substantially spherical or aspherical in shape.

7. Lighting apparatus according to any one preceding claim, wherein the intermediate lens (7) has a diameter greater than the proximal end (6a) of the optical fibre (6).
8. Lighting apparatus according to any one of the preceding claims, wherein the lighting assembly (4) moreover comprises centring and fixing mechanical members (12) that are adapted to connect the proximal end (6a) of the optical fibre (6) rigidly to the light source (5), and are structured so as to stably keep the proximal end (6a) of the optical fibre (6) centred and stationary in front of said light source (5) and/or said intermediate lens (7).
9. Lighting apparatus according to Claim 8, wherein the intermediate lens (7) is supported by said centring and fixing members (12).
10. Lighting apparatus according to any one of the preceding claims, wherein said optical fibre (6) is a radially-emitting optical fibre and/or wherein said light source (5) is a laser light source.
11. Lighting apparatus according to any one of the preceding claims, wherein the lighting assembly (4) additionally comprises a distal photometric sensor (10) which is placed in front of the distal end (6b) of the optical fibre (6), and is adapted to capture/detect the light exiting from the distal end (6b) of the optical fibre (6).
12. Lighting apparatus according to any one of the preceding claims, wherein the intermediate lens (7) is arranged spaced in front of the light source (5), at a distance (d) lower than or equal to 0,5 mm.
13. Lighting apparatus according to any one of the preceding claims, wherein the lighting assembly (4) additionally comprises an electronic control unit (8) which is adapted to power and/or command said light source (5) on the basis of the signals coming from said at least one proximal photometric sensor (9).
14. Lighting apparatus according to Claim 13, wherein the electronic control unit (8) is adapted to power and/or command said light source (5) also on the basis of the signals coming from said at least one distal photometric sensor (10).
15. Lighting apparatus according to any one of the preceding claims, **characterized by** additionally comprising:
a substantially basin-shaped rear body (2), which is adapted to be fixed to the vehicle; and a front half-shell (3) arranged to close the mouth of said rear body (2); the lighting assembly (4) being located inside the rear body (2) and being able to backlight,
- on command, a corresponding transparent or semi-transparent sector of the front half-shell (3).
16. The lighting apparatus according to any one of the preceding claims, wherein the lighting apparatus (1) is an automotive headlight or a taillight.

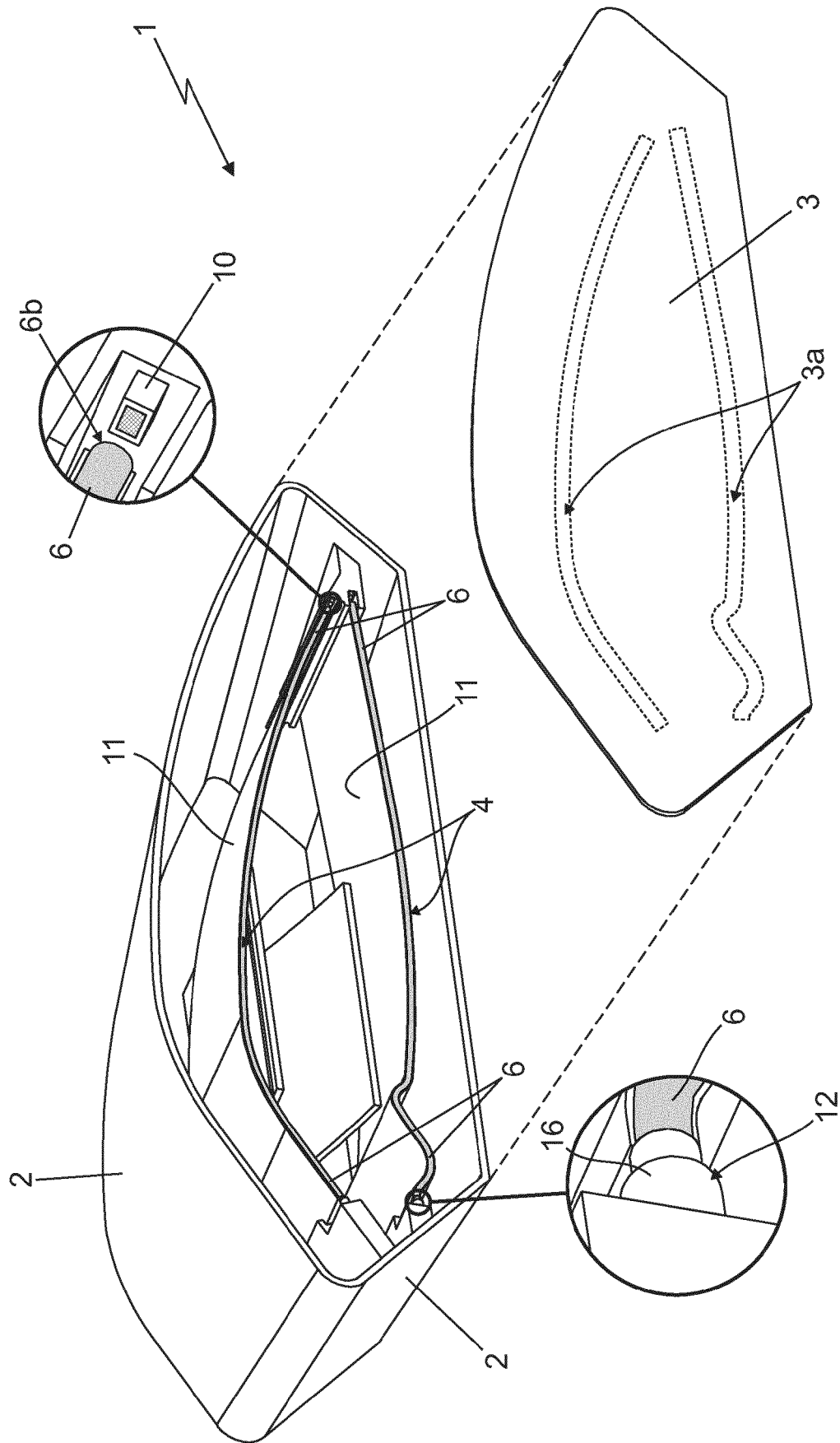


Fig. 1

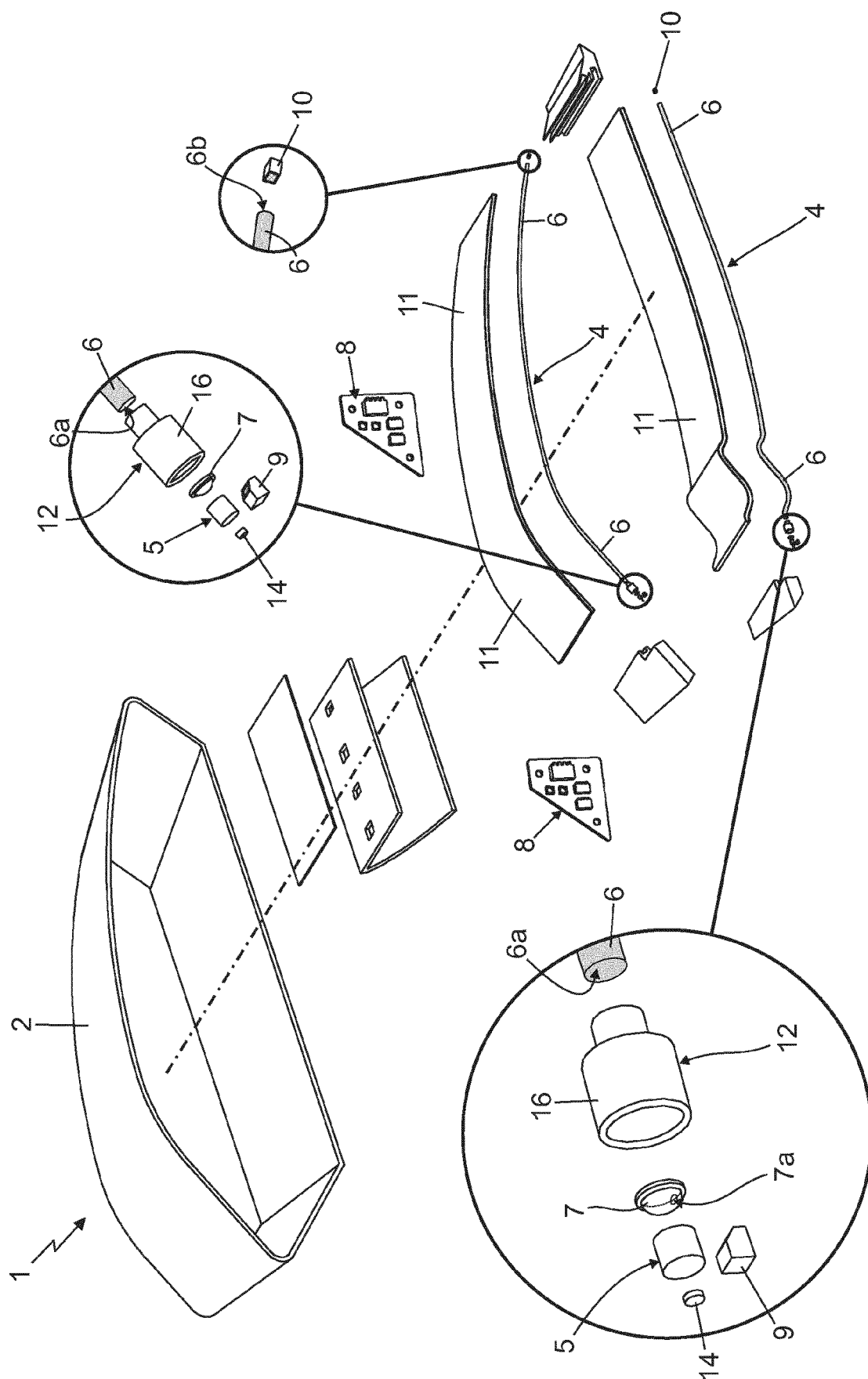


Fig. 2

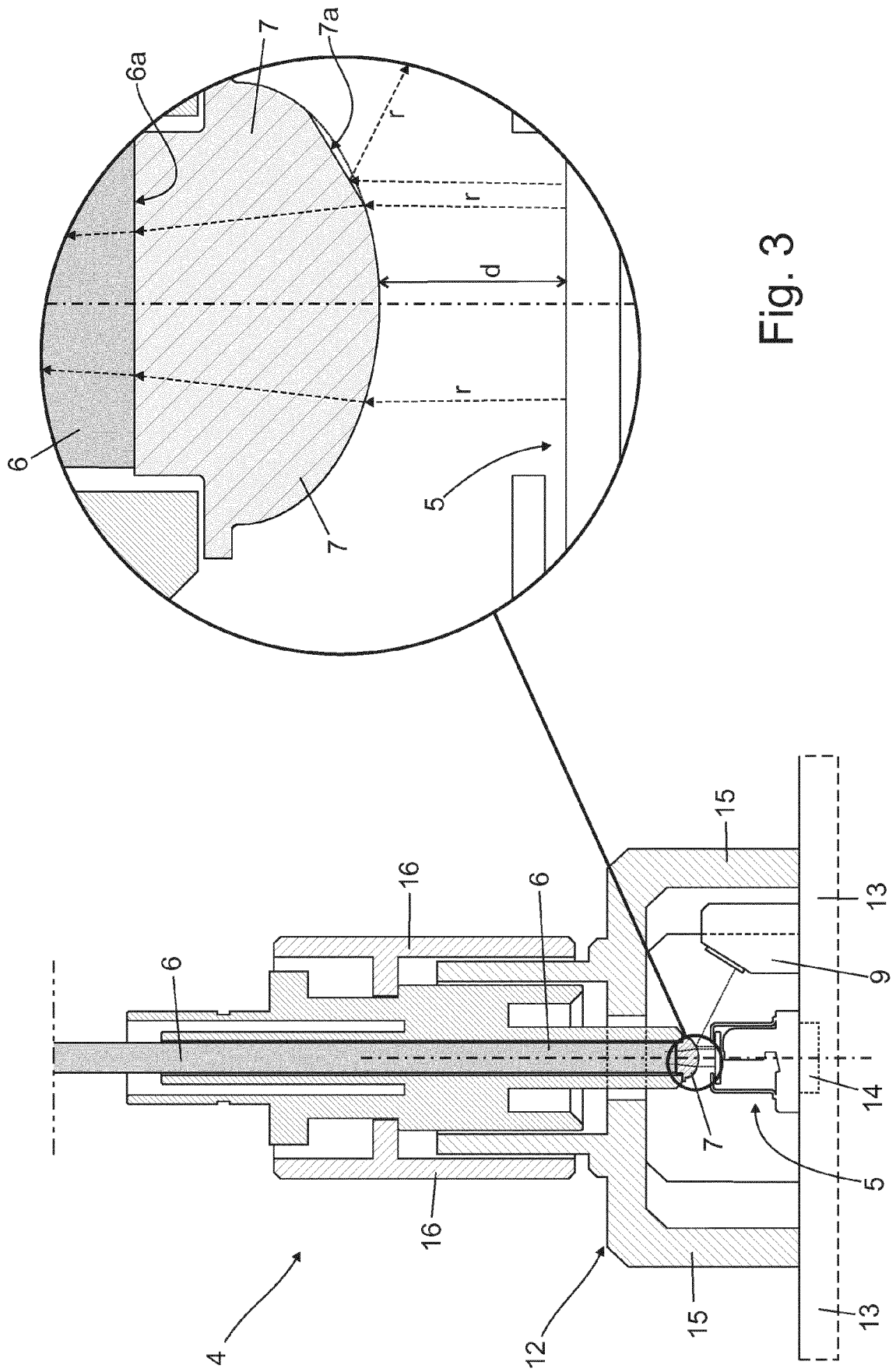


Fig. 3

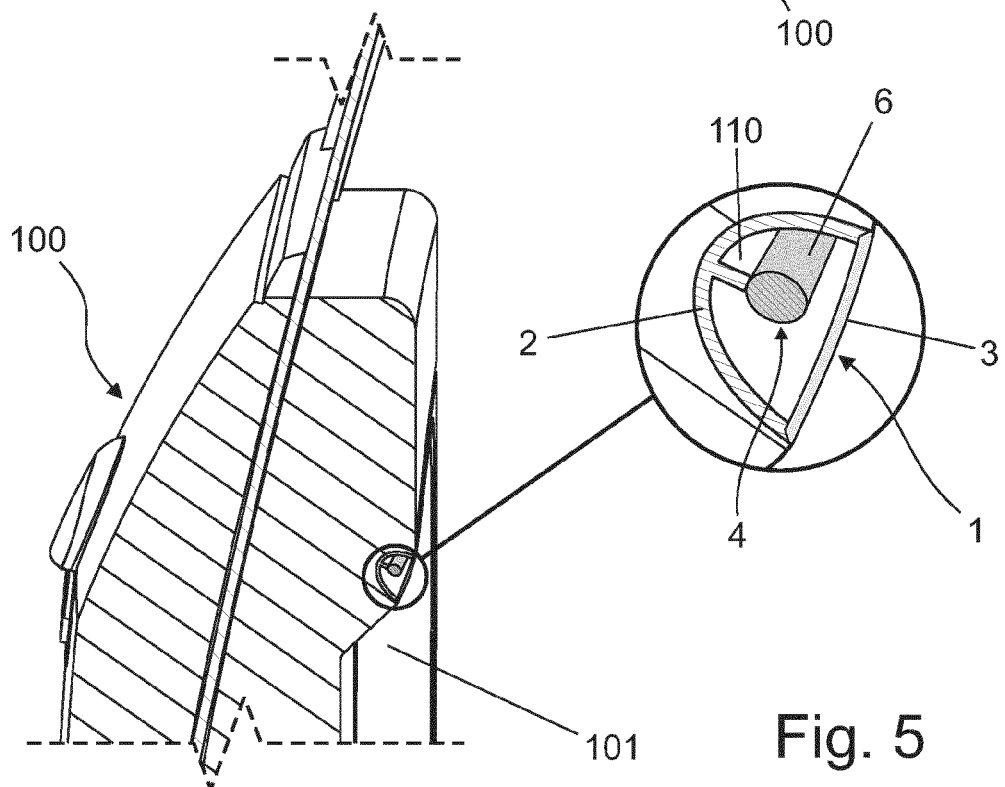
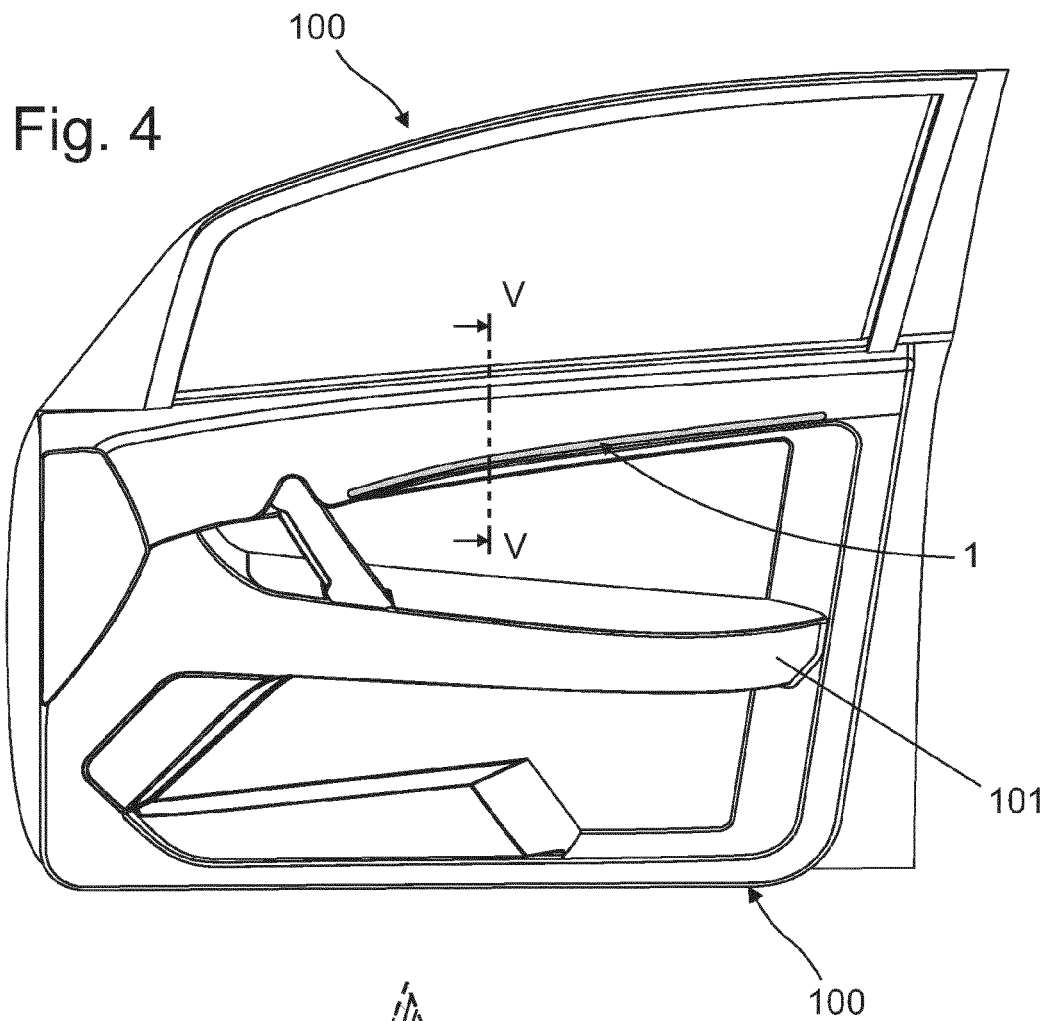


Fig. 5



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