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(54) **LED RETROFIT LAMP**

(57) According to the invention, a lighting device is provided, comprising: a support structure; at least one light emitting element arranged on the support structure; at least one air source configured to generate an air flow; at least one air guiding element configured to confine at least part of an air flow generated by the at least one air

source, wherein the at least one air guiding element comprises at least one inner air guiding face being arranged to guide at least part of the air flow generated by the at least one air source in between the support structure and the at least one inner air guiding face.

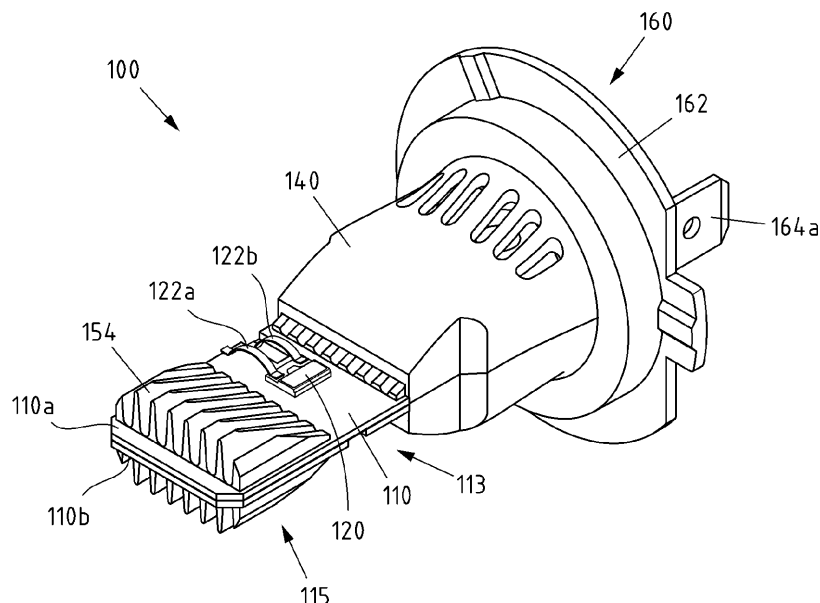


Fig.1

Description

FIELD OF THE INVENTION

[0001] The present disclosure relates to a lighting device such as e.g. a light source for an automotive headlight.

BACKGROUND OF THE INVENTION

[0002] Lighting devices such as halogen lamps have been used as light sources for automotive headlights for many years. However, recent advances in light-emitting diode, LED, technology have enabled developments of lighting devices providing replacements for halogen lamps. Such lighting devices replacing halogen lamps may be referred to as LED retrofits.

[0003] While LED retrofits often allow for efficient halogen lamp replacements, at least in certain situations, heat usually produced by operating LEDs has to be guided away from operating LEDs. To this end, heatsinks may be used, i.e. components of the corresponding LED retrofits that usually are in thermal contact with corresponding LEDs and that are formed from a material with sufficiently high thermal conductivity, to guide heat away from the LEDs when operating. In addition, it is desirable to provide LED retrofits of substantially similar dimension as compared to typical halogen lamps.

SUMMARY OF THE INVENTION

[0004] In view of this, it is an object of the present invention to provide a lighting device with an improved solution for guiding heat away from operating LEDs of the lighting device. It is a further object of the present invention, to enable a lighting device with improved heat guiding capability having dimensions comparable to existing halogen lamps.

[0005] According to a first aspect of the present invention, a lighting device is provided, comprising: a support structure; at least one light emitting element arranged on the support structure; at least one air source configured to generate an air flow; at least one air guiding element configured to confine at least part of an air flow generated by the at least one air source, wherein the at least one air guiding element comprises at least one inner air guiding face being arranged to guide at least part of the air flow generated by the at least one air source in between the support structure and the at least one inner air guiding face.

[0006] According to a second aspect of the present invention, an automotive headlight is provided, comprising a lighting device according to the first aspect.

[0007] Exemplary embodiments of the first and second aspect of the invention may have one or more of the properties described below.

[0008] In an exemplary embodiment, the lighting device is a light source for an automotive headlight, e.g. a

retrofit lamp for automotive headlight applications. Thus, as explained further herein, in an exemplary embodiment, the at least one light emitting element is or comprises at least one light-emitting diode, LED. In addition, in an exemplary embodiment, the lighting device is provided with suitable means to be mounted to a vehicle, e.g. a car, a motorcycle or a truck. To this end, the lighting device comprises in particular adapter means for mounting the lighting device. In an exemplary embodiment, the adapter means comprises an adapter ring of dimensions according to corresponding regulations and standards, e.g. according to UNECE RE5 and/or R37 and/or IEC 60061.

[0009] In an exemplary embodiment, the support structure of the lighting device at least in part corresponds to or comprises a heatsink and may thus support cooling of the at least one light emitting element. In other words, in an exemplary embodiment, the support structure is configured to guide heat generated by the at least one light emitting element at least away from the at least one light emitting element. Alternatively or in addition, in an exemplary embodiment, the support structure at least in part corresponds to or comprises a printed circuit board, PCB, and/or a printed wiring board, PWB, and/or a lead-frame and/or a metal piece. In other words, in an exemplary embodiment, the support structure at least comprises at least one thermal connection to the at least one light emitting element, an electrical function may be included in the support structure. In an exemplary embodiment, the electrical function may be separated from the support structure, e.g. the electrical function may be included in a separate PCB.

[0010] In order to support a cooling effect of the support structure, the lighting device is provided with the at least one air source, e.g. a fan, for generating an air flow in particular along and in contact with a corresponding surface of the support structure. Being provided with the at least one air guiding element and the at least one inner air guiding face, such air flow from the at least one air source can be guided by the at least one inner air guiding face in between the support structure and the at least one inner air guiding face, in particular to be guided towards and at least in part along the support structure, thus cooling the support structure. The support structure and the at least one inner guiding face may thus form a cooling channel through which air passes and thus enables an advantageous cooling effect. Thus, the at least one inner air guiding face may advantageously help to confine, e.g. to guide and/or concentrate the air flow towards the surface of the support structure, thereby not only guiding such air flow but further also preventing an undesired loss of cooling air and enabling a particularly efficient use in cooling of the at least one air source.

[0011] As mentioned, the at least one light emitting element is arranged on the support structure. Thus, in an exemplary embodiment, the support structure comprises a mounting surface configured to support and/or hold the at least one light emitting element. For example,

the support structure may in an exemplary embodiment, comprise or correspond to, at least in part, an essentially flat member, e.g. with an elongated, e.g. essentially rectangular, shape, forming a mounting surface for supporting the at least one light emitting element.

[0012] As further mentioned, the support structure may comprise or correspond to a printed circuit board (PCB), and/or a printed wiring board (PWB), and/or a lead frame. Thus, in an exemplary embodiment, the at least one light emitting element may be electrically connected to an energy source and/or electrically controlled via the PCB and/or via the PWB. In an exemplary embodiment, the support structure corresponds to or comprises at least one metal carrier. In an exemplary embodiment, the support structure comprises two metal carriers, being mutually isolated. In this case, electrical contacts of the at least one light emitting element may respectively be electrically connected to corresponding ones of the at least two electrical carriers via ribbon-bonding. In an exemplary embodiment, the support structure comprises two sides with at least one light emitting element and/or at least one cooling element being arranged on each of the two sides of the support structure.

[0013] In an exemplary embodiment, the support structure is configured to transfer heat. To this end, the support structure may be formed, at least in part, from a heat conductive material, in particular from a metal. In an exemplary embodiment, the support structure may thus comprise at least one material selected from copper, aluminum, and/or alloys of copper and/or aluminum. Use of such material may be advantageous in that heat is guided away from the at least one light emitting element in a particularly efficient manner. In an exemplary embodiment, the support structure may be formed by extrusion molding, by turning processes and/or by milling processes. In an exemplary embodiment, the support structure may be formed by cold forming. Extrusion molding is a process that allows forming the support structure in a non-complex way nevertheless allowing for sufficient production quality. At the same time, further components such as cooling elements provided on the support structure may be formed in combination with the support structure in a single production step.

[0014] In an exemplary embodiment, the at least one light emitting element is a light emitting diode (LED), for example a light emitting diode configured for emitting light in a color temperature range of 2500-7500K, in particular of 4000-7000K, in particular of 5000-6500K. Such light emitting diodes are suitable light sources in particular for automotive applications as they enable emitting light of suitable color at advantageous brightness. Thus, in an exemplary embodiment, the at least one light emitting element is configured to emit light at a luminous flux of 600-2400 lumen (lm), in particular of 1350-1650 lm. Luminous flux ranges suitable for exemplary embodiments may be taken from UNECE RE5 or R37 for respective examples of a halogen lamp the lighting device, in particular an LED lamp, shall replace.

[0015] In an exemplary embodiment, the at least one light emitting element is arranged directly on the support structure, e.g. attached thereto. In other words, in an exemplary embodiment, the at least one light emitting element is arranged on the support structure with no further components of the lighting device being arranged in between the at least one light emitting element and the support structure except for potential attachment components such as glue, solder and/or parts of attachment means. Thereby, in an exemplary embodiment, the at least one light emitting element is directly glued to the support structure. Alternatively or in addition, in an exemplary embodiment, the at least one light emitting element is soldered and/or riveted and/or screwed to the support structure. Thus, in this example, the at least one light emitting element is in direct or almost direct thermal contact with the support structure and heat is transferred from the at least one light emitting element to the support structure in an efficient and almost direct manner.

[0016] In an exemplary embodiment, the at least one air source configured to generate an air flow is or comprises a fan, for example an axial fan with an air flow being generated and output in a direction essentially vertical to a plane of rotation of the fan. Alternatively, such fan may be a radial fan with an air flow being generated and output in a direction essentially vertical to the axis of rotation of the fan. In an exemplary embodiment, the at least one air source may be arranged on the support structure, e.g. a radial fan may be attached to the support structure with the plane of rotation being essentially parallel to a surface of the support structure. In an exemplary embodiment, the at least one air source may be arranged on a component of the lighting device other than the support structure, e.g. in an exemplary embodiment, the at least one air source is supported by the adapter means.

[0017] As mentioned, according to the first aspect, the at least one air guiding element is configured to guide at least part of an air flow generated by the at least one air source. In other words, in an exemplary embodiment, the at least one air guiding element is configured to prevent the air flow generated by the at least one air source from diverging beyond a boundary set or defined by the at least one air guiding element, in particular by the at least one inner air guiding face. Thus, the at least one air guiding element may in an exemplary embodiment serve as a means to guide an air flow in a desired direction predefined by the at least one air guiding element. In an exemplary embodiment, the at least one air guiding element comprises a surface essentially parallel to the support structure and, e.g. two, side walls connected to the surface configured to be in contact with the support structure when mounted. In such case, at least one inner air guiding face of the at least one air guiding element may be formed by inner surfaces of the surface essentially parallel to the support structure and the side walls.

[0018] In an exemplary embodiment, the at least one air guiding element is arranged and configured to guide an air flow generated by the at least one air source in a

general direction essentially towards the at least one light emitting element along the support structure. In such case, the air flow may at the same time be guided towards a window, e.g. a glass window, of an automotive headlight comprising the lighting device, the window being exposed to an outside airflow caused by movement of a vehicle comprising the automotive headlight. The window thus being cooled by the outside airflow, the window may advantageously help to cool the airflow generated by the at least one air source which may have been itself heated after having passed components of the lighting device such as the support structure and/or the at least one light emitting element. Further, during wintertime, when ice may have formed on an outside face of the window, such heated air flow generated from the at least one air source and having passed the lighting device may advantageously help to warm up said window thus potentially supporting a melting of such ice.

[0019] While in certain embodiments, the at least one air guiding element may be formed of a thermally high conductive material corresponding to the material of the support structure, e.g. from aluminum or copper, embodiments of the present disclosure attribute a main heat guiding function to the support structure, which may thus correspond to a main heat sink of the lighting device. In this way, it becomes possible to form in particular air guiding means of the lighting device, in particular the at least one air guiding element from a different material, such as a plastic material. Thus, in an exemplary embodiment, the at least one air guiding element may thus comprise a material with a thermal conductivity of less than $385 \text{ W/(m}\cdot\text{K)}$, in particular less than $205 \text{ W/(m}\cdot\text{K)}$, in particular less than $20 \text{ W/(m}\cdot\text{K)}$. In an exemplary embodiment, the at least one air guiding element is formed at least in part from a plastic material and/or from a glass material and/or from a transparent ceramic material and/or from polymethylmethacrylate (PMMA), e.g. so-called "LED grade" PMMA, and/or transparent silicones.

[0020] In an exemplary embodiment, the at least one air guiding element comprises a first guiding section, e.g. at least in part formed from a plastic material and in an exemplary embodiment at least in part surrounding at least part of the support structure. In addition or alternatively, the at least one air guiding element comprises a second guiding section connected to or integrally formed with the first guiding section and being at least in part formed from a material transparent for at least part of light emitted from the at least one light emitting element, e.g. a glass material or a transparent plastic material. The second guiding section may for example be formed at least in part as an at least partly transparent tube.

[0021] In an exemplary embodiment, the second guiding section is at least in part formed from a material transparent only for light of a predefined color or color range. For example, the material of the second guiding section is transparent for light within the visible wavelength spectrum (within a wavelength range of approx. 380 nm to approx. 780 nm). Thus, the lighting device may

be capable of emitting light in particular suitable for automotive headlight applications. In an exemplary embodiment, the second guiding section is at least in part coated to reduce reflections, e.g. an inner air guiding face of the second guiding section is provided with an inner anti-reflection coating.

[0022] In addition or alternatively, in an exemplary embodiment, at least part of the inner air guiding face of the second guiding section is shaped such that at least part of light emitted from the at least one light emitting element passes through the inner air guiding face of the second guiding section essentially orthogonal. For example, at least part of the inner air guiding face of the second guiding section may be shaped essentially spherically, wherein the at least one light emitting element is located essentially in a center of the corresponding sphere. For example, in this way, light emitted by the at least one light emitting element which is reflected off the inner air guiding face of the second guiding section is reflected in directions towards the at least one light emitting element which may at least help to avoid ghost images otherwise resulting from reflections off the support structure.

[0023] In an exemplary embodiment, the first and/or the second guiding section are arranged at the lighting device to guide at least part of an air flow generated by the at least one air source along and in contact with the support structure.

[0024] In an exemplary embodiment, the at least one inner air guiding face of the at least one air guiding element surrounds at least part of the support structure. In other words, in an exemplary embodiment, the at least one inner air guiding face encapsulates and/or encloses at least part of the support structure. In an exemplary embodiment, at least a first part or a first section of the at least one inner air guiding face surrounding at least part of the support structure may be an inner surface of the first guiding section and/or of the second guiding section.

[0025] In an exemplary embodiment, the at least one air guiding element is arranged and configured to guide the at least part of the air flow generated by the at least one air source essentially in a direction towards the at least one light emitting element. In other words, in an exemplary embodiment, the at least one inner air guiding face is arranged to guide at least part of the air flow generated by the at least one air source essentially along the support structure and towards the at least one light emitting element. Thereby, it is to be noted that a movement of the at least part of the air flow guided by the at least one inner air guiding face along the support structure may have at least a component towards the support structure to thus concentrate the air flow along the support structure, while a general direction of movement of the air flow may be towards the at least one light emitting element. The air flow may thus enable an efficient cooling of the support structure and of the at least one light emitting element itself.

[0026] In an exemplary embodiment, the at least one

air guiding element separates an input air flow from an output air flow of the at least one air source. Thus, in an exemplary embodiment, the at least one air guiding element is in direct contact with the at least one air source. In this way, an air flow supplying air to the at least one air source (input air flow) is separated by the at least one air guiding element from an air flow generated by the at least one air source (output air flow). Thus, the at least one air guiding element may prevent a backflow of an air flow generated by the at least one air source.

[0027] In an exemplary embodiment, the lighting device further comprises at least one first cooling element arranged on the support structure or being part of the support structure. In an exemplary embodiment, the at least one first cooling element is arranged in between the at least one air source and the at least one light emitting element. In addition or alternatively, in an exemplary embodiment, the at least one first cooling element is arranged in between the support structure and the at least one inner air guiding face. In this way, an air flow generated by the at least one air source flows at least along one face of the at least one first cooling element and/or may flow around the at least one first cooling element, such that the at least one first cooling element advantageously contributes to an efficient cooling of the support structure by the air flow.

[0028] In an exemplary embodiment, the at least one first cooling element is in thermal contact with the support structure. The at least one first cooling element may in an exemplary embodiment be formed as an integral component of the support structure. In an exemplary embodiment, the at least one first cooling element is or comprises a cooling fin comprising a cooling surface, e.g. of essentially rectangular or triangular shape, the cooling surface being arranged essentially parallel to a main direction of the air flow along the support structure. In an exemplary embodiment, the at least one first cooling element is or comprises a cooling pin, e.g. of essentially round or rectangular shape comprising a height of the cooling pin at least three times larger, in particular at least five times larger, in particular at least ten times larger than a width and length of the cooling pin. In an exemplary embodiment, the at least one first cooling element is formed by cold forming in a single production step with the support structure. In an exemplary embodiment, the at least one first cooling element is soldered and/or glued onto the support structure.

[0029] In an exemplary embodiment, the at least one air source is arranged essentially adjacent to the at least one first cooling element. In other words, in an exemplary embodiment, the at least one air source is arranged next to the at least one (first) cooling element with no further component of the lighting device being arranged in between the at least one air source and the at least one first cooling element. Thereby, in an exemplary embodiment, a distance between the at least one air source and the at least one first cooling element is smaller than 10 mm, in particular smaller than 5 mm, in particular smaller than 3

mm, in particular smaller than 2 mm, in particular smaller than 1 mm.

[0030] In an exemplary embodiment, the at least one light emitting element is arranged essentially adjacent to the at least one (first) cooling element. In other words, in an exemplary embodiment, the at least one light emitting element is arranged next to the at least one (first) cooling element with no further component of the lighting device being arranged in between the at least one light emitting element and the at least one (first) cooling element. Thereby, in an exemplary embodiment, a distance between the at least one light emitting element and the at least one (first) cooling element is smaller than 10 mm, in particular smaller than 5 mm, in particular smaller than 3 mm, in particular smaller than 2 mm, in particular smaller than 1 mm.

[0031] The at least one (first) cooling element being arranged essentially close to the at least one light emitting element, heat generated by the at least one light emitting element can be transferred to the at least one (first) cooling element via the support structure in an especially efficient manner due to its proximity to the at least one light emitting element (which upon operation acts as a heat source). In an exemplary embodiment, the lighting device further comprises at least two first cooling elements being arranged so that at least part of the air flow generated by the at least one air source passes through the at least two first cooling elements. For example, in an exemplary embodiment, the at least two first cooling elements are arranged on the support structure with a mutual angle smaller than 120° , in particular smaller than 90° , in particular smaller than 45° , or are arranged essentially mutually parallel to each other. Thereby, being essentially mutually parallel is to be understood such that an angle formed by the at least two first cooling elements is smaller than 10° , in particular smaller than 5° , in particular smaller than 2° .

[0032] In an exemplary embodiment, the at least one first cooling element comprises an edge with at least one section being inclined with respect to the support structure. In an exemplary embodiment, the at least one first cooling element is inclined continuously along this section, for example in a direction away from a portion of the support structure supporting the at least one light emitting element. The edge of the at least one first cooling element may be inclined away from the portion of the support structure supporting the at least one light emitting element to avoid an obstruction of light emitted from the at least one light emitting element. For example, an inclination with respect to the support structure may be smaller than 50° , in particular smaller than 40° , in particular smaller than 30° .

[0033] In an exemplary embodiment, the at least one air guiding element, e.g. the at least one inner air guiding face of the at least one air guiding element, e.g. an inner face of the first guiding section, is arranged at least in part surrounding at least part of the at least one first cooling element. Alternatively or in addition, in an exemplary

embodiment, the at least one air guiding element, e.g. the at least one inner air guiding face, e.g. an inner face of the second guiding section, is arranged at least in part surrounding at least part of the at least one light emitting element. Thus, the at least one air guiding element, e.g. the at least one inner air guiding face thereof, may be an inner face of a component of the lighting device that extends over at least part of the at least one first cooling element and/or the at least one light emitting element and that guides an air flow generated by the at least one air source along the support structure to facilitate cooling of the support structure.

[0034] In an exemplary embodiment, at least part of the at least one air guiding element, e.g. the first and/or the second guiding section, is tapered in at least one dimension towards the at least one light emitting element. In other words, in an exemplary embodiment, at least a section of the at least one air guiding element, e.g. the first and/or the second guiding section, comprises a cross-section decreasing in size towards the at least one light emitting element. Thereby, the first and or the second guiding section may in an exemplary embodiment comprise a tubular section having an essentially circular, an essentially elliptical, an essentially rectangular or an irregular cross-section. The at least one inner air guiding face may thus reduce the space in between the support structure and the at least one inner air guiding face and may thus act in a nozzle-like way not only guiding but also intensifying an air flow onto the support structure, in particular within an area of the support structure supporting the at least one light emitting element thus facilitating an improved cooling effect in particular in this area.

[0035] In an exemplary embodiment, at least part of the at least one inner air guiding face follows an inclination of the inclined section of the edge of the at least one first cooling element. In other words, in an exemplary embodiment, at least part of the at least one inner air guiding face has essentially a same or at least similar angle with respect to the support structure as at least a part of the inclined section of the edge of the at least one first cooling element. In other words, in an exemplary embodiment, at least part of the at least one inner air guiding face is essentially parallel to at least part of the inclined section of the edge of the at least one first cooling element. In this way, an air flow intensifying effect of the at least one air guiding face may be optimized while at the same time reducing a potential light obstruction effect the at least one air guiding face may have for light emitted from the at least one light emitting element.

[0036] In an exemplary embodiment, the lighting device further comprises at least one second cooling element being arranged opposite to the at least one first cooling element with respect to the at least one light emitting element. In other words, in an exemplary embodiment, the lighting device further comprises at least one second cooling element being spatially separated from the at least one first cooling element by the at least one

light emitting element.

[0037] For example, in an exemplary embodiment, the at least one first cooling element is arranged on an essentially proximal section of the support structure with respect to the at least one air source and the at least one second cooling element is arranged on an essentially distal section of the support structure with respect to the at least one air source. Thereby, the at least one light emitting element is arranged in between the at least one first cooling element and the at least one second cooling element, e.g. on a central section of the support structure. The at least one second cooling element may be provided to be in contact with an air flow generated by the at least one air source that has passed the at least one first cooling element and the at least one light emitting element. In this way, the air flow is used in an optimized way for cooling the support structure as the at least one second cooling element yet further increases a cooling surface of the support structure that contributes to the cooling effect of the air flow.

[0038] In an exemplary embodiment, at least a section of the at least one air guiding element, e.g. a third guiding section, is arranged at least in part surrounding at least part of the at least one second cooling element. In an exemplary embodiment, this section of the at least one air guiding element comprises at least one further inner air guiding face arranged at least in part surrounding at least part of the at least one second cooling element. In this way, an air flow generated by the at least one air source is confined towards the support structure not only near said proximal section of the support structure but also near said distal section, thus further enhancing a cooling effect of the air flow.

[0039] As mentioned further herein, in an exemplary embodiment, at least a section of the at least one air guiding element is arranged at least in part surrounding at least part of the at least one light emitting element. This section of the at least one air guiding element may be formed as a tubular member extending further along the support structure. Thus, in an exemplary embodiment, at least part of the at least one air guiding element corresponds to a tubular member surrounding and/or enclosing at least a part of the support structure, the at least one light emitting element and at least part of the at least one first cooling element and at least part of the at least one second cooling element. A further part of the at least one air guiding element may correspond to at least part of a housing of the lighting device being mechanically connected to and/or formed integrally with at least part of said tubular member. The at least one air guiding element thus helps to confine an air flow generated by the at least one air source along the support structure, thus enabling an advantageous cooling of the support structure by the air flow.

[0040] In an exemplary embodiment, the at least one air guiding element comprises an at least partially transparent member, e.g. corresponding to the second guiding section, that extends along the support structure sur-

rounding the at least one light emitting element. As mentioned above, being transparent, the at least partially transparent member is at least in part transparent for light emitted from the at least one light emitting element.

[0041] In an exemplary embodiment, the at least partially transparent member further surrounds the at least one first cooling element and the at least one second cooling element. In an exemplary embodiment, the at least partially transparent member comprises a tube or a tube section, e.g. corresponding to said tubular member surrounding and/or enclosing at least a part of the support structure, the at least one light emitting element and at least part of the at least one first cooling element and at least part of the at least one second cooling element. Thus, the at least partially transparent member further helps to confine an air flow along the support structure further facilitating cooling of the at least one light emitting element while at the same time allowing for transmission of light emitted by the at least one light emitting element. In an exemplary embodiment, the at least partially transparent member comprises at least one portion tapered towards the at least one light emitting element, thus further enhancing an effect of confining and concentrating the air flow.

[0042] The features and example embodiments of the invention described above may equally pertain to the different aspects according to the present invention. In particular, with the disclosure of features relating to the lighting device according to the first aspect, also corresponding features relating to the automotive headlight according to the second aspect are disclosed.

[0043] It is to be understood that the presentation of embodiments of the invention in this section is merely exemplary and non-limiting.

[0044] Other features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims. It should be further understood that the drawings are not drawn to scale and are merely intended to conceptually illustrate the structures and procedures described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045] Examples of the invention will now be described in detail with reference to the accompanying drawings, in which:

- Fig. 1 exemplarily illustrates a lighting device according to an embodiment of the invention;
- Fig. 2 illustrates an exploded view of the lighting device of Fig. 1;
- Figs. 3 a-f illustrate cross-sectional side-views of lighting devices according to an embodi-

ment of the invention;

Figs. 4 a-j illustrate cross-sectional front-views of lighting devices according to an embodiment of the invention;

5 Figs. 5 a-c illustrate cross-sectional side-views of lighting devices according to an embodiment of the invention;

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0046] Fig. 1 shows an example of a lighting device 100 according to an exemplary embodiment of the invention. The lighting device 100 is an LED retrofit which contains an adapter means 160 to connect the LED retrofit to an automotive headlight unit. The adapter means 160 comprises an adapter ring 162 and two power pins 164a and 164b for electrical connection (only pin 164a being visible in Fig. 1). A central section 113 of the support structure 110 supports a top-contact LED 120, which is an example of a light emitting element. A further LED 120 is provided on the opposing side of the support structure 110 which is not visible in the figure. The top-contact LED 120 is electrically connected through ribbon-bonding connections 122a, 122b to respective sides (carriers) 110a, 110b of the support structure 110 for electrically connecting LED 120. Eight cooling fins 154 are arranged on each of sides 110a, 110b of the support structure, resembling the at least one second cooling element, the cooling fins 154 being arranged on a distal section 115 of the support structure 110. Corresponding cooling fins 152 resembling the at least one first cooling element are shown in Fig. 2 along with an air source 130, in the shown example a radial fan as described further herein. As shown in Fig. 1, a housing 140 (part of which forms a first guiding section of an air guiding element) is provided surrounding the proximal section of support structure 110 and the first cooling fins 152, the housing 110 being tapered towards the LED 120.

[0047] Fig. 2 shows an exploded view of the lighting device 100 of Fig. 1. As can be taken from this figure, an air flow that can be generated by the air source 130 exits a housing of air source 130 at its side directly adjacent to cooling fins 152 to pass through cooling fins 152 over LED 120 and further through cooling fins 154 such that a cooling effect of the air flow on the support structure 110, which acts not only as a support for the LED 120 but also as a heat sink for the lighting device, is further enhanced by cooling fins (cooling elements) 152 and 154. As visible in Fig. 2, respective air sources 130 are provided on either side of the support structure 110.

[0048] While not shown in the figures, in an exemplary embodiment, the lighting device 100 further comprises driver electronics configured to operate electronic components of the lighting device, e.g. the at least one air source 130 and/or the at least one light emitting element 120 and/or further electronic components depending on a particular application. Such driver electronics may be arranged on the support structure 110 and/or (e.g. in case

that driver electronics comprise sub-components) on a separate PCB.

[0049] As shown in Fig. 2, the cooling fins 152 have respective inclined edges (inclined section 156) being inclined away from the section 113 supporting the LED 120. In the shown example, housing 140 has two mutually opposing inner air guiding faces 142 respectively surrounding or enclosing at least part of the support structure 110 and the cooling fins 152, 154, the inner air guiding faces 142 being arranged to guide at least part of the air flow generated by the at least one air source 130 in between the support structure 110 and the at least one inner air guiding face 142. Additionally, the housing 140 is arranged to separate the inlet air flow from the outlet air flow. Inside of the tapered section 144 of housing 140, the inner air guiding face 142 follows the inclination of inclined section 156. In the shown example, the support structure 110 is formed from a heat conductive material such as a metal, in particular aluminum or copper to facilitate a spreading of heat from the LED 120. At the same time, the provision of further cooling elements, i.e. cooling fins 152, 154 in the shown example enhances a cooling effect of an air flow generated by the at least one air source 130. The advantageous cooling effects provided by support structure 110 with cooling elements 152, 154 allows for housing 140 to be fabricated from a material that does not need to be heat conductive, e.g. a plastic material.

[0050] Figs. 3a, 3b, 3c, 3d, 3e and 3f show schematic cross-sectional side-views of examples of a lighting device 100 according to exemplary embodiments of the invention. In all figures, a respective transparent guiding section 141a-f (an example of a second guiding section) formed as an at least partly transparent tube is provided which may be connected to housing 140 (not shown in these figures). As shown in Figs. 3a, 3b, 3c, 3d, 3e and 3f, an air flow indicated by arrows 170 generated from respective air sources 133, 135 is confined along the support structure 110 by inner air guiding faces 142 of guiding sections 141a-f which prevent loss of air and thus contribute to an efficient cooling of support structure 110 also enhancing the effect of cooling fins 152, 154 which are provided in the examples of Figs. 3a, 3b, 3c, 3d. In the shown examples, the air source is a radial fan 133 (see Figs. 3a, 3b) or an axial fan 135 (see Figs. 3c, 3d, 3e, 3f). An effect of the guiding section can be further enhanced by tapering at least part thereof as illustrated in Figs. 3b, 3d and 3f. For example, in Fig. 3b, the transparent tube 141b has a tapered section 144 (only one of two tapered sections being indicated in the figure) further concentrating the air flow (arrows 170) in a region of the support structure supporting LED 120. By thus confining an air flow e.g. generated by fan 135 (see Figs. 3c, 3d, 3e, 3f) using transparent tube 141c-f it may become possible to achieve sufficient cooling of the support structure 110 even omitting cooling fins such as cooling fins 152, 154 as shown in Figs. 3e, 3f.

[0051] Figs. 4a-j show cross-sectional views of further

examples of at least sections of the air guiding element. Examples as shown in Figs. 4a-g may correspond e.g. to the first, the second and/or to the third guiding section and may resemble parts of the air guiding element used by themselves or in combination. Figs. 4a, 4b, 4c and 4d illustrate cross-sections of guiding sections 141g-141j enclosing or exemplarily surrounding cooling fins 150a-d which may correspond to cooling fins 152 and/or 154 of Fig. 1. Thereby, in an exemplary embodiment, as shown in Figs. 4a and 4b, the at least one of a plurality of cooling fins 150a, 150b extends from the support structure 110 and at least in part abuts an inner surface of the guiding section 141g, e.g. of the first and/or the third guiding section. Thus, a height of the cooling fins 150a, 150b is chosen such that some or all of the cooling fins extend until the guiding section, which increases or in case of Fig. 4a maximizes a cooling surface provided by the cooling fins.

[0052] As can be taken from Figs. 4a and 4b, in an exemplary embodiment, at least a section of the air guiding element, e.g. guiding sections 141g, 141h, e.g. the first, the second and/or the third guiding section comprises an essentially circular cross-section. Alternatively, as shown in Figs. 4c and 4d, in an exemplary embodiment, a cross-section of the guiding sections 141i, 141j, e.g. of the first, the second and/or the third guiding section is essentially rectangular (Fig. 4c), possibly with rounded edges, or essentially elliptical (Fig. 4d).

[0053] Figs. 4e-j illustrate further examples of cross-sections of at least a section of the air guiding element, e.g. of guiding sections 141k-p, e.g. of the second guiding section with an inner surface surrounding LED 120. As shown in Figs. 4e and 4f, in an exemplary embodiment, a width of the support structure 110 corresponds to an inner width of the guiding sections 141k, 141l. While this may be advantageous in terms of stability of the lighting device, it is possible, in an exemplary embodiment, that a width of the support structure 110 is smaller than an inner width of the guiding section 141m. This latter example may be advantageous in terms of homogeneity of an air flow provided by a corresponding air source.

[0054] Figs. 4h-j illustrate further examples of cross-sections of at least a section of the air guiding element, e.g. of guiding sections 141n-p, e.g. of the second guiding section. In Fig. 4h, the guiding section 141n comprises an essentially circular cross-section, while Fig. 4i shows an example of an essentially rectangular cross-section of the guiding section 141o which may be a result of tapering (see Fig. 3b).

[0055] Figs. 4h-j show examples in which the guiding sections 141n-141p are formed as (at least part of) a transparent tube configured such that the light emitted by the LED 120 passes through the surface of the transparent tube at an essentially right angle with respect to the surface. Thus, reflections of the light on the surface of the tube as indicated by arrows 172a-c are directed back towards the LED 120 to reduce ghost images due to

reflections off of the support structure 110 which results in a more precise lighting behavior.

[0056] Figs. 5a, 5b and 5c illustrate cross-sectional side-views of examples of a lighting device 100 according to exemplary embodiments of the invention. The lighting device 100 further comprises a glare cap 180 ("light obstruction element") arranged at or around the lighting device 100 and configured to block at least part of light emitted from LED 120. It thus becomes possible to prevent light from being emitted in undesired directions, e.g. with angles 174a-c with respect to a main plane of the support structure of less than 30 degrees. In Fig. 5a, the glare cap 180 is mounted within a housing of the automotive headlight comprising the lighting device 100. In Fig. 5b, the glare cap 180 is mounted to the support structure 110 of the lighting device 100 and Fig. 5c shows an example of the glare cap 180 being connected to the transparent tube 141s. To allow an air flow (arrows 170) to escape the transparent tubes 141 q-s to allow for a cooling of the lighting device, the glare cap can be mounted leaving a gap between the glare cap and a transparent tube such as shown in Figs. 5a and 5b for transparent tubes 141q, 141r. In Fig. 5c, the glare cap 180 is coupled directly to the transparent tube 141s and ventilation slits 146 are arranged on the end of the transparent tube 141s to allow for an air flow to exit the lighting device.

LIST OF REFERENCE SIGNS:

[0057]

Lighting device	100
Support structure	110
Electrical contact side	110a, 110b
Central section	113
Distal section	115
Light emitting element	120
LED top connection	122a, 122b
Air source	130
Radial fan	133
Axial fan	135
Housing	140
Guiding section	141a-s
Inner air guiding face	142
Tapered section	144
Ventilation slit	146
Cooling element	150a-d
First cooling element	152
Second cooling element	154
Inclined section	156
Adapter means	160
Adapter ring	162
Power pins	164a, 164b
Air flow	170

(continued)

Reflected light	172a-c
Light emission angle	174a-c
Glare cap	180

Claims

1. A lighting device (100) comprising:
 - a support structure (110);
 - at least one light emitting element (120) arranged on the support structure (110);
 - at least one air source (130) configured to generate an air flow;
 - at least one air guiding element (140) configured to confine at least part of an air flow generated by the at least one air source (130), wherein the at least one air guiding element (140) comprises at least one inner air guiding face (142) being arranged to guide at least part of the air flow generated by the at least one air source (130) in between the support structure (110) and the at least one inner air guiding face (142).
2. The lighting device according to claim 1, wherein the at least one air guiding element (140) is arranged and configured to guide the at least part of the air flow generated by the at least one air source (130) essentially in a direction towards the at least one light emitting element (120).
3. The lighting device according to any of claims 1 and 2, wherein the at least one air guiding element (140) separates an input air flow from an output air flow of the at least one air source (130).
4. The lighting device according to any of claims 1 to 3, further comprising at least one first cooling element (152) arranged on the support structure (110) or being part of the support structure (110).
5. The lighting device according to claim 4, wherein the at least one light source (130) is arranged essentially adjacent to the at least one cooling element (152).
6. The lighting device according to any of claims 4 and 5, wherein the at least one first cooling element (152) comprises an edge with at least one section being inclined with respect to the support structure (110).
7. The lighting device according to any of claims 4 to 6, wherein the at least one air guiding element (140) is arranged at least in part surrounding at least part of the at least one first cooling element (152).
8. The lighting device according to any of claims 1 to 7,

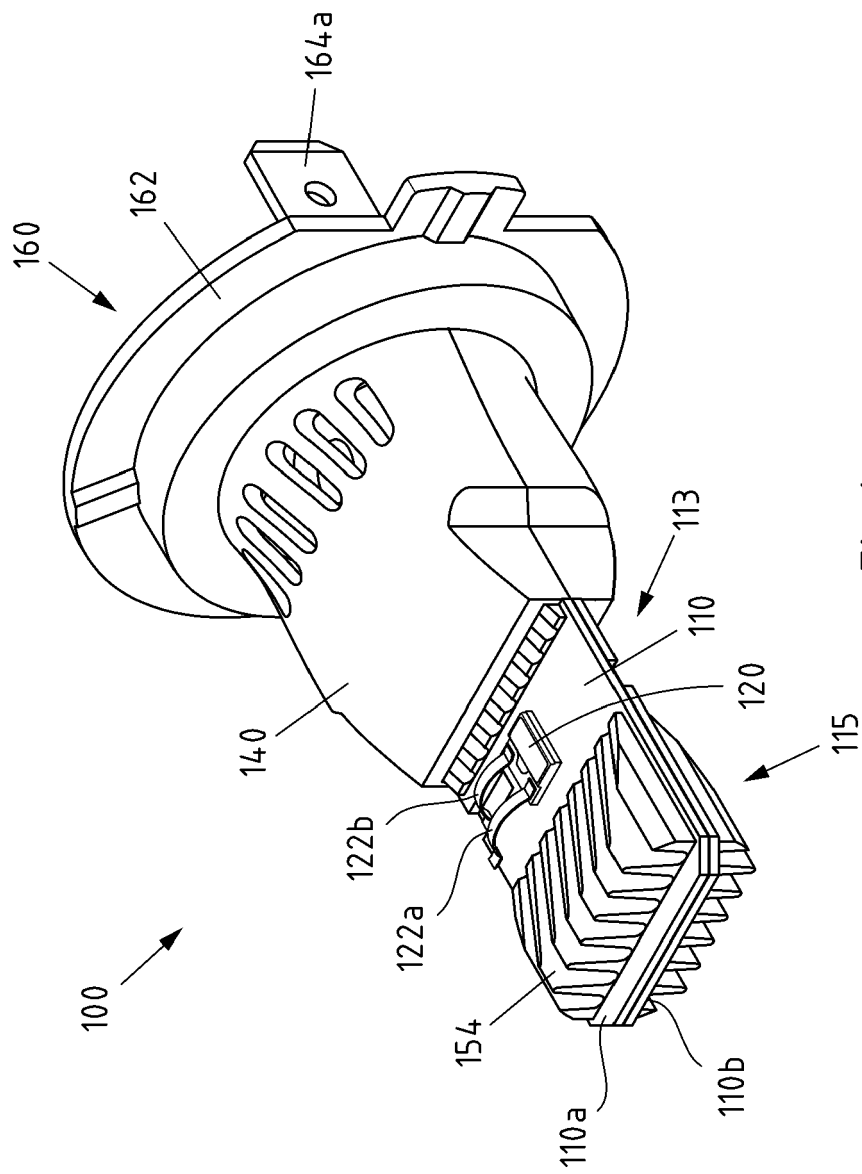
wherein at least part of the at least one air guiding element (140) is tapered in at least one dimension towards the at least one light emitting element (120).

9. The lighting device according to any of claims 4 to 8,
further comprising at least one second cooling element (154) being arranged opposite to the at least one first cooling element (152) with respect to the at least one light emitting element (120). 5
10. The lighting device according to claim 9, wherein at least a section of the at least one air guiding element (140) is arranged at least in part surrounding at least part of the at least one second cooling element (154). 10
11. The lighting device according to any of claims 1 to 10, wherein at least a section of the at least one air guiding element (140) is arranged at least in part surrounding at least part of the at least one light emitting element (120). 15 20
12. The lighting device according to any of claims 1 to 11, wherein the at least one air guiding element (140) comprises an at least partially transparent member that extends along the support structure (110) surrounding the at least one light emitting element (120). 25
13. The lighting device according to claim 12, wherein the at least partially transparent member comprises at least one portion tapered towards the at least one light emitting element (120). 30
14. The lighting device according to any of claims 1 to 13, further comprising a light obstruction element (180) arranged at or around the lighting device (100) and configured to block at least part of light emitted from the at least one light emitting element (120). 35
15. Automotive headlight comprising the lighting device according to any of claims 1 to 14. 40

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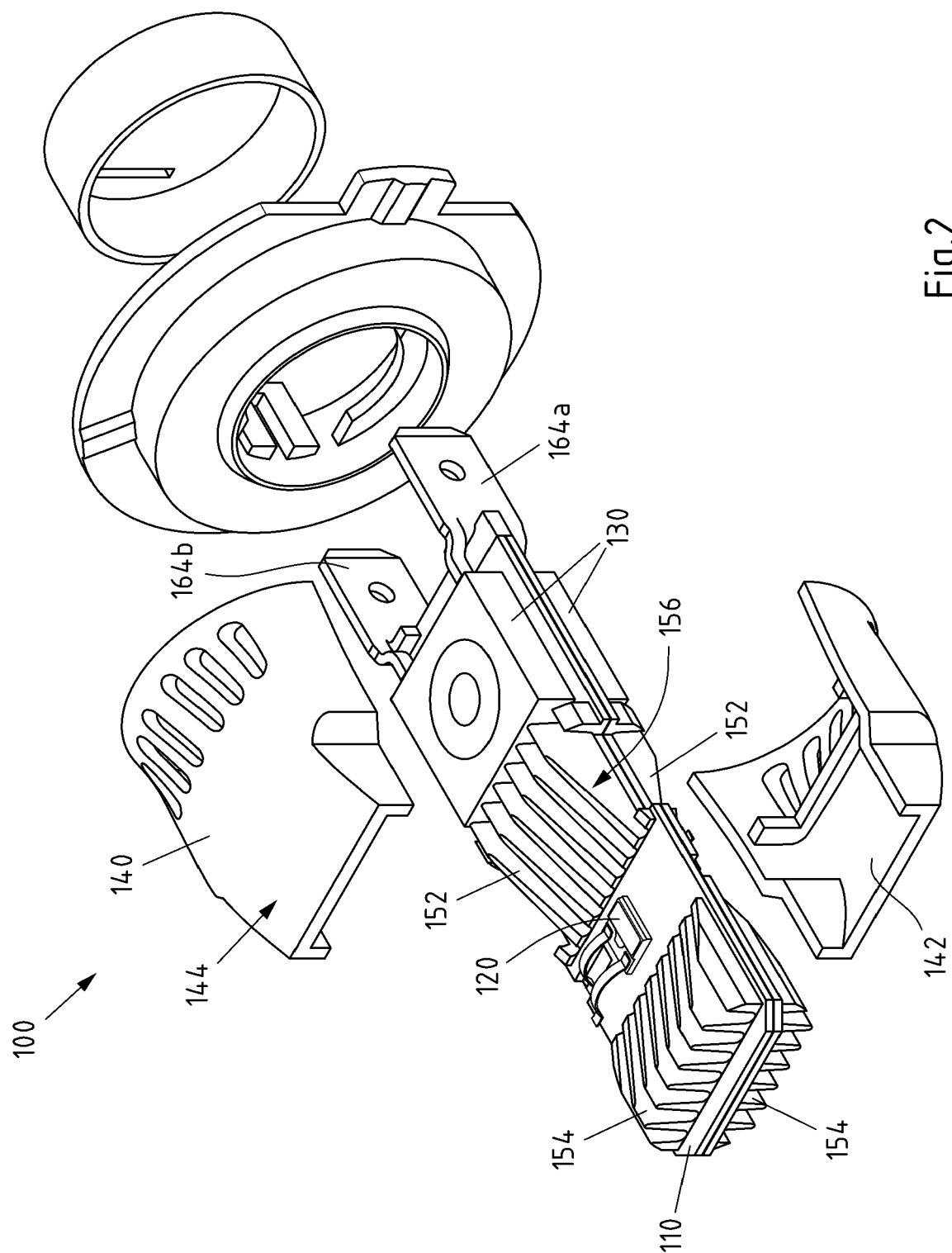


Fig.2

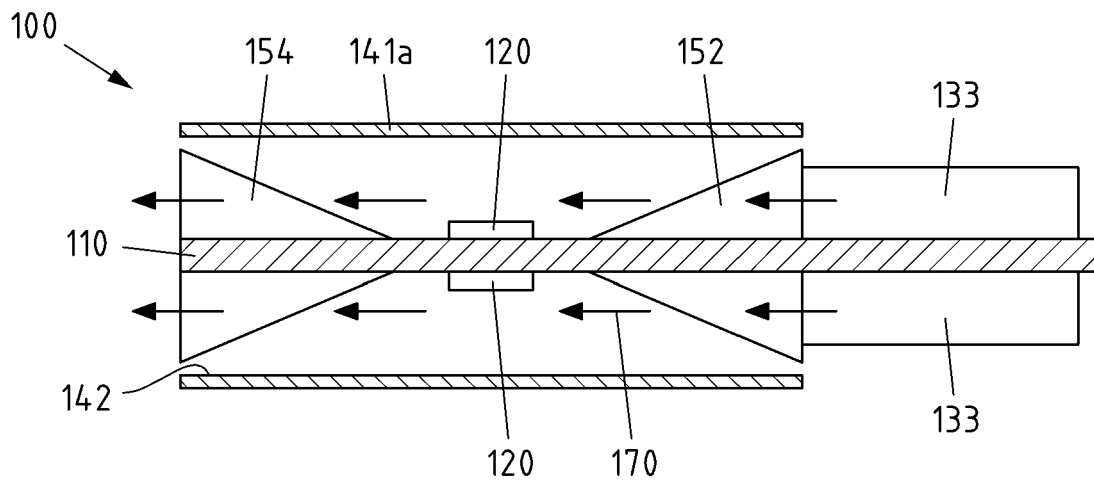


Fig.3a

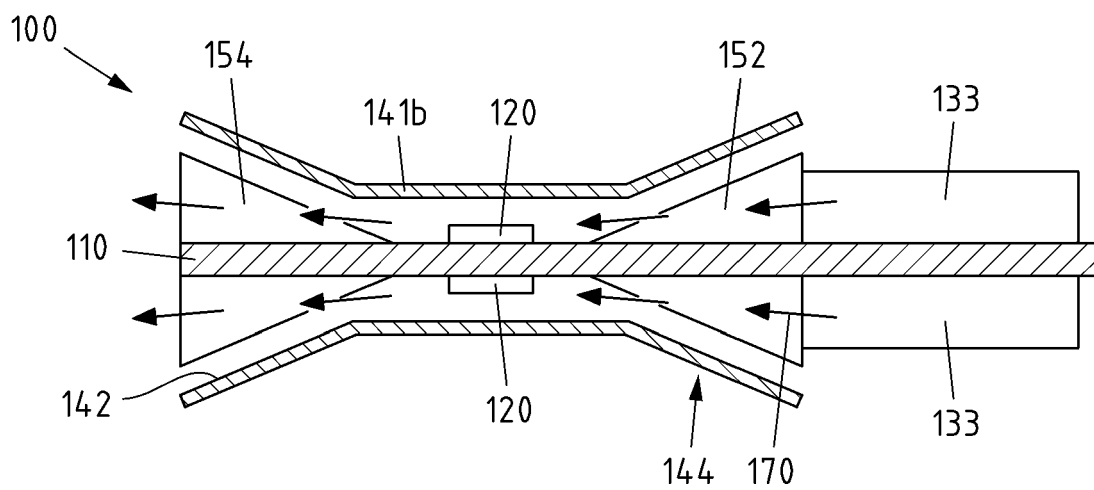


Fig.3b

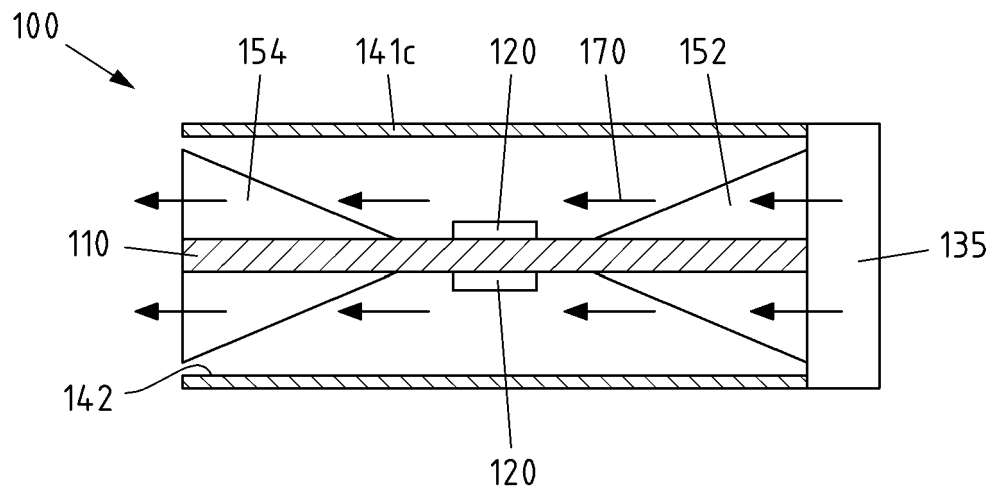


Fig.3c

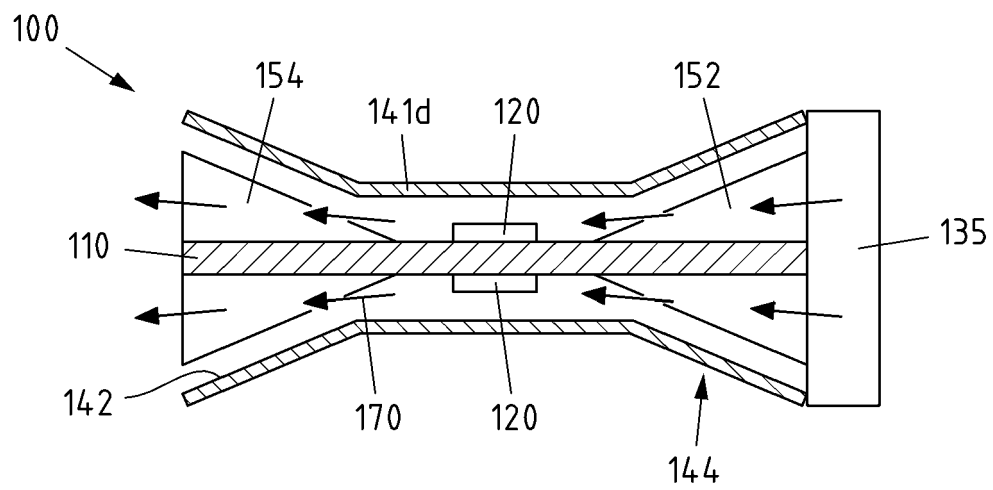


Fig.3d

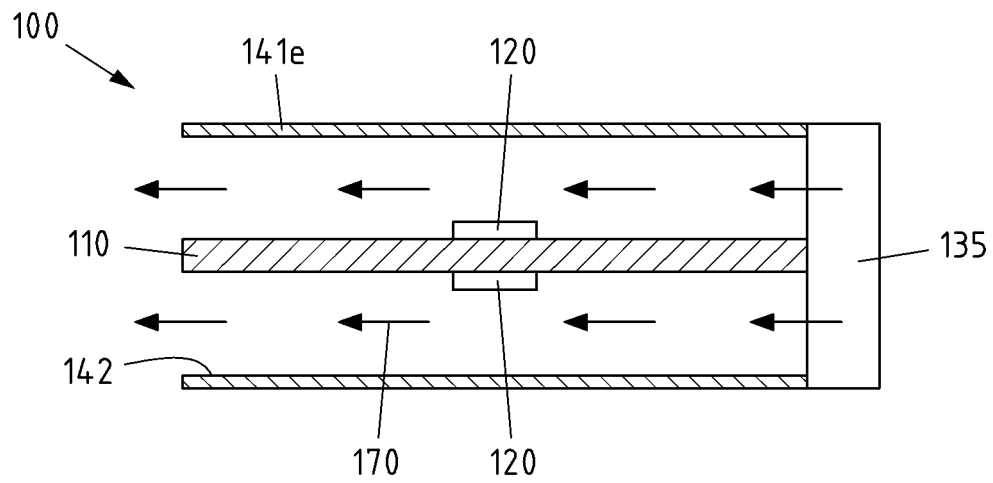


Fig.3e

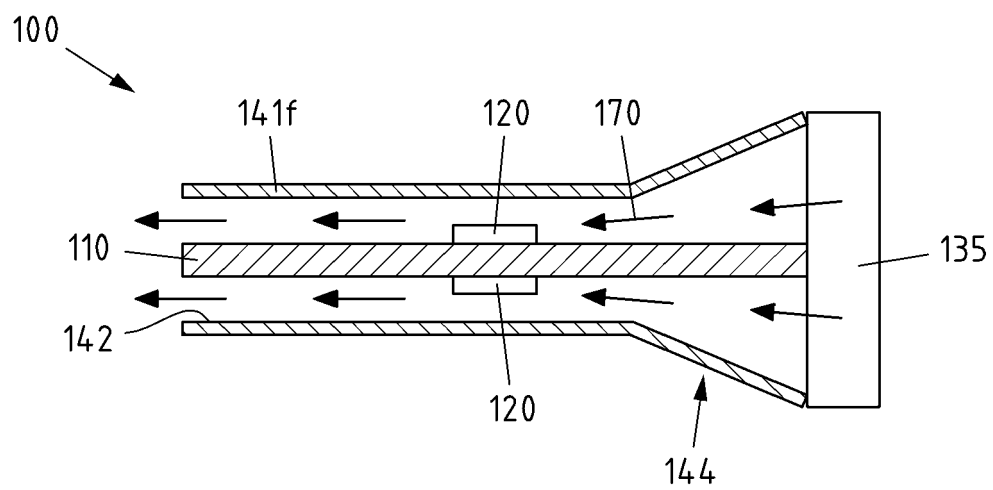
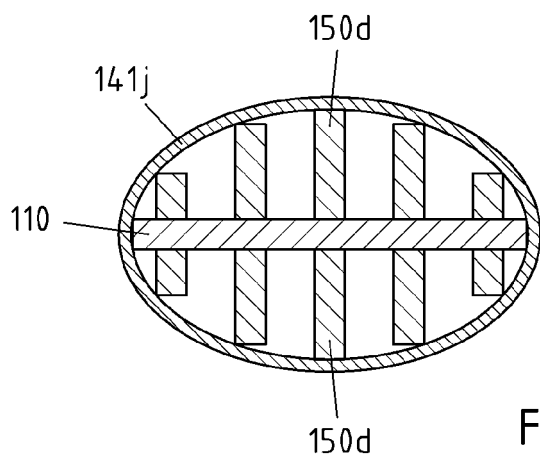
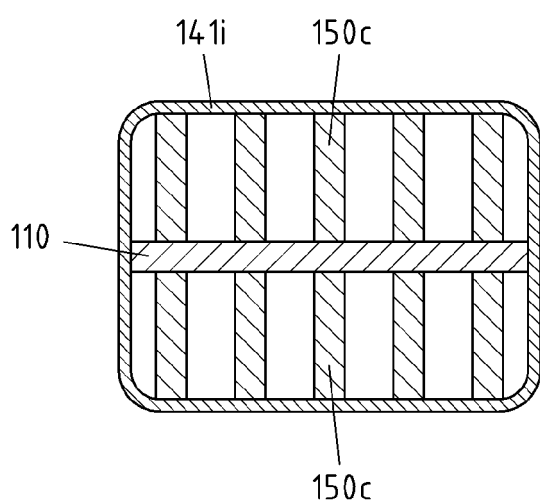
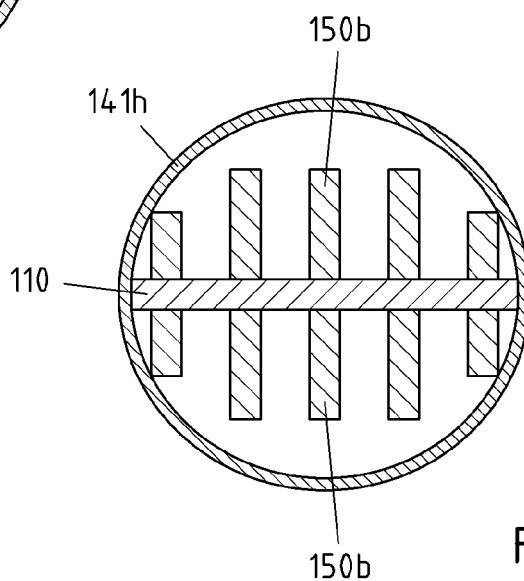
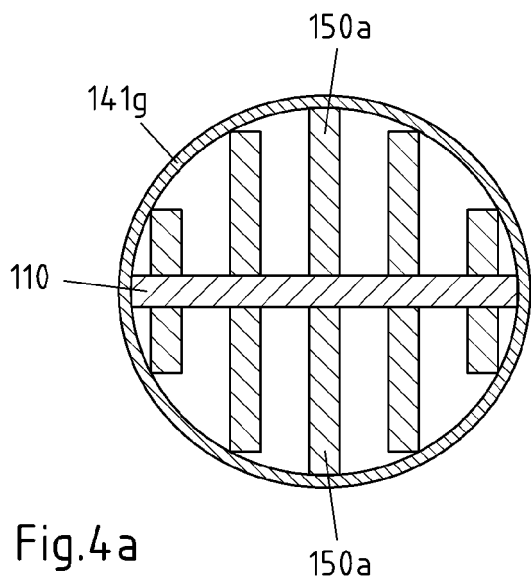


Fig.3f



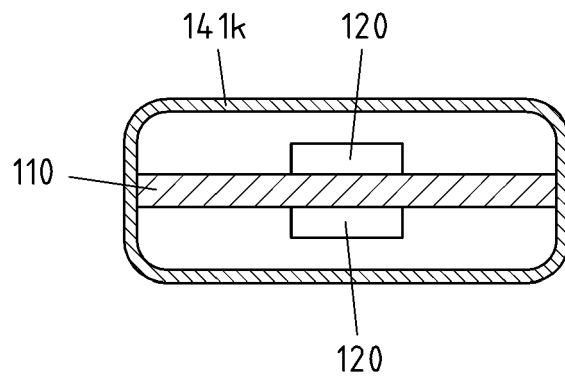


Fig.4e

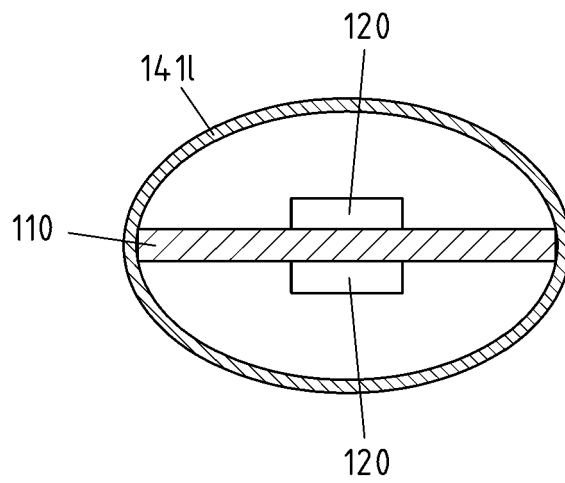


Fig.4f

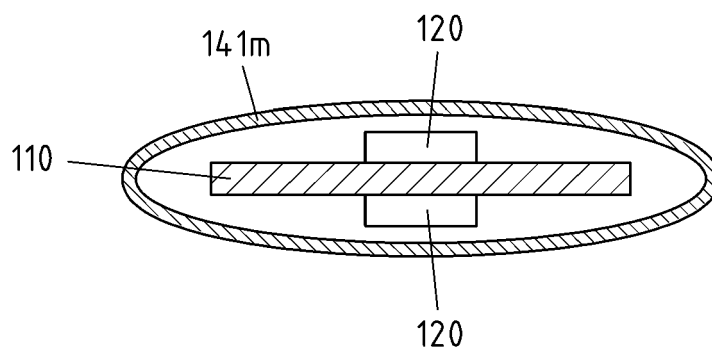


Fig.4g

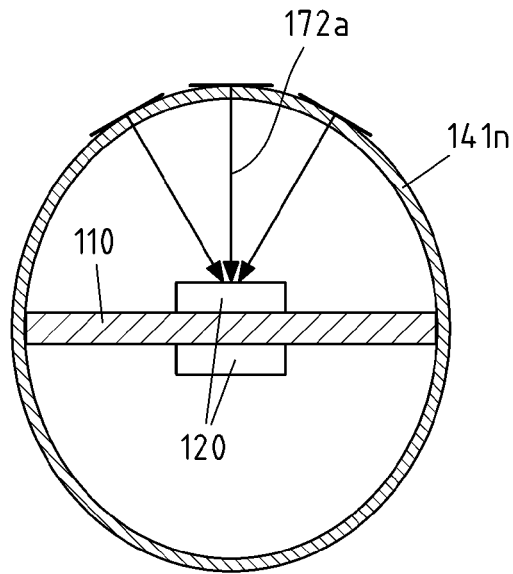


Fig.4h

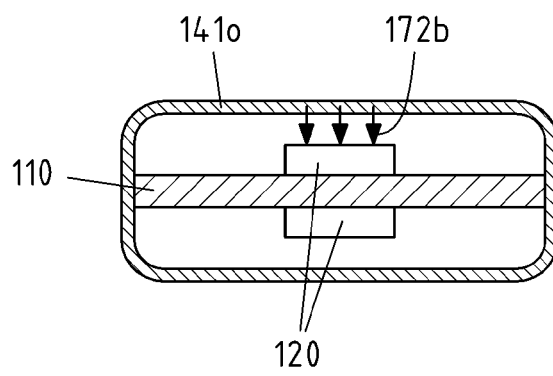


Fig.4i

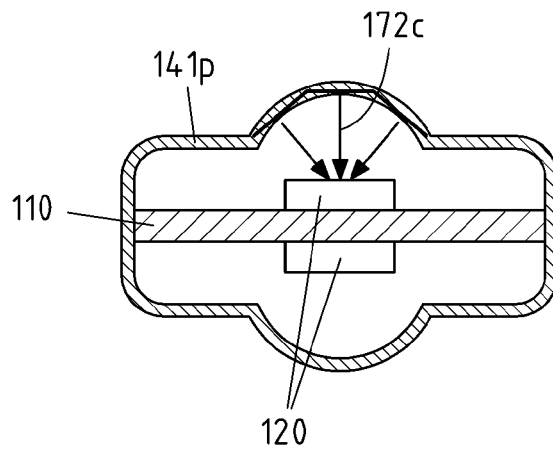


Fig.4 j

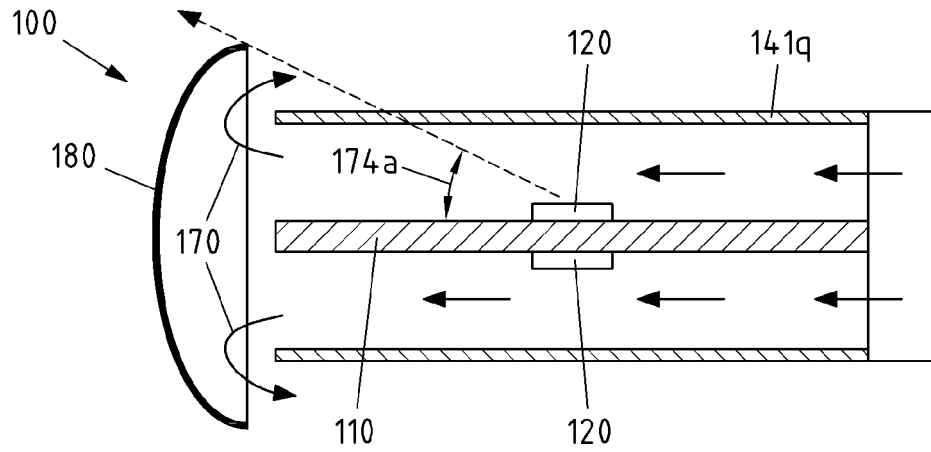


Fig.5a

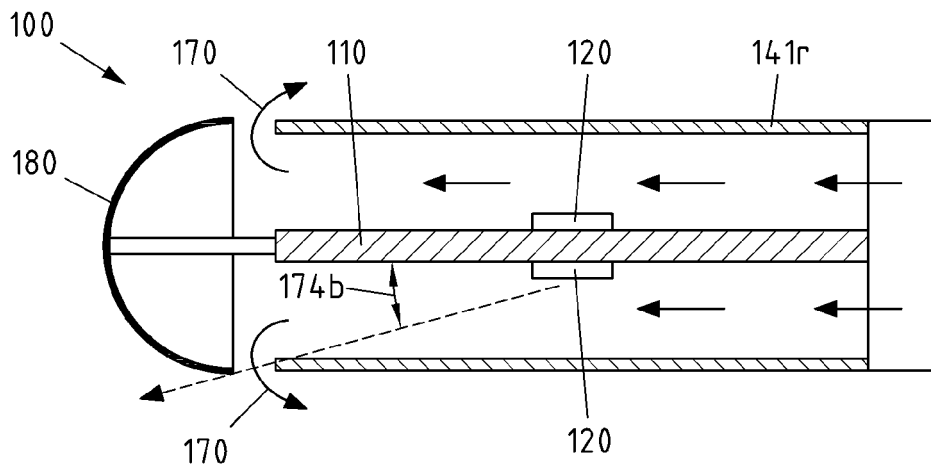


Fig.5b

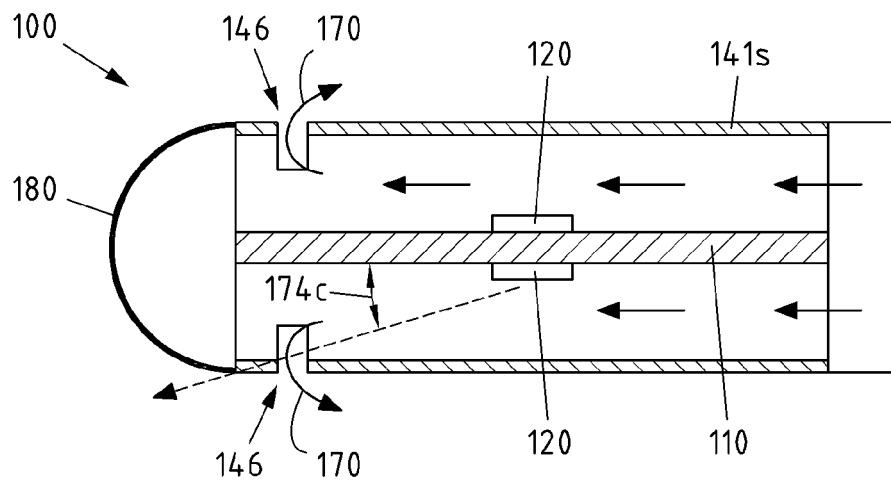


Fig.5c



EUROPEAN SEARCH REPORT

Application Number

EP 23 21 3476

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 102156 A1 (AUTOMOTIVE LIGHTING REUTLINGEN GMBH [DE]) 1 August 2019 (2019-08-01) * figure 1 *	1-15	INV. F21S41/148 F21S41/19 F21S41/43 F21S45/43
X	US 2023/272898 A1 (MOCHIZUKI KAZUMA [JP] ET AL) 31 August 2023 (2023-08-31) * paragraph [0002]; figures 2,5 *	1-15	
X	US 2023/272903 A1 (KESSELS MARCUS JOZEF HENRICUS [NL] ET AL) 31 August 2023 (2023-08-31) * figure 2 *	1-6, 8, 9, 14, 15	
X	JP 3 195848 U (-) 5 February 2015 (2015-02-05) * paragraph [0004]; figures 4,7 *	1-5, 7-9, 14, 15	
X	EP 3 385 605 A1 (VALEO ILUMINACION SA [ES]) 10 October 2018 (2018-10-10) * figures 1,4 *	1-10, 15	TECHNICAL FIELDS SEARCHED (IPC)
X	US 2015/354775 A1 (KÜRPICK RAINER [DE] ET AL) 10 December 2015 (2015-12-10) * figure 3 *	1-8, 11, 14, 15	F21S
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 19 April 2024	Examiner Guénon, Sylvain
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 23 21 3476

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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19-04-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102018102156 A1	01-08-2019	DE 102018102156 A1	01-08-2019
		EP 3746697 A1	09-12-2020
		WO 2019149398 A1	08-08-2019
US 2023272898 A1	31-08-2023	CN 116157626 A	23-05-2023
		JP WO2022009683 A1	13-01-2022
		US 2023272898 A1	31-08-2023
		WO 2022009683 A1	13-01-2022
US 2023272903 A1	31-08-2023	CN 116324268 A	23-06-2023
		EP 3945240 A1	02-02-2022
		EP 4189281 A1	07-06-2023
		JP 2023536859 A	30-08-2023
		KR 20230044458 A	04-04-2023
		US 2023272903 A1	31-08-2023
		WO 2022026615 A1	03-02-2022
JP 3195848 U	05-02-2015	NONE	
EP 3385605 A1	10-10-2018	NONE	
US 2015354775 A1	10-12-2015	CN 105180049 A	23-12-2015
		DE 102014106342 A1	12-11-2015
		US 2015354775 A1	10-12-2015

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