



(11) **EP 2 538 133 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.12.2012 Bulletin 2012/52

(51) Int Cl.:
F21V 29/00^(2006.01) F21V 29/02^(2006.01)

(21) Application number: **11305796.2**

(22) Date of filing: **23.06.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventor: **The designation of the inventor has not yet been filed**

(74) Representative: **Roche, Denis
Société Civile SPID
33 Rue de Verdun
92156 Suresnes (FR)**

(71) Applicant: **Koninklijke Philips Electronics N.V.
5621 BA Eindhoven (NL)**

Remarks:

Claim 16 is deemed to be abandoned due to non-payment of the claims fee (Rule 45(3) EPC).

(54) **Remote heat sink**

(57) The invention is about a cooling system, comprising a heat sink made of thermally conductive material and comprising an open cavity (19) extending along a main axis.

The heat sink further comprises:

- a heat core (11) having an inner surface limiting a portion of the cavity (19);
- a base plate (12), arranged in the cavity (19) to bear a LED-based device (20), extending transversally to the main axis; and
- fins (15) being oriented from the heat core (11) to the base plate (12);

wherein the base plate (12) is thermally linked to the heat core (11) such that at least one gap (14) is provided between the heat core (11) and the base plate (12) allowing some air to flow through this gap (14), between some fins (15).

The invention further relates to a LED-based luminaire comprising said heat sink and a LED-based device (20).

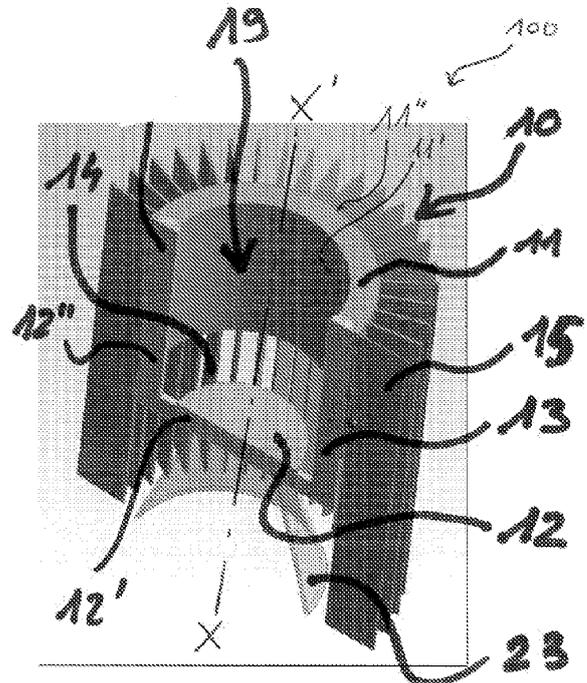


FIG. 1B

EP 2 538 133 A1

Description

FIELD OF APPLICATION

[0001] The invention relates to the field of LED-based systems, and more especially to the field of cooling systems usually provided within.

BACKGROUND OF THE INVENTION

[0002] Thermal dissipation of the heat produced by LED-based systems or devices is a key factor that limits the lumen output of an LED-based system.

[0003] Moreover improvement at low costs of such heat dissipation is needed.

[0004] The most cost-effective known solution for dissipating heat is the use of passive cooling systems, whose principle is the association of thermally conductive material with LED-based devices. Efficiency of heat dissipation depends on the configuration and design of the cooling system, in particular some heat sinks, which has nevertheless to comply with the design, optical and electrical constraints of the LED-based device.

[0005] Thus, it is known to provide a thermally conductive heat sink to LED-based devices comprising:

- a central open cavity or through hole, typically cylindrical, extending along a main axis, in which the LED-based device is positioned;
- a heat core limiting the cavity;
- a base plate arranged in the cavity to bear the LED-based device, extending in the cavity from the heat core transversally to the main axis; and
- fins fixed to the outer surface of the heat core to increase the surface of the heat sink in contact with air, improving accordingly heat dissipation.

[0006] Due to the increase of light power emitted by the new type of LEDs, thermal management challenges are increasing. And there is a need still to find more efficient, more compact, more reliable and cheaper thermal management solutions to succeed in the design of high lumen output solutions.

SUMMARY OF THE INVENTION

[0007] The invention attempts to solve said problem, by proposing a cooling system according to claim 1.

[0008] By spacing apart the base plate from the heat core, the gap thus created between them allows to increase significantly the possibility of air flow within the cavity, and between the fins, improving therefore the cooling. In particular some air which is trapped between some fins is released by this additional air flow.

[0009] Moreover this gap can be seen as a removal of materials between the base plate and the heat core from known thermal solutions, which may lead to a decrease of the weight of the heat sink.

[0010] Moreover the distance creating between the base plate and the heat core allows to use this new free space in the heat sink for other purposes (e.g. adding some additional fins, lodging components inside this space, etc.).

[0011] Preferably, the cavity is a through hole in order for the user or assembler of the overall lighting system to access the cavity from both the rear side and the front side of the heat sink, and therefore having an easy access to the LED-based device, to both sides of the base plate and to the interior part of the heat core. This through hole can also be useful for facilitating the cleaning of the heat sink (and especially of the fins).

[0012] According to an option, the gap separates entirely the base plate from the heat core. Alternatively, some mechanical structures, preferably made of thermal material, may be configured between the base plate and the heat core so as to exhibit some openings or gaps therethrough.

[0013] The air flow between the heat core and the base plate, through the gap, is therefore maximized.

[0014] According to another option, the cavity and the gap are both cylindrical. This design allows the air flow to be equally distributed within the heat sink, optimizing the cooling efficiency. In particular, one may provide the fins arranged around the main axis to further facilitate the equal cooling distribution.

[0015] Alternatively, the cavity and gap may be differently configured, in order for instance to lead to different air flows in the heat sink or an asymmetric cooling: this configuration may be useful if it is preferable to cool warm area of the LED-based device more than cold area and/or to cool fins in contact with warm air more than other fins in contact with cold air.

[0016] According to another option, the heat core and the base plate are thermally linked by at least one heat pipe. Heat pipe is typically a pipe having an internal circuit of liquid, successively heated and cooled depending on the water is located respectively close to a warm or cold environment, increasing therefore the transfer of heat between the base plate and the heat core (and potentially the fins). An advantage of a heat pipe is its good thermal conductivity with regard to its dimensions (especially its diameter), which allows to provide the gap while keeping a satisfactory heat transmission between the base plate and the heat core. A heat pipe is further a cheap solution for performing such a thermal link between two parts of a system.

[0017] Alternatively or in combination, other means for thermally linking the base plate and the heat core may be chosen, e.g. any kind of element made of thermally conductive material. This part may be inserted, screwed, over molded or soldered to the heat core and/or the base plate. Another way to create the gap for air flow between the base plate and the heat core is to start from a cavity comprising a long heat core attached to a base plate, and create openings by machining between the heat core and the base plate. The parts of the heat core not re-

moved can be the said thermal link between the base plate and the heat core.

[0018] Optionally, said fins extend parallel to the main axis. Such configuration may optimize the cooling since the fins may be in the general direction of the heat exchange or heat convection.

[0019] Optionally, some additional fins extend in the cavity: (i) from the heat core; and/or (ii) from the base plate.

[0020] These inner fins (i.e. located in the cavity) allow increasing the cooling surfaces of the heat sink, while keeping a good air flow (especially via said gap) and restricting the size of the outer fins (i.e. the fins being oriented from the outer surface of the heat core) and therefore the size of the heat sink.

[0021] Optionally, active cooling device for flowing the air is provided in the cavity, on the side of the base plate opposite to the LED-based device. In particular, this active cooling device is provided between the heat core and the base plate, and more especially this active cooling device fits in the gap. This active cooling device might be a fan or another type of active cooling system. The presence of the cavity and said gap (which might increase the distance between the base plate and the heat core) allows to lodge such active cooling device inside the heat sink, hiding this active cooling device from an external view, leading to a lighting system more esthetically attractive. This embodiment can also lead to a more compact lighting system. Moreover this active cooling device should increase the air flow and therefore the cooling of the lighting system, especially through the gap.

[0022] Optionally, LED-driving device for driving the LEDs is provided in the cavity, on the side of the base plate opposite to the LED-based device. The presence of the cavity and said gap (which might increase the distance between the base plate and the heat core) allows to lodge such LED-driving device inside the heat sink. Accordingly: (i) the size of the LED-based device can be reduced since a part of the electronics is now provided elsewhere than in the LED-based device; and/or (ii) these LED-driving device can be hidden from an external view, leading to a lighting system more esthetically attractive. This embodiment can also lead to a more compact lighting system. Moreover this LED-driving device can receive an additional air flow due to the proximity with the gap, and be cooled accordingly.

[0023] Optionally the LED-based device comprises one or several LEDs attached directly or indirectly (e.g. via a circuit board) to the base plate and an optical member positioned in front of the LED(s), and wherein at least a part of the fins are arranged to further extend at the level of the optical member.

[0024] According to another aspect, the invention proposes a LED-based luminaire comprising said heat sink and a LED-based device.

[0025] Optional embodiments of such LED-based luminaire are recited in claims 13 through 16.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Other features and advantages of the invention appear from the following detailed description of one of its embodiments, given by way of non-limiting example, and with reference to the following drawings:

FIG. 1A shows a longitudinal cross-section view, with respect to a plane including a main axis XX', of a first embodiment of a lighting device according to the invention.

FIG. 1B shows a perspective view of an half part of the lighting device of FIG. 1, cut according to a plane including the main axis XX'.

FIG. 2 shows a perspective view of an half part of a second embodiment of a lighting device according to the invention, cut according to a plane including a main axis XX'.

FIG. 3 shows a longitudinal cross-section view of another embodiment of a lighting device according to the invention.

FIG. 4 shows a longitudinal cross-section view of another embodiment of a lighting device according to the invention.

FIG. 5 shows a longitudinal cross-section view of another embodiment of a lighting device according to the invention.

FIG. 6A shows a longitudinal cross-section view of a known lighting device, horizontally positioned.

FIG. 6B shows a longitudinal cross-section view of a lighting device according to FIG. 3, horizontally positioned.

FIG. 7A shows a longitudinal cross-section view of a known lighting device, vertically positioned.

FIG. 7B shows a longitudinal cross-section view of a lighting device according to FIG. 3, vertically positioned.

FIG. 8A shows a longitudinal cross-section view of a first known lighting device, comprising active cooling.

FIG. 8B shows a longitudinal cross-section view of a second known lighting device, comprising active cooling.

FIG. 8C shows a longitudinal cross-section view of a lighting device according to another embodiment of the invention, comprising active cooling.

DETAILED DESCRIPTION OF THE INVENTION

[0027] FIG. 1A and 1B show a first embodiment of a lighting device 100 according to the invention, comprising a LED-based device 20 and a heat sink 10.

[0028] The LED-based device 20 comprises at least one or several LEDs 21 which are directly or indirectly thermally linked to the heat sink 10. The LEDs 21 may be fixed to a circuit board 22. The circuit board 22 comprises circuitry and optionally some electronic components such as for example drivers and/or memories. The

LED-based device 20 may further comprise at least one optical member 23 positioned on top of LEDs 21 and acting on the light beam shape, direction and/or density of energy outputting the LEDs 21. In this example, the optical member 23 is represented by a collimator designed to guide the light outside the lighting device 100.

[0029] The heat sink 10 is made of thermally conductive material (e.g. aluminum alloys (e.g. ADC1, ADC10, Al1050,...), copper, zamac, ceramics (AlN, Al2O3), thermal plastics) and comprises an open cavity 19 (here a through hole 19) extending along an XX' axis, a heat core 11 whose inner surface limiting a portion of the through hole 19, a base plate 12 arranged in the through hole 19 to bear the LED-based device 20 and spaced apart from the heat core 11 by a gap 14, a heat pipe 13 thermally (and possibly mechanically) linking the base plate 12 to the heat core 19, fins 15 fixed to the heat core 11 and being oriented from the heat core 11 to the base plate 12 and optionally extending at the level of the optical member 23 (as depicted in FIG. 1A and 1B).

[0030] The through hole 19 preferably extends with respect to a main axis XX', which can be the main optical axis of the LED-based device 20. Without any limitation, the through hole 19 may have a general cylindrical shape (e.g. having a circular, elliptical, squared, rectangular cross-section) or a general tapered shape or any other appropriate shape for design and/or cooling purpose of the lighting device 100. In the specific configuration of FIG. 1A and 1B, the through hole 19 has a general cylindrical shape with a circular cross section - the circular cross-section might be particularly useful for use with spots and advantageous because the design is compact for a symmetrical light distribution.

[0031] The heat core 11 extends generally with respect to the XX' axis, and comprises an inner surface 11' and an outer surface 11". If the through hole 19 is cylindrical, the inner surface 11' of the heat core 11 might be accordingly cylindrical, too, as depicted in FIG. 1A and 1B. The inner surface 11' limits only a top portion of the through hole 19.

[0032] Fins 15 are oriented from the heat core 11 to the base plate 12. Preferably, the fins 15 are fixed to the outer surface 11" of the heat core 11. Fins 15 may be flat and thin blades or the like, arranged around the XX' axis. Fins 15 can be plane, extending parallel the XX' axis or slightly twisted. As an option, these fins 15 (as depicted in FIG. 1A and 1B) further extend beyond the base plate 12, so as to surround at least a part of the optical member 23. Fins 15 may be arranged one to the other around the XX' axis according to a specific pitch. In the case of a cylindrical heat core 11, fins can further extend radially from the outer surface 11" of the heat core 11, with respect to XX' axis.

[0033] Size and shape of the base plate 12 can be determined by the size of the LED-based device 20, and especially of the circuit board 22. Thickness of the base plate 12 is adjusted with regard to heat dissipation, weight, costs considerations. Its thickness and geometry

is also adjusted to have a good thermal transfer with the heat pipe 13. Base plate 12 is either only fixed to the heat core 11 via the heat pipe 13 (the base plate 12 and the LED-based device 20 are therefore suspended in the through hole 19) and/or fixed to some fins 15. For example, LED-based device 20 may be fixed (e.g. by screwing, clipping, sticking, and/or clamping) onto the base plate 12, and the heat pipe 13 being fixed onto the base plate 20 (e.g. by soldering and/or pressing), and the heat pipe 13 is then fixed onto the heat core 11 (e.g. by soldering and/or pressing): in this case the heat pipe 13 ensures the mechanical bound between the base plate 12 and the heat core 11. Other way of fixing the heat pipe 13 / base plate 12 / heat core 11 / LED-based device 20 may nevertheless be used, such that the base plate 12 and the heat core 11 are sufficiently thermally linked together according to the invention.

[0034] The heat pipe 13 is provided between the base plate 12 and the heat core 11. A heat pipe is typically a pipe having an internal circuit of liquid, successively heated and cooled depending on the water is located successively close to a hot or cold environment, increasing therefore the transfer of heat between the base plate 12 on one hand and the heat core 11 (and potentially the fins 15) on the other hand. Movement of the liquid in the circuit is caused by the convection, and also some optionally capillarity elements located inside the heat pipe 13 to counterbalance the gravity force. The heat pipe 13 is preferably arranged in the through hole 19 such that the part of the through hole 19 above the base plate 12 is still accessible and not obstructed by the heat pipe 13. To this purpose the heat pipe 13 may first extend transversally to the XX' axis through the base plate 12 until the sides of the through hole 19 or until the gap 14 (this is the first section 13' of the heat pipe 13), second extends parallel the XX' axis on sides of the through hole 19 to the heat core 11 (this is the second sections 13" of the heat pipe 13). Heat pipe 13 may be fixed by different manner to the base plate 12 and the heat core 11. For example, the heat pipe 13 can be soldered to the base plate 12 and/or the heat core 11 with or without a groove provided into the base plate 12 and/or the heat core 11. Alternatively or in combination, the heat pipe 13 can be pressed into the base plate 12 and/or the heat core 11, inside a groove provided in the base plate 12 and/or the heat core 11.

[0035] In another embodiment, more than one heat pipe 13 may be provided between the base plate 12 and the heat core 11.

[0036] Additionally, some other mechanical reinforcement might be provided between the base plate 12 and the heat core 11, like e.g. a cage-structure.

[0037] As a way of example, the following process for manufacturing a heat sink according to the invention is provided:

1. Manufacture the base plate 12;
2. Manufacture the heat pipe 13 + Bend the heat

pipe 13 according to the heat sink dimensions and shape;

3. Assemble the heat pipe 13 onto the base plate 12;

4. Manufacture the heat core 11;

5. Assemble the heat pipe 13 onto the heat core 11;

■ If the heat sink comprises some fins 16, 17 inside the through hole 19 (see e.g. FIG. 2 and 3), assemble the heat pipe 13 outside the through hole 19;

■ If the heat sink does not comprise fins 16, 17 inside the through hole 19, assemble the heat pipe 13 inside or outside the through hole 19;

6. Press fit the fins 15 onto the heat core 11.

[0038] FIG. 2 depicts another lighting device 100' similar to the lighting device 100 of FIG. 1B, but further comprising inner lateral fins 16 extending from the inner surface 11' of the heat core 11. In this configuration the through hole 19 hosts these additional inner fins 16, increasing therefore the contact surface of the heat sink 10 with air while not significantly hampering the air flow.

[0039] FIG. 3 shows another lighting device 100" similar to the lighting device 100' of FIG. 2, but further comprising inner bottom fins 17 extending in the through hole 19 from the surface of the base plate 12 opposite to the surface of the base plate 12 receiving the LED-based device 20. In this configuration the through hole 19 hosts the additional inner lateral and bottom fins 16, 17 increasing therefore the contact surface of the heat sink 10 with air while not significantly hampering the air flow.

[0040] Another embodiment (not depicted) is about another lighting device similar to the lighting device 100 of FIG. 1B, but further comprising inner bottom fins 17 extending in the through hole 19 from the surface of the base plate 12 opposite to the surface of the base plate 12 receiving the LED-based device 20. In this configuration the through hole 19 hosts these additional inner bottom fins 17, increasing therefore the contact surface of the heat sink 10 with air while not significantly hampering the air flow.

[0041] As an alternative or a combination with previous embodiments, the through hole 19 may further host LED-driving device 29 of the LEDs 21 of the LED-based device 20, this LED-driving device 29 being connected to the LED-based device 20 via connectors 28, as shown in FIG. 4. The LED-driving device 29 can be fixed to the inner surface of the heat core 11 and/or to the base plate 12 via elements of fixation (e.g. attachment means, slots, etc.). As a first example, the LED-driving device 29 may be a plastic circuit board ("PCB") in a (electrostatic) box or housing, screwed in the through hole 19 or clipped within if inner surface of the heat core 11 is provided with complementary clipping elements. Alternatively, the LED-driving device 29 may be stuck or potted inside the through hole 19 with ensuring electrical insulation: latter

solution may be chosen if the LED-driving device 29 is a PCB with components (i.e. without housing or box for protecting it). By providing at least a part of the LED-driving device 29 in the through hole 19 instead of within the LED-based device 20, this leads to space the heat produced by this LED-driving device 29 apart from the base plate 12 and therefore to reduce the quantity of heat to be communicated to the base plate 12 and to position this LED-driving device 29 within the increased air flow. Furthermore, the separation of this LED-driving device 29 from the LED-based device 20 allows to reduce the weight of the LED-based device 20, especially advantageous in case the assembly of LED-based device 20 and base plate 12 is suspended from the heat core 11 (via the heat pipe 13). Moreover, the constraints related to the design and size of the LED-driving device 29 are less important if it is positioned in the through hole 19 than in the LED-based device 20.

[0042] As an alternative or a combination with previous embodiments, the through hole 19 may further host activable cooling device 30, such as for example a fan. The presence of such activable cooling device 30 further increase the air flow within the heat sink 10, and especially through the gap(s) 14. Moreover this activable cooling device 30 is invisible from an external viewer, since it is hidden by the heat sink 10, leading to a lighting device 100 aesthetically nicer.

[0043] FIG. 8C shows a LED-based luminaire 200, including a lighting device 100" according to the invention comprising an activable cooling device 30 positioned in the through hole 19, and more especially (in this case) in the portion of the through hole 19 limited by the inner surface of the heat core 11, below the inner lateral fins 16 and above the optional inner bottom fins 17. Active cooling device 30 allows to increase the air flow by forcing the air to flow along an air path, especially via the gap 14. The LED-based luminaire 200 comprises a housing 60, made typically of electrically insulating material, lodging most of the lighting device 100" (which comprises through hole 19, heat sink 11, base plate 12, heat pipe 13, gap 14, outer fins 15, inner lateral fins 16, inner bottom fins 17 as discussed previously). This housing 60 comprises a front opening 61 on a front side allowing the light outputting the optical member 23 and a rear opening 62 on a back side allowing the external air to communicate with the inner lateral fins 16 and the outer fins 15. The rear opening 62 may be annular, leaving a solid central disk covering a central portion of the through hole 19. The housing 60 may be made of two parts: a back housing 60' arranged to lodge the heat sink 10 and a front housing 60" arranged to lodge the optical member 23. The back housing 60' and the front housing 60" may be connected via an intermediate opening 63 arranged to receive the LEDs 21 therethrough.

[0044] FIG. 6A and 6B depict how the heat dissipation is improved in a light device according to the invention (FIG. 6B) in comparison with a known light device (FIG. 6A) if they are positioned horizontally (i.e. the main axis

XX' is perpendicular to the direction of gravity). It is to be noted that the two light devices are made of similar materials and have similar dimensions of heat sinks 10, similar fins 15, and similar LED-based devices 20. Heat exchange is depicted on the FIGs by the arrows. For the known light device, the heat exchange by convective heat transfer is limited as the fins 15 orientation is not in the gravity direction ("G") - indeed hot dissipated to the air via the bottom part of the light device is trapped between the bottom fins 15' (since hot air goes naturally up) - leading to a low efficiency of the LEDs located close to the bottom fins 15' with respect to the efficiency of the LEDs located close to upper fins 15". Now, the "opening" of the heat core 11 according to FIG. 6B, by providing a gap 14 between the heat core 11 and the base plate 12, allows the releasing of the trapped hot air through the heat sink 10, creating furthermore an air flow as depicted by the arrow.

[0045] FIG. 7A and 7B depict how the heat dissipation is improved in a light device according to the invention (FIG. 7B) in comparison with a known light device (FIG. 7A) if they are positioned vertically (i.e. the main axis XX' is parallel to the direction of gravity). It is to be noted that the two known light devices are made of similar materials and have similar dimensions of heat sinks 10, similar fins 15, and similar LED-based devices 20. Heat exchange is depicted on the FIGs by the arrows. For the known light device, the heat exchange by convective heat transfer is performed principally via the fins 15 due to the high surface of the fins 15 in contact with air. Now, the "opening" of the heat core 11 according to FIG. 7B, by providing a gap 14 between the heat core 11 and the base plate 12, allows creating a natural air flow (since hot air naturally goes up) inside the light device, through (in this case) inner fins 16 (as depicted by the arrow). By spreading heat cooling through the entire heat sink 10, heat dissipation is therefore improved.

[0046] FIG. 8A, 8B and 8C depict how the heat dissipation is improved in a light device according to the invention (FIG. 8C) in comparison with two known light devices (FIG. 8A and 8B). It is to be noted that the two known light devices have identical LED-based devices 20. Heat exchange is depicted on the FIGs by the arrows.

[0047] The first known light device (FIG. 8A) is a luminaire comprising a back housing 40 arranged to lodge an active cooling device 30 (e.g. a fan), a front housing 40' arranged to lodge the LED-based device 20, and a heat sink or radiator 10 positioned between the back housing 40 and the front housing 40'. In order to dissipate the heat by leaving the hot air flowing through the sides of the heat sink 10 (see heat exchange depicted by arrows in FIG. 8A), a gap 40" is to be provided between the back housing 40 and the front housing 40', allowing for an external viewer to see the heat sink 10, which is not desirable for aesthetical reasons. Moreover, the cooling of such heat sink 10 requires a powerful, cumbersome and noisy cooling system 30.

[0048] The second known light device (FIG. 8B) is a

luminaire comprising a housing 40 arranged to maintain an active cooling device 30 (e.g. a fan) and a heat sink 10 or radiator positioned between the active cooling device 30 and the LED-based device 20. This configuration allows to dissipate the heat from the back side of the housing 40 to the front side of the light device, through openings 41 provided around the light output of the housing 40 (see heat exchange depicted by arrows in FIG. 8B). This second known light device needs to be wider than the first known device, since some additional space needs to be provided around the LED-based device 20, which is not desirable for aesthetical and practical reasons..

[0049] An LED-based luminaire 200 of the invention, shown in FIG. 8C, has been previously described. Due to its specific configuration, the air flows through an air path between an air inlet (cool air) being the portion of the back opening 62 facing the inner lateral fins 16, and an air outlet (hot air) being the portion of the back opening 62 facing the outer fins 15. From the air inlet, air mostly flows successively via the inner lateral fins 16, via the fan 30, via the gap 14 and via the outer fins 15. Air flow may be improved by the presence of said inner bottom fins 17 located between the fan 30 and the air gap 14 in the air path. Heat dissipation is therefore mostly performed through the rear side of the LED-based luminaire 200. This configuration allows both to hide the active cooling device 30 from an external viewer and to use an active cooling device 30 without involving a significant increase of the size of the luminaire 200. Additionally, due to the proximity of the cooling device 30 to the LEDs 21 and to the greater surface exchange (with inner fins 16, 17) of the luminaire 200, the cooling device 30 may be smaller.

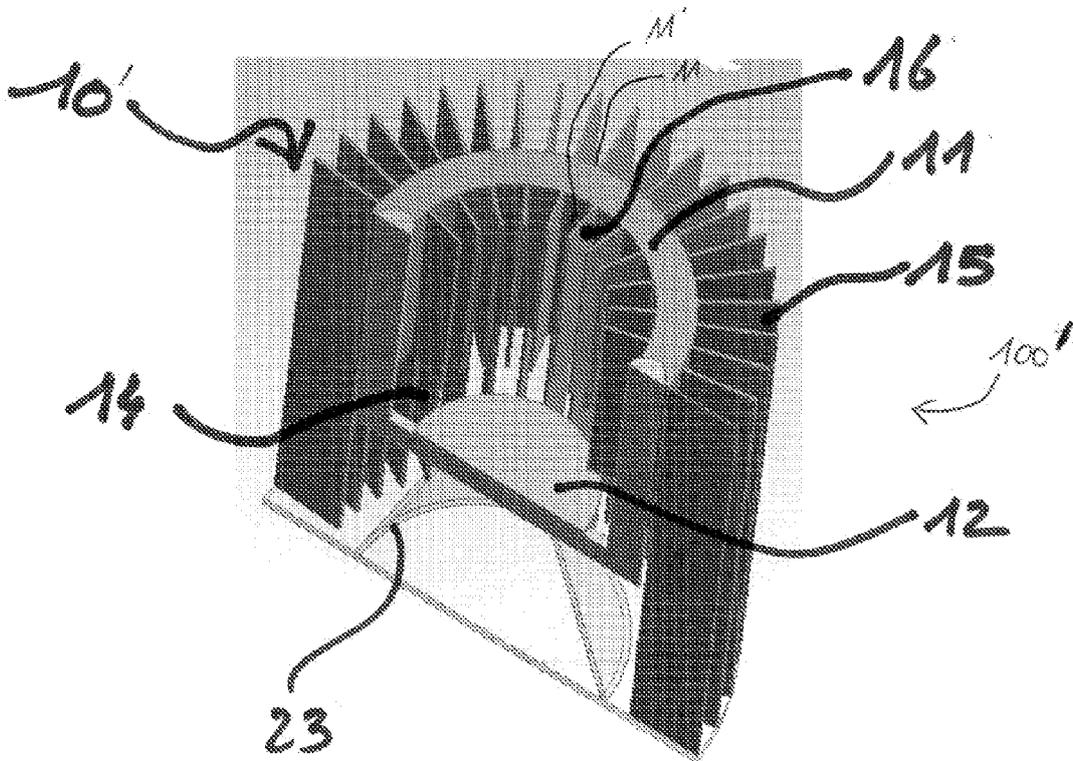
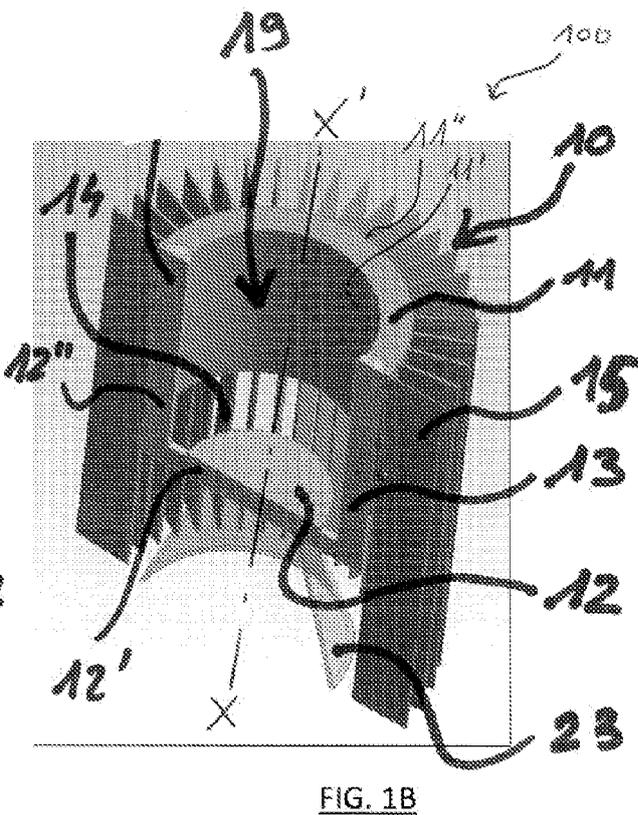
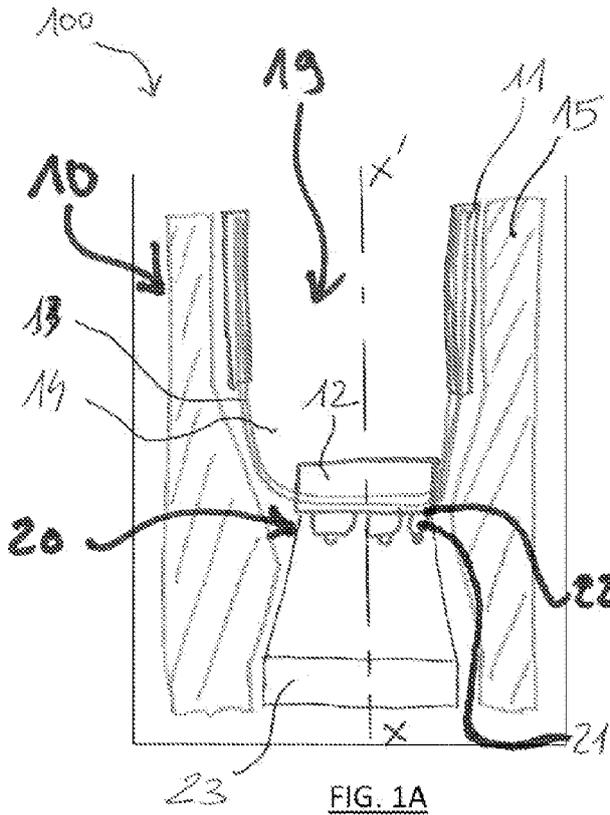
[0050] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments, and the person skilled in the art can clearly adapt the teaching of the invention, especially relating to the remote heat core principle, to any other light configurations. In particular the lighting system does not necessarily comprise identical shapes of optical modules.

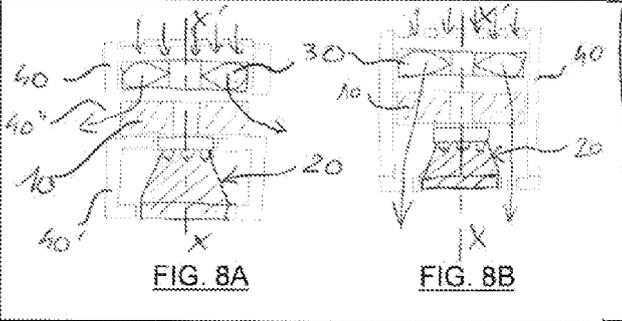
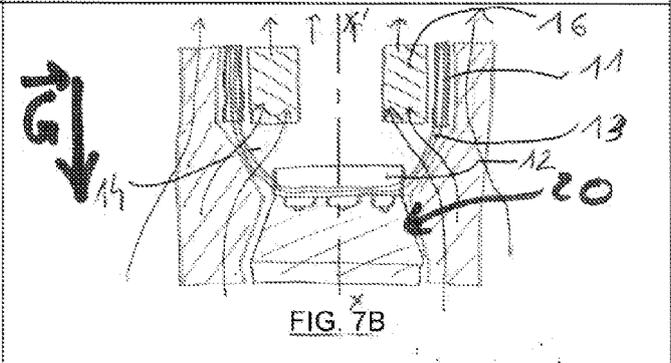
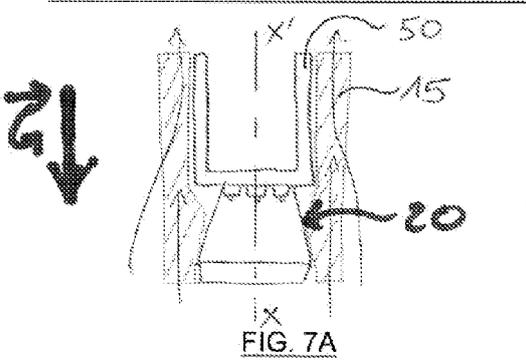
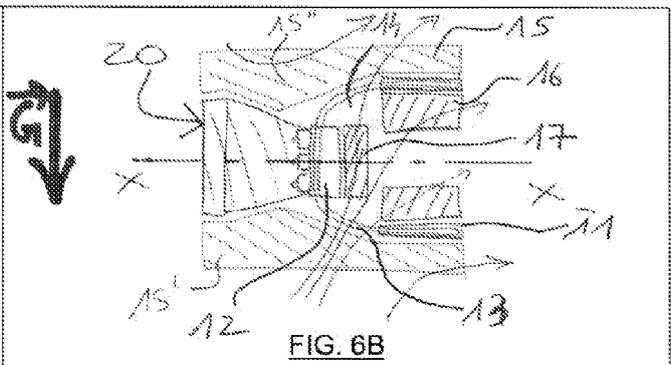
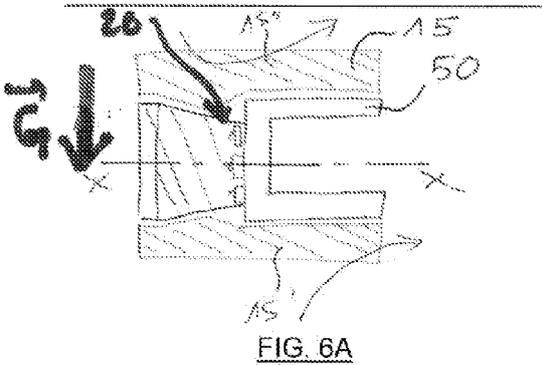
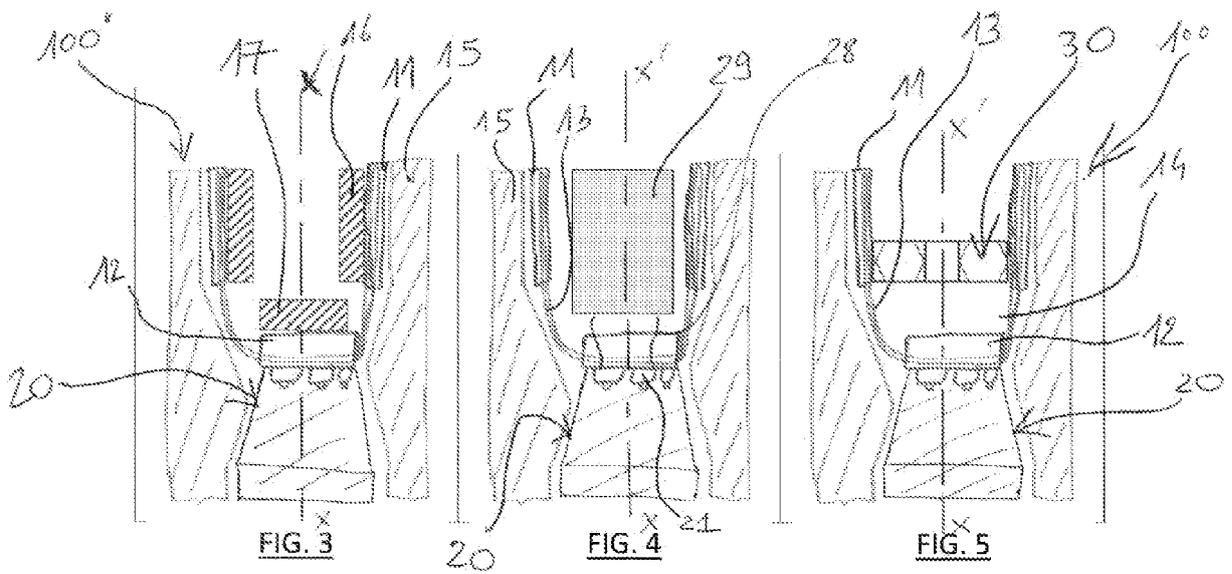
[0051] Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality.

Claims

1. Cooling system, comprising a heat sink made of thermally conductive material and comprising an open cavity (19) extending along a main axis, the heat sink further comprising:

- a heat core (11) having an inner surface limiting a portion of the cavity (19);
 - a base plate (12), arranged in the cavity (19) to bear a LED-based device (20), extending transversally to the main axis; and
 - fins (15) being oriented from the heat core (11) to the base plate (12);
 wherein the base plate (12) is thermally linked to the heat core (11) such that at least one gap (14) is provided between the heat core (11) and the base plate (12) allowing some air to flow through this gap (14), between some fins (15).
2. Cooling system of claim 1, wherein the heat core (11) and the base plate (12) are thermally linked by at least one heat pipe.
 3. Cooling system of claim 1, wherein some additional fins (16) extend in the cavity (19) from the heat core (11).
 4. Cooling system according to one of claims 1 to 3, wherein some additional fins (17) extend in the cavity (19) from the base plate (12).
 5. Cooling system of claim 1, wherein an active cooling device (30) for generating additional air flow is provided in the cavity (19), and is located on the side of the base plate (12) opposite to the LED-based device (20).
 6. Cooling system of claim 5, wherein the active cooling device (30) fits in the gap (14).
 7. Cooling system of claim 1, wherein the LED-based device (20) comprises at least one LED (21) attached directly or indirectly to the base plate (12) and an optical member (23) positioned in front of the LED (s) (21), and wherein at least a part of the fins (15) are arranged to extend at the level of the optical member.
 8. Cooling system of claim 1, wherein the cavity (19) is cylindrical and the gap (14) is cylindrical.
 9. Cooling system according to claim 1, wherein the gap separates entirely the base plate (12) from the heat core (11).
 10. Cooling system according to claim 1, wherein the open cavity (19) is provided with two openings located at two opposite ends of the cavity (19) so as to form a through hole (19).
 11. LED-based luminaire comprising a cooling system of any one of claims 1 through 10 and a LED-based device (20).
 12. LED-based luminaire of claim 11, further comprising:
 - an active cooling device for creating the air flow (30), provided in the cavity (19) of the heat sink,
 - a housing (60) for lodging said heat sink and optionally the LED-based device (20),; wherein the housing (60) comprises air opening (s) (62) to determine air inlet and air outlet.
 13. LED-based luminaire of claim 12, wherein the air opening(s) (62) are located at the side of the housing (60) opposite the side of the LED-based luminaire from which the light outputs.
 14. LED-based luminaire of claim 12, further comprising inner fins (16) extending in the cavity (19) from the heat core (11), wherein the active cooling device (30) is positioned between these inner fins and the base plate (12), and wherein the air opening(s) are located such that the air flows first through the inner fins (16) and then to the fins (15) located outside the cavity (19).
 15. LED-based luminaire of claim 14, further comprising internal fins (17) extending in the cavity (19) from the base plate (12), and located such that at least part of the air flowing between the inner fins (16) to the fins (15) located outside the cavity (19) passes through the internal fins (17).
 16. LED-based luminaire of claim 11, further comprising LED-driving device (29) for driving the LEDs (21) provided in the cavity (19), and is located on the side of the base plate (12) opposite to the LED-based device (20).





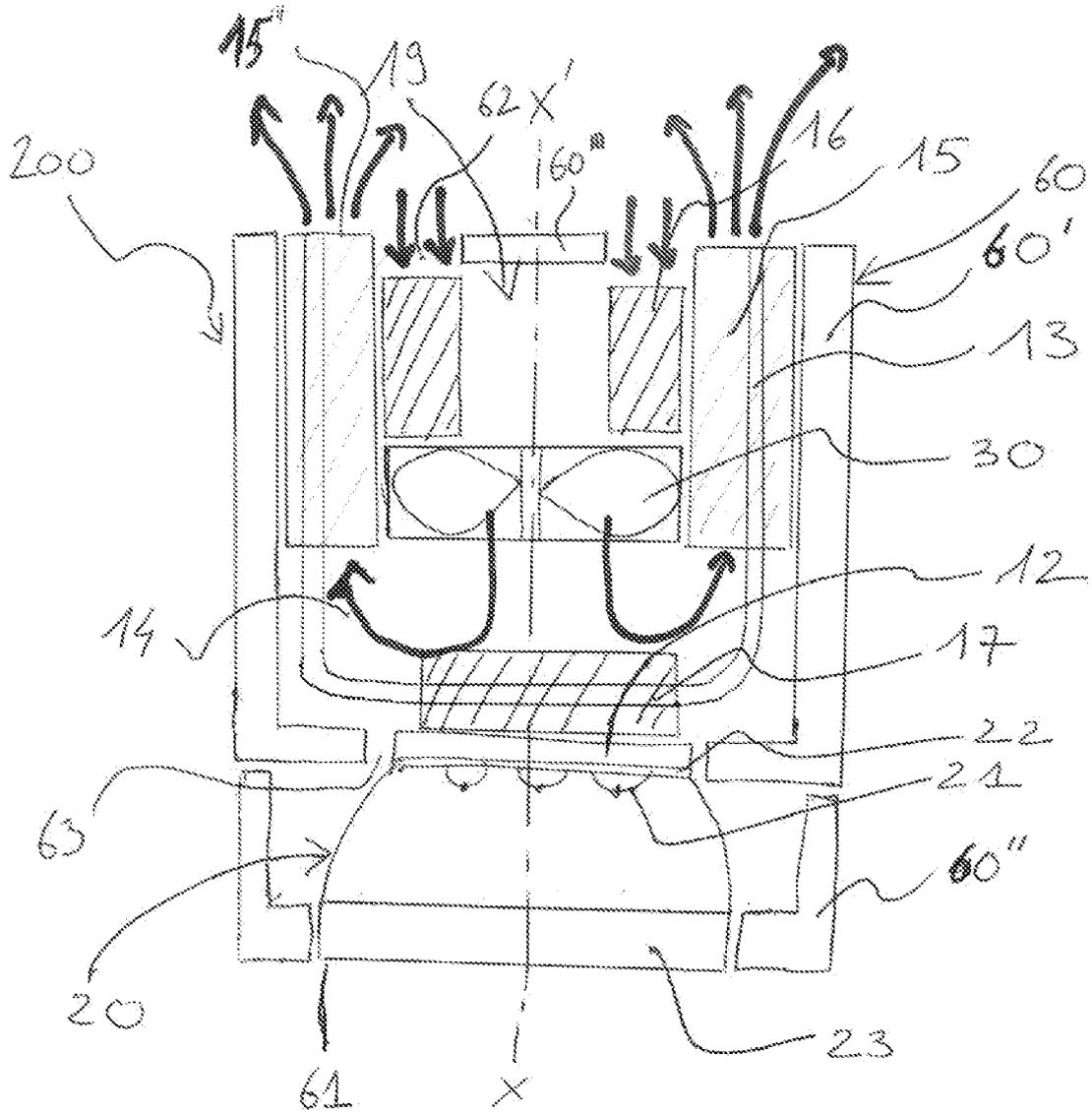


FIG. 8C



EUROPEAN SEARCH REPORT

Application Number
EP 11 30 5796

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	EP 2 128 522 A1 (DELTA ELECTRONICS INC [TW]) 2 December 2009 (2009-12-02)	1-3,5,8,9,11-14,16	INV. F21V29/00 F21V29/02
Y	* paragraph [0039] - paragraph [0043] * * figures 1,3,4,5,9 * * paragraphs [0045], [0046] *	4,15	
X	EP 2 025 992 A2 (TOPCO INNOVATION CO LTD [TW]; LUSTROUS INTERNAT TECHNOLOGY L [TW]) 18 February 2009 (2009-02-18) * figures 4,5 * * paragraphs [0032], [0034], [0035] * * figures 2,3 *	1,3-13	
X	EP 1 528 315 A2 (CHEN JEFFREY [TW] NEOBULB TECHNOLOGIES INC [BN]) 4 May 2005 (2005-05-04) * figures 5-10,13 * * paragraphs [0009], [0011], [0012] *	1,5,11	
Y	US 2004/222516 A1 (LIN TING-HAO [TW] ET AL) 11 November 2004 (2004-11-11) * figures 1-4 *	4,15	TECHNICAL FIELDS SEARCHED (IPC) F21V
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 10 May 2012	Examiner Pérennès, Frédéric
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	

1
EPO FORM 1503 03/02 (P04C01)

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

EP 11 30 5796

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-05-2012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
EP 2128522	A1	02-12-2009	EP 2128522 A1	02-12-2009
			JP 4677016 B2	27-04-2011
			JP 2009289725 A	10-12-2009
			TW 200949149 A	01-12-2009
			US 2009296411 A1	03-12-2009

EP 2025992	A2	18-02-2009	CN 101368719 A	18-02-2009
			EP 2025992 A2	18-02-2009
			JP 4673389 B2	20-04-2011
			JP 2009048994 A	05-03-2009
			US 2009046473 A1	19-02-2009

EP 1528315	A2	04-05-2005	AT 438828 T	15-08-2009
			EP 1528315 A2	04-05-2005
			ES 2331077 T3	21-12-2009

US 2004222516	A1	11-11-2004	NONE	
