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(71) Applicants:  
• **Automotive Lighting Italia S.p.A.**  
**10078 Venaria Reale (Torino) (IT)**  
• **PSA Automobiles SA**  
**78300 Poissy (FR)**

(72) Inventors:  
• **GONCALVES, Whilk Marcelino**  
**78300 POISSY (FR)**

• **LE DALL, Christophe**  
**78300 POISSY (FR)**  
• **BORE, Michael**  
**78300 POISSY (FR)**  
• **ZATTONI, Sergio**  
**10078 VENARIA REALE (IT)**  
• **RENARD, Stephanie**  
**10078 VENARIA REALE (IT)**  
• **CERONE, Roberto**  
**10078 VENARIA REALE (IT)**

(74) Representative: **Plebani, Rinaldo et al**  
**Studio Torta S.p.A.**  
**Via Viotti, 9**  
**10121 Torino (IT)**

(54) **MODULAR LIGHTING DEVICE FOR VEHICLE HEADLAMP**

(57) Vehicle lighting device (1) including a main lighting module (7), secondary lighting modules (8) carried rotatable in relation to the main lighting module, each around a first axis (A,B,C), which are arranged parallel to each other, and around at least a second axis (D) arranged perpendicular to the first axes, and a control unit (13); the main lighting module being designed to generate a first light beam (DB) configured for a dipped beam function and a second light beam (HB) configured for a high beam function, forming on a test screen a first and second light projections (LP1,LP2); the secondary lighting modules (8) being designed to generate each a third light beam (LB) forming on the test screen a third light projections (T1-T3); the control unit (13) being configured to rotate the secondary lighting modules (8) to overlap all the third light projections (T1-T3) onto one another and onto the second light projection (LP2), substantially at the center thereof.

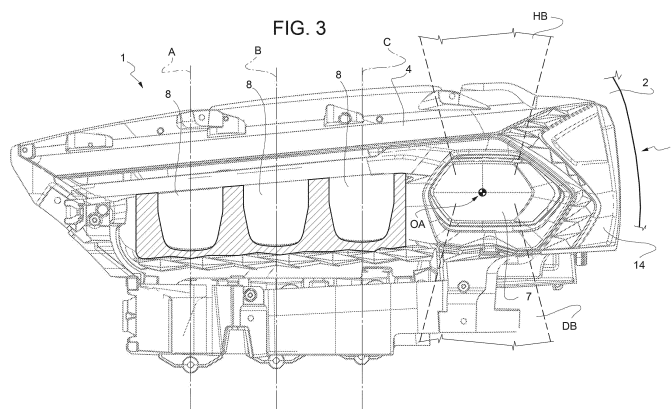


FIG. 4

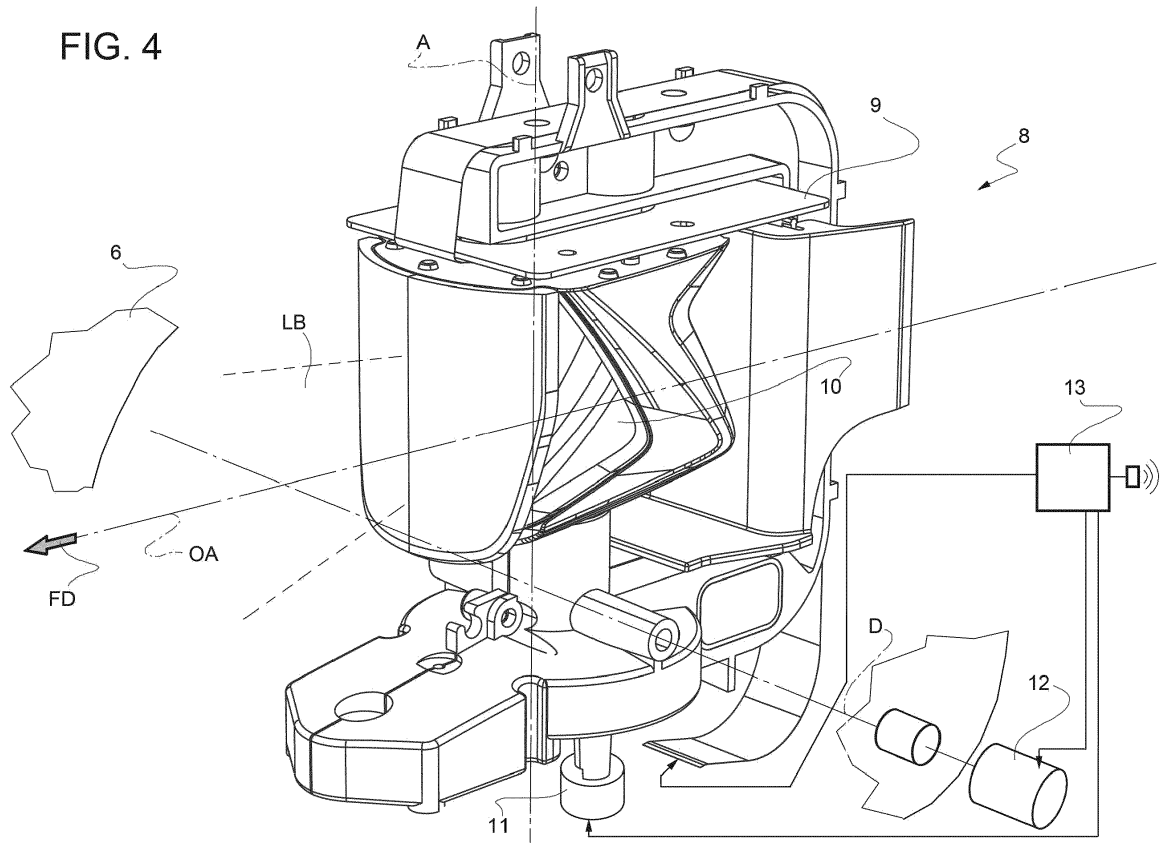
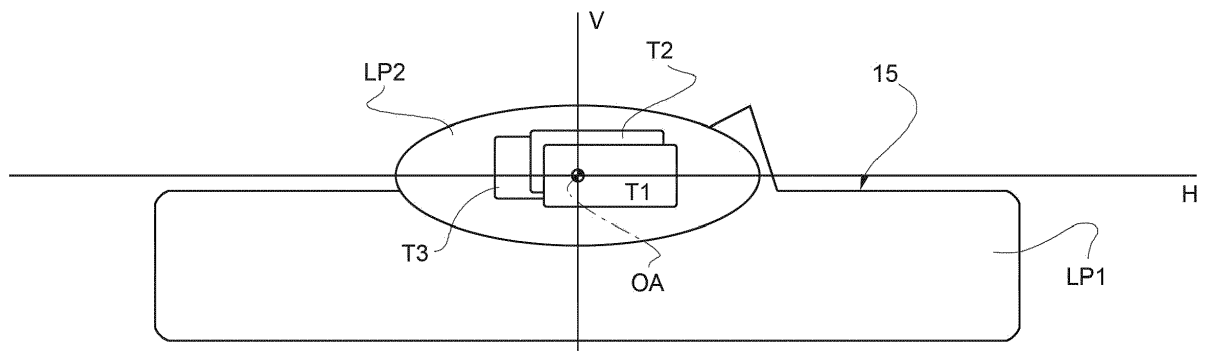


FIG. 5



## Description

### Technical field of the invention

[0001] The present invention relates to a modular lighting device for vehicles, equipped with a main lighting module and with a plurality (i.e. at least two) of secondary lighting modules having a double rotation capability in order to create selectively a combined overall high beam and a combined dipped/low beam, both formed by at least in part superimposing at a prefixed distance from the lighting device the projections of the individual light beams generated by each single lighting module, such as to provide a better forward illumination and a smooth passage from the dipped/low beam generation to the high beam generation.

### Technical Background

[0002] Lighting devices for vehicles comprising a plurality of individual lighting module, some of which are provided with rotating elements, like e.g. a rotating reflector, are known in the art.

[0003] EP2902701 discloses a lighting device having a fixed light source consisting of a LED and a rotating support having two opposite faces, one constituting a reflector and the other realizing a second function, e.g. an aspect function; a fixed motor rotates the support with respect to the fixed light source in order to bring selectively the two faces on the front side of the device facing toward the direction of motion of the vehicle.

[0004] WO2016083689 discloses a modular lighting device equipped with one main lighting module, which is fixed, and with a plurality, e.g. three, of secondary lighting modules each of which generate a light beam which may be rotated sequentially both in elevation and azimuth around an horizontal axis and a vertical axis of each secondary lighting module, respectively, in order to form differently shaped overall forward light beams.

[0005] While the lighting device of WO2016083689 is satisfactory for obtaining a dipped/low light beam of a desired shape, e.g. having an oblique cut-off line oriented either on the right side or the left side of the overall light beam with the same device, it is not satisfactory if a high beam has to be generated. Moreover, the passage from generating the dipped/low beam to generating the high beam may create a discontinuity in the generation of the light beam and may be anyway annoying for the driver of the vehicle equipped with such lighting device.

### Summary of the invention

[0006] The object of the present invention is to provide a lighting device for vehicles comprising at least one main lighting module and a plurality (e.g. at least two) of secondary lighting modules, at least the secondary lighting modules being provided with rotation capabilities around two different axes arranged perpendicular to each other,

which is free from the drawbacks of the prior art and in particular is designed to generate selectively both a dipped/low forward light beam and a high forward light beam having both optimal illumination performances and which is at the same time of simple, compact, cost-effective construction and is highly reliable, and wherein the passage from the generation of the dipped/low beam to the generation of the high beam is smooth and gradual, do not provide lighting discontinuities and avoid the driver of the vehicle to be annoyed by the passage from dipped/low beam to high beam.

[0007] According to the invention, therefore, a lighting device for vehicles is provided having the features set out in the appended claims.

### Brief description of the drawings

[0008] Further features and advantages of the present invention will become more apparent from the following description of one non-limiting embodiment thereof, made with reference to the figures in the accompanying drawings, in which:

- figure 1 and 2 show schematically a light distribution (as it appears on the standard test screen at 25 m) generated by a prior art lighting device, e.g. of the type of that of WO2016083689, when the dipped/low beam (figure 1) and the high beam (figure 2) functions are activated;
- figure 3 shows schematically a front elevation view of a lighting device for vehicles according to the invention;
- figure 4 shows in an enlarged scale a perspective view seen three quarter from the front, i.e. from the side facing the forward driving direction of the vehicle, of a rotating lighting module of the lighting device of figure 3;
- figure 5 shows, still schematically, the light distributions (as it appears on the standard test screen at 25 m) which can be generated by the lighting device of the invention; and
- figure 6 shows schematically an example of a trajectory of a light projection generated on the standard test screen at 25 m by a secondary lighting module when the lighting device of the invention switches from the dipped/low beam to the high beam.

### Detailed description

[0009] With reference to figures 3 and 4, reference number 1 indicates as a whole a lighting device for vehicles, in the non-limiting embodiment shown, a vehicle headlight assembly, which is only schematically shown from the front, with parts, which are not essential for describing the invention, removed for sake of simplicity.

[0010] The lighting device 1 is designed to be assembled on a vehicle 2 (shown only schematically and only in part in figure 3) on an outboard side 3 of the vehicle

2, facing the forward driving direction FD of the vehicle 4, indicated by an arrow in figure 4.

**[0011]** The lighting device 1 comprises a generally cup-shaped housing body 4, shown only in part in figure 3, which housing body 4 is designed to be mounted on vehicle 2 in a known manner. The housing body 4 is made of synthetic plastic material by injection molding and has a front inlet opening 5 in use facing opposite to the vehicle 2 and toward the forward driving direction FD of the vehicle 1; the front inlet openings 5 is closed by a transparent cover 6 (figure 4), normally constituted by a terse lens (i.e. a transparent lens not provided with optical functions).

**[0012]** According to one aspect of the present invention, the housing body 4 carries at the interior thereof at least one main lighting module 7 and at least two, preferably three or more, in the embodiment shown three, secondary (or auxiliary) lighting modules 8, arranged side by side to one another and all at the same side of the main lighting module 7, opposite to the outboard side 3 of vehicle 2.

**[0013]** All the lighting modules 7 and 8 may be visible from the outside through the transparent cover 6 closing the inlet openings 5.

**[0014]** Of course the lighting device 1 may include more than one main lighting module 7, e.g. two arranged side by side, e.g. at the outboard side 3 of vehicle 2.

**[0015]** The housing body 4 is designed to be mounted in a known manner on vehicle 2 with the front inlet opening 5 arranged to face in use toward the forward driving direction FD; the main lighting module 7 and the at least two (three in the embodiment shown) secondary lighting modules 8 are arranged inside the housing body 4 facing the inlet opening 5.

**[0016]** The main lighting module 7 is carried in a stationary but adjustable manner within the respective housing body 4 by means of articulated joints provided with adjusting screws, known and not shown for sake of simplicity, while the secondary lighting modules 8 are carried within the housing body 4 rotatable in relation to the housing body 4 itself and to the main lighting module 7 each around a respective its own first axis, each indicated in figure 3 with a different reference letter "A", "B" and "C".

**[0017]** The first axes A,B,C of the secondary lighting modules 8 are arranged parallel to each other and transverse to an horizontal plane crossing transversally the lighting device 1 and containing the optical axes OA of the lighting devices 7,8, i.e. the axes along which their generated light beams travel forward.

**[0018]** For sake of simplicity, in figure 4 is shown in more details and in an enlarged scale one lighting module 8 only, having an optical axis OA along which the light beam (indicated as LB in figure 4) generated thereby travels forward.

**[0019]** All the rotating lighting modules 8 have an identical structure and comprise, each, (as it is described in greater details in the parallel patent application EP16200369.3 filed on November 23, 2016 in the name of the same applicants and the whole content of which

is incorporated herein by reference), one or more light sources, such LEDs, borne by a printed circuit board 9, at least one reflector 10 and at least one first actuator 11 to rotate the reflector 10 of each lighting module 8 relative to the printed circuit board 9 bearing the light source(s) and relative to the main lighting module 7 around the first axis A, B, C (axis A in figure 4) of each module 8.

**[0020]** The secondary lighting modules 8 are rotatable around their respective first axes A,B,C independently of one another, since each one is equipped with an independent actuator 11; moreover, they are further rotatable, all together or independently of one another, around a second axis D (figure 4) arranged substantially perpendicular to the first axes A,B,C. The second axis D may be one in common for all the lighting modules 8, or each module 8 may have its own axis D perpendicular to the respective axis A,B,C, the axes D of all the modules 8 being parallel to one another. The rotation of the lighting modules 8 around axis/axes D is controlled by a second actuator 12, one in common for all the modules 8 or one for each module 8.

**[0021]** The lighting device 1 also comprises a control unit 13 (figure 4), e.g. arranged inside or outside the housing body 4, designed to selectively rotate the secondary lighting modules 8 of the same or different angles around the first axes A,B,C and around the second axis/axes D and to switch on/off the secondary lighting modules 8, as well as the main lighting module 7, independently of one another.

**[0022]** In particular, the secondary lighting modules 8 are preferably each independently controlled by the control unit 13 via the first and second actuators 11,12, as mentioned above.

**[0023]** According to a feature of the present invention, the main lighting module 7 is designed to generate selectively, when it is switched on, a first light beam DB (figure 3) configured for a dipped beam function and a second light beam HB configured for a high beam function. For instance, this function may be obtained by providing the main lighting module 7 with two different light sources, e.g. LEDs, positioned in different manner.

**[0024]** The first and second light beams DB and HB form on a same standard test screen placed in front of the lighting device 1 at 25 m (figure 5) a first light projection LP1 and a second light projection LP2, respectively.

**[0025]** Likewise, the secondary lighting modules 8 are designed to generate, when they are switched on, a third light beam LB for each lighting module 8 forming on the same standard test screen at 25 m third light projections T1, T2 and T3, which may partially overlap the first and/or the second light projections LP1 and LP2.

**[0026]** The control unit 13 is configured to switch on/off selectively the main lighting module 7 and the secondary lighting modules 8 and to rotate each secondary lighting module 8 around either the first axes A,B,C or the second axis/axes D.

**[0027]** According to the main aspect of the present invention, the control unit 13 is also configured to make all

the third light projections T1-T3 to overlap on the test screen onto one another and onto the second light projection LP2, i.e. all onto the light projection generated by the light beam HB configured as a high beam, when the lighting device 1 is in a high beam configuration, wherein the module 7 is switched on to emit the light beam HB and the modules 8 are switched on and rotated around all the axes A,B,C,D, so as to be tilted relative to both the horizontal plane and the vertical plane.

**[0028]** All the light projections T1-T3 overlaps onto each other for the major part thereof, namely for more than 60%, substantially at the center of the second light projection LP2, namely are more or less symmetrically centered within the light projection LP2 relative to the optical axis OA of the main lighting module 7, which, in the schematic drawings of figures 5 and 6, coincides with the crossing between the two reference axes H (horizontal) and V (vertical) of the test screen.

**[0029]** In particular, the control unit 13 is configured to make all the third light projections T1-T3 to overlap on the test screen onto one another and onto the second light projection LP2 by simultaneously rotating at least one, and preferably all, of the secondary lighting modules 8 simultaneously around both the first axes A,B,C and the second axis/axes D.

**[0030]** Moreover, the control unit 13 is configured to carry out the simultaneous rotation of the at least one or of all the secondary lighting modules 8 around the first axis A, B, C and the second axis D thereof simultaneously by making the third light projection  $T_{(1,2,3)}$  of the at least one or of all the secondary lighting modules 8 to describe on the test screen a pre-established trajectory TR passing through the optical axis OA of the main lighting module 7.

**[0031]** According to one preferred embodiment, shown in figure 6, the trajectory TR is linear, i.e. it is described by the mathematical equation of a straight line.

**[0032]** According to another preferred embodiment, not shown for sake of simplicity, the trajectory TR is mathematically represented by a polynomial function of the 3<sup>rd</sup> degree.

**[0033]** It has been surprisingly discovered that these two specifically selected kinds of trajectory ensure a smooth and quick shifting of the whole lighting device 1 from the dipped/low beam configuration to the high beam configuration without causing, at the same time, any annoyance to the driver of the vehicle

**[0034]** According to a further feature of the invention, the control unit 13 is configured to overlap on the test screen, as already mentioned above, all the third light projections T1-T3 onto one another and onto the second light projection LP2, substantially at the center of the second light projection LP2, in such a manner that the projections T1-T3 still are almost completely overlapped (i.e. for more than 60% of their amplitude) onto one another, but are at the same time arranged shifted laterally to one another; such a feature is obtained by rotating the secondary lighting modules 8 around the first axes A,B,C so

as that the third light beams LB hit the test screen rotated of few degrees relative to each other.

**[0035]** According to another feature of the invention, the lighting device 1 is configured such that all the third light projections T1-T3 are always inscribed within the second light projection LR2 when the lighting device 1 is in the high beam configuration, with the lighting module 7 switched on so as to generate the light beam HB and having the lighting modules 8 rotated such as to overlap their light beams LB with the light projection LP2.

**[0036]** In this manner the lighting performances of the high beam function of the second light beam HB are surprisingly greatly improved, especially on the long distance.

**[0037]** As mentioned before, the secondary lighting modules 8 are arranged side by side and on one side of the main lighting module 7 opposite to a first lateral end 14 of the housing body 4 designed to be mounted at the outboard side 3 of vehicle 2 and receiving the main lighting module 7.

**[0038]** In use, the vehicle 2 is provided with a pair of complementary lighting devices 1 as described above, shaped specular symmetrical and arranged on the opposite outboard sides of the vehicle 2.

**[0039]** It has to be noted finally that, according to the light patterns configurations shown in figures 5 and 6, the control unit 13 is configured to have, in the high beam configuration of the lighting device 1, the light projections T1-T3 almost totally contained only within the light projection LP2 and therefore arranged substantially outside of (i.e. not contained in) the light projection LP1, which may remain also in the high beam configuration, since in this case the lighting module 7 may be switched on in such a manner to emit both the light beams DB and HB.

**[0040]** In particular, the light projections T1-T3 are substantially aligned immediately above a cut -off line 15 (figure 5) of the light projection LP1.

**[0041]** From the above description, compared with reference to figures 1 and 2 showing the light patterns which may be obtained on the test screen with the lighting devices of the prior art, it is clear that even in lighting devices having substantially the same overall structure of the lighting device 1, the advantageous configurations of light patterns as herein described have been never obtained: according to the prior art, in fact, the light projections T1-T3 of the secondary lighting modules 8 are always substantially aligned below the cut -off line 15 of the light projection LP1, both in the high beam configuration (figure 2) and in the dipped/low beam configuration (figure 1) of the lighting device.

**[0042]** All the aims of the invention are therefore accomplished.

## Claims

1. A lighting device (1) for vehicles comprising an housing body (4) having a front inlet opening (5) arranged

to face in use toward a forward driving direction of the vehicle, a main lighting module (7) and at least two secondary lighting modules (8) arranged inside the housing body, facing the inlet opening (5), the at least two secondary lighting modules (8) being carried rotatable in relation to the housing body (4) and to the main lighting module (7), each around a respective its own first axis (A,B,C), the first axes (A,B,C) being arranged parallel to each other and transverse to an horizontal plane in use, and around at least a second axis (D) arranged perpendicular to the first axes; said main lighting module (7) being designed to generate selectively, when it is switched on, a first light beam (DB) configured for a dipped beam function and a second light beam (HB) configured for a high beam function, said first and second light beam forming on a test screen placed in front of the lighting device a first light projection (LP1) and a second light projection (LP2), respectively; and said secondary lighting modules (8) being designed to generate each, when they are switched on, a third light beam (LB) forming on the test screen a third light projections (T1, T2, T3) which may partially overlap the first and/or the second light projections (LP1,LP2); the lighting device further comprising a control unit (13) to switch on/off selectively the main lighting module (7) and the secondary lighting modules (8) and to rotate each secondary lighting module around either the first (A,B,C) or the second axes (D); **characterized in that**

- the control unit (13) is configured to make all the third light projections (T1-T3) to overlap on the test screen onto one another and onto the second light projection (LP2), substantially at the center of the second light projection.

2. A lighting device according to claim 1, **characterized in that** the control unit (13) is configured to make all the third light projections (T1-T3) to overlap on the test screen onto one another and onto the second light projection (LP2) by simultaneously rotating at least one of the secondary lighting modules (8) around both the first (A,B,C) and the second (D) axis.
3. A lighting device according to claim 1 or 2, **characterized in that** the control unit (13) is configured to make all the third light projections (T1-T3) to overlap on the test screen onto one another and onto the second light projection (LP2) by simultaneously rotating all the secondary lighting modules (8) around both the first (A,B,C) and the second (D) axis thereof.
4. A lighting device according to anyone of the preceding claims, **characterized in that** the control unit (13) is configured to carry out the simultaneous rotation of the at least one or of all the secondary lighting modules (8) around the first and second axis thereof

by making the third light projection (T1-T3) of the at least one or of all the secondary lighting modules (8) to describe on the test screen a linear trajectory (TR) passing through an optical axis (OA) of the main lighting module (7).

5. A lighting device according to anyone of the preceding claims from 1 to 3, **characterized in that** the control unit (13) is configured to carry out the simultaneous rotation of the at least one or of all the secondary lighting modules (8) around the first and second axis thereof by making the third light projection (T1-T3) of the at least one or of all the secondary lighting modules (8) to describe on the test screen a trajectory (TR) passing through an optical axis (OA) of the main lighting module (7), said trajectory (TR) being mathematically represented by a polynomial function of the 3<sup>rd</sup> degree.
6. A lighting device according to anyone of the preceding claims, **characterized in that** the control unit (13) is configured to overlap on the test screen all the third light projections (T1-T3) onto one another and onto the second light projection (LP2), substantially at the center of the second light projection, shifted laterally to one another, by rotating the secondary lighting modules (8) around the first axes (A,B,C) so as the third light beams (LB) hit the test screen rotated of few degrees relative to each other.
7. A lighting device according to claim 6, **characterized in that** it is configured such that all the third light projections (T1-T3) are inscribed within the second light projection (LP2), in order to improve the lighting performances of the high beam function of the second light beam (HB).
8. A lighting system according to anyone of the preceding claims, **characterized in that** the secondary lighting modules (8) are arranged side by side and on one side of the main lighting module (7) opposite to a first lateral end (14) of the housing body (4) designed to be mounted at an outboard side (3) of a vehicle (2) and receiving the main lighting module (7).
9. A lighting device according to anyone of the preceding claims, **characterized in that** the secondary lighting modules (8) are each independently controlled by said control unit (13) via first and second actuators (11, 12).
10. Vehicle (2) provided with a pair of lighting devices (1) according to anyone of the preceding claims arranged on opposite outboard sides of the vehicle.

FIG. 1

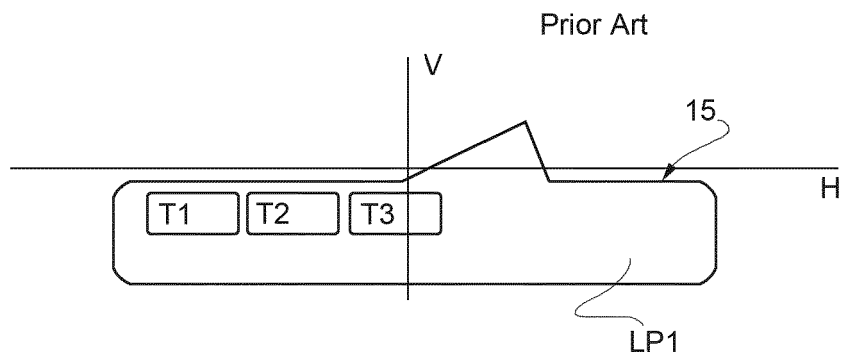
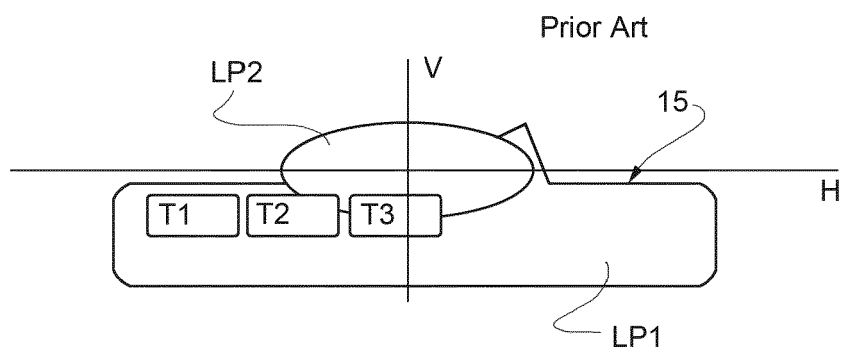
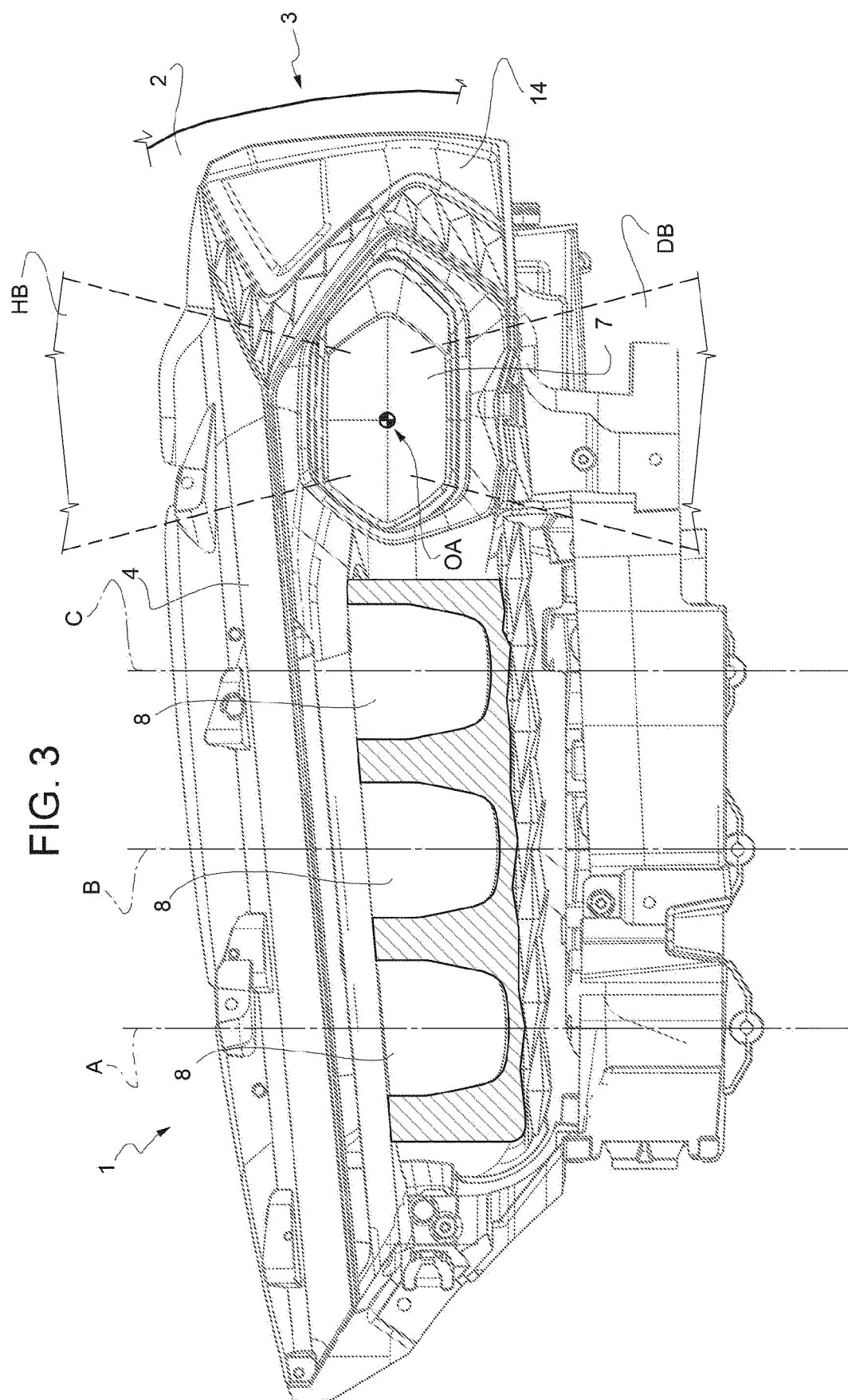


FIG. 2







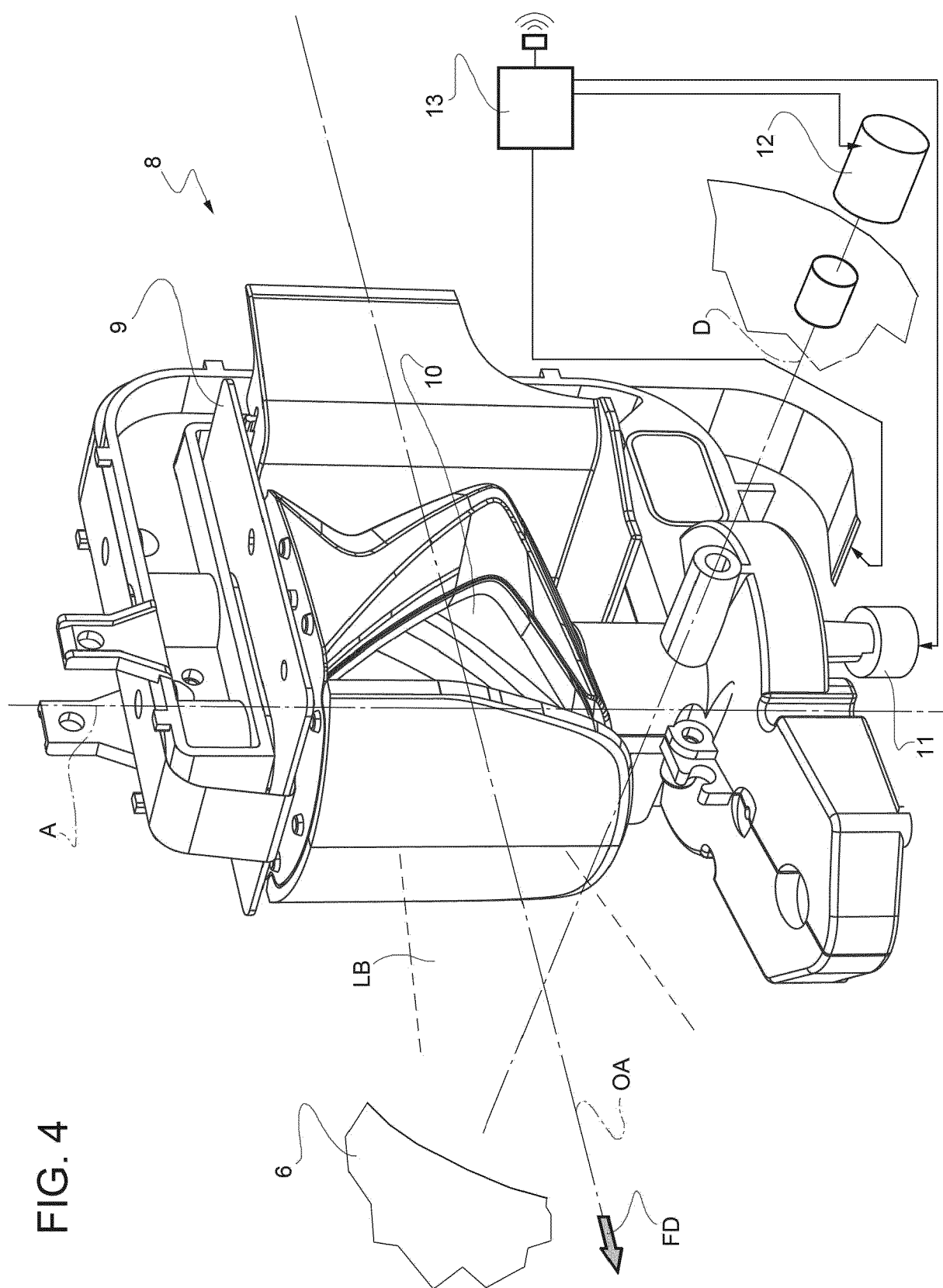


FIG. 4

FIG. 5

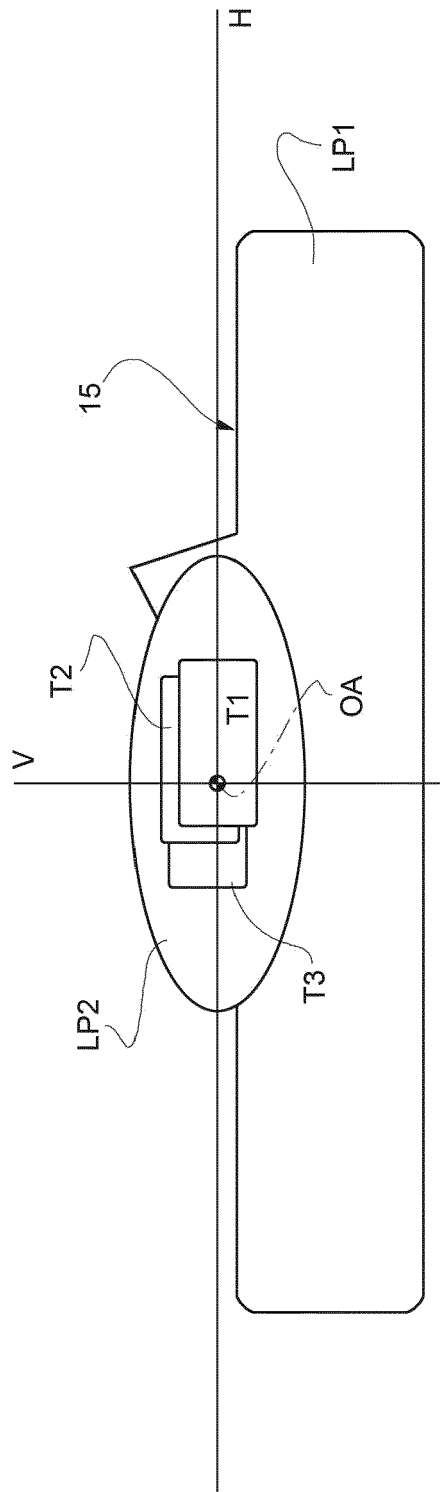
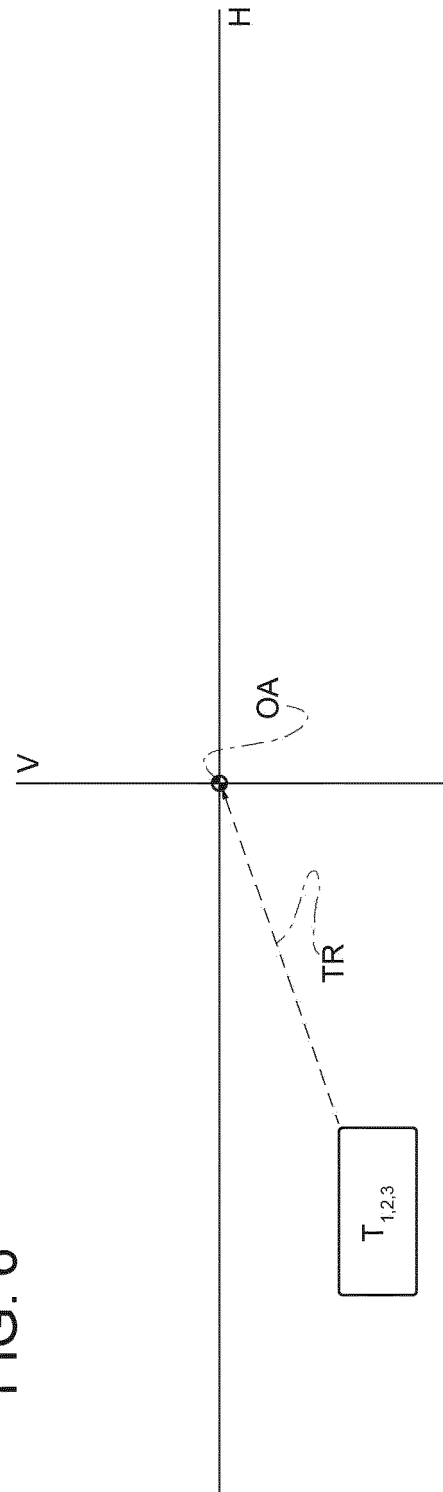


FIG. 6





## 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)                                                                                                                                        |
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| Place of search                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                    | Date of completion of the search | Examiner                                                                                                                                                                       |
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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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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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