(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 089 324 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
16.11.2022 Bulletin 2022/46

(21) Application number: **22290030.0**

(22) Date of filing: **11.05.2022**

(51) International Patent Classification (IPC):
F21V 29/81 *(2015.01)* *F21V 29/89* *(2015.01)*
F21V 21/30 *(2006.01)* *F21Y 105/12* *(2016.01)*
F21W 131/10 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F21V 29/81; F21V 21/30; F21V 29/89;
F21W 2131/10; F21Y 2105/12

(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
Designated Validation States:
KH MA MD TN

(30) Priority: **12.05.2021 EP 21290030**

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(54) **HEAT SINK FOR LIGHTING DEVICE**

(57) Heat sink (1) for a lighting device (100), comprising a base panel (2) having a top surface (20) and a bottom surface (21), and a plurality of pin fins (3) each extending outwardly from the top surface (20) in a protruding direction (4). The bottom surface (21) comprises a mounting section (22) for mounting a light source (200) so as to transfer heat from the light source (200) via the base panel (2) to the pin fins (3) by thermal conduction. The pin fins (3) each have a cross-sectional configuration (Q), when viewed along the protruding direction (4), with a central section (30) and two extension sections (31) extending along an extension direction (5) from opposite sides of the central section (30) so as to taper with increased distance from the central section (30).

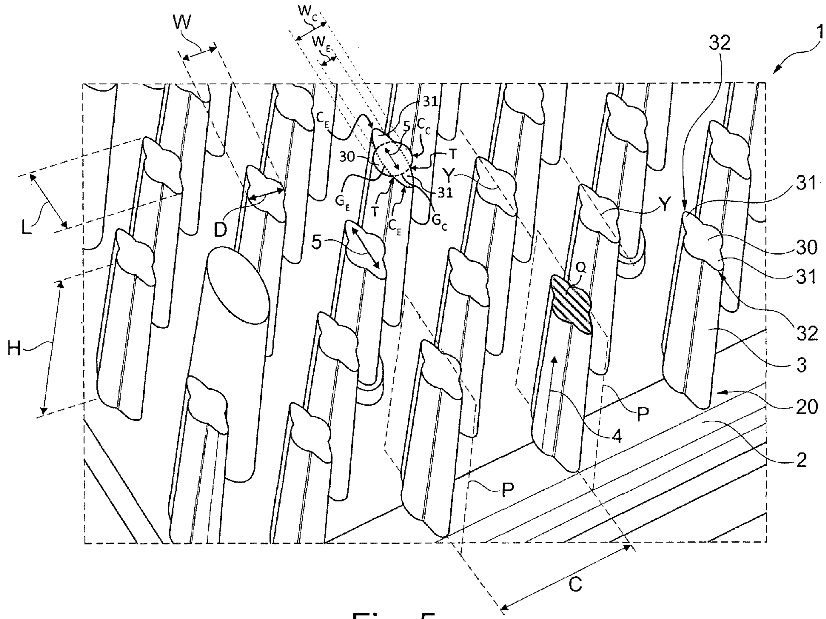

Fig. 5

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Description

[0001] The present invention is directed to a heat sink for a lighting device, to the lighting device comprising said heat sink and a light source mounted thereto, and to a lighting arrangement comprising said lighting device and a support arrangement for supporting the lighting device.

[0002] Heat sinks for lighting arrangements are generally known in the prior art. Usually, a light source, like an LED (light emitting diode) module are directly mounted on such a heat sink to allow heat dissipation from the light source when in operation by thermal conduction. To increase heat dissipation it is known that heat sinks comprise protruding structures, which are designed to allow a fluid, like air or cooling liquid, to flow around these structures thus increasing the cooling effect. Such protrusions are usually in the form of fins. Particularly flat fins are widely used, which offer a reduced complexity and thus allow for a comparably simple production process. Flat fins provide a quite large surface area thus allowing for a good heat dissipation. Flat fins usually extend along a defined direction and are arranged in parallel so that these cooling fins exhibit their cooling capabilities mainly in the direction of their extension. Due to the quite large surface area, flat fins are prone to high drag forces particularly in application areas where the flow direction of cooling fluid is not known or not constrained, e.g. when the heat sink is used in wind affected areas like floodlight applications.

[0003] For such applications, the use of pin-shaped protrusions with circular cross-section is known. The pin-shaped protrusions have a reduced drag area but a less heat dissipation ability compared to flat fins due to their reduced surface area.

[0004] It is thus an object of the present invention to provide a heat sink as well as a lighting device and a lighting arrangement, which feature a good balance between a low drag area and a good heat dissipation.

[0005] This object is achieved by the subject-matter of the independent claims. The dependent claims study further the central idea of the present invention.

[0006] According to an aspect, the present invention is directed to a heat sink for a lighting device. The heat sink comprises a base panel having a top surface and a bottom surface. The heat sink further comprises a plurality of pin fins each extending outwardly from the top surface in a protruding direction. The bottom surface comprises a mounting section for mounting a light source so as to transfer heat from the light source via the base panel to the pin fins by thermal conduction. The pin fins each have a cross-sectional configuration (i.e. a configuration of their cross-section, in the following simply referred to as a cross-section; this preferably along their entire height), when viewed along the protruding direction, with a central section and two extension sections extending along an extension direction from opposite sides of the central section so as to taper with increased distance from the central section.

[0007] According to the invention, the pin fins each have a cross-sectional configuration, i.e. a configuration of their cross-section, which by definition requires the central section and the respective extension sections be distinguishable over each other in their shape and/or contour, i.e. be structurally distinct. Hence, these sections - as being part of the mentioned cross-sectional configuration - are structurally distinguishable; i.e. each being recognizable (e.g. by its contour) as individual shape/structure/contour or the like, which together result in the overall configuration. This distinction excludes any cross-section in which the sections (i.e. central section and extension sections) are only virtually distinguishable or sub-dividable. This distinction allows the central section and the extension sections each being functionally optimized. In particular, the heat sink according to the present invention provides a comparably high exchange area to volume ratio compared to the known pin protrusions. Also, as the pin fins still have a generally pin-like structure, they permit the flow of a cooling fluid around the pin fins from every direction without substantially being affected by increased drag forces. Moreover, the streamlined shaped of the pin fins due to the extension sections is able to reduce the pressure losses and to improve fluid flow even in cases of natural convection. Hence, the heat sink according to the present invention provides a good balance between high cooling abilities due to good heat dissipation on the one side and low impact of drag forces due to a low drag area (SCx) on the other side.

[0008] As mentioned, the cross-sectional configuration and thus the advantages as defined herein above are preferably obtained by the central section being preferably structurally distinct, i.e. structurally recognizable, over the extension sections, respectively.

[0009] The central section may have a first outer contour and the extension sections each may have a second outer contour, wherein preferably the first outer contour is geometrically distinct to the second outer contour or contours, respectively. Hence, the cross-sectional configuration with its distinguishable sections can be easily tailored according to the desired functions of the respective sections, and thus the advantages as defined herein above are obtained in an easy and effective way.

[0010] Preferably, the central section and the extension sections, preferably their outer contours, meet in a structural (i.e. a structurally or geometrically recognizable) transition area, respectively. Hence, the distinct sections can be easily provided and their transition be functionally and physically be optimized; e.g. with a transition - even though being structurally distinguishable and thus recognizable - being as smooth or as sharp as desired.

[0011] The transition areas may preferably be defined at transition points of the first outer contour with the second outer contours, respectively. Hence, the transition are can be provided so as to interfere the functions of the respective contours as little as possible or as desired.

[0012] The two extension sections or their second outer contours, by virtual extension of their shapes towards each other, have a combined geometrical shape, preferably an oval shape. Hence, the respective sections can easily and effectively be provided in respect of function and manufacturing. An oval shape further allows for a particularly effective low drag area and good heat dissipation while having a comparably easily manufacturable shape.

[0013] The central section or its first outer contour, by virtual extension of its shape, may preferably have a defined geometrical shape. Hence, production of the heat sink may be facilitated while the respective sections be still optimized in respect of their function to allow for a good balance between low drag area and good heat dissipation.

[0014] The central section or its first outer contour, by virtual extension of its shape, may have a cyclically or rotationally symmetric shape; i.e. the defined geometrical shape may be a cyclically or rotationally symmetric shape. Preferably, the central section or its first outer contour may have a cyclically symmetric shape. Hence, production of the heat sink may be facilitated. Also, the shape of the central section may be designed to allow for a most effective and improved fluid flow in combination with the tapering extension sections extending from the so formed central section.

[0015] The central section or its first outer contour, by virtual extension of its shape, may have a circular, oval, polygonal, square, or rectangular shape; i.e. the defined geometrical shape may be a circular, oval, polygonal, square, or rectangular shape. Of course, the central section may also have any other shape. In particular, a circular shape allows for a good balance of limited amount of material be used and thus reduction of weight on the one hand and a comparably large exchange area while still providing a reduced drag area on the other hand. An oval shape may, for instance, allow for a quite smooth transition - e.g. at the transition areas or transition points - between the central section and the extension sections thus further reducing the pressure losses and improving the fluid flow. Polygonal shapes, like a square or rectangular shape, may allow for an easy production process and good junction with the extension sections.

[0016] Preferably, in a direction orthogonal to the extension direction (i.e. within the cross-section or plane spanned by the cross-sectional configuration being oriented orthogonally to the protruding direction; as this feature defines the central and extension sections which all extend, by definition, in the cross-sectional configuration), the central section, preferably its defined geometrical shape, extends beyond the respective extension sections, preferably their combined geometrical shape, preferably on opposite sides with respect to the direction orthogonal to the extension direction. Hence, a stable central section can be provided with a comparably large heat dissipation area, while the extension sections or even the overall pin fin allow for a comparably low drag area with still good - i.e. effective - heat dissipation function.

[0017] Preferably, when being measured in a direction orthogonal to the extension direction (i.e. within the cross-section or plane spanned by the cross-sectional configuration being oriented orthogonally to the protruding direction; as this feature refers to or defines the central and extension sections which all extend, by definition, in the cross-sectional configuration), a maximum width of the central section, preferably of the first outer contour or the defined geometrical shape, is larger than a maximum width of the respective extension sections, preferably of the respective second outer contours or the combined geometrical shape. Preferably, a ratio of the maximum width of the central section to the maximum width of the respective extension sections of the respective pin fin is from 1:1,2 to 1:4, or from 1:1,5 to 1:3, or about 1:2. Hence, the two sections can geometrically be optimized with respect to their technical requirements; i.e. providing a stable central section with a comparably large heat dissipation area, while the extension sections or even the overall pin fin allow for a comparably low drag area with still good - i.e. effective - heat dissipation function.

[0018] When measured in a direction orthogonal to the extension direction, a width of the central section, preferably of the first outer contour or the defined geometrical shape, may preferably taper (e.g. continuously or discontinuously) towards the respective extension sections. This allows for the central section having a defined and preferably comparably low drag area while also having a good - i.e. effective - heat dissipation function.

[0019] The two extension sections preferably each have an arcuate form or a parabolic form or a form of a polynomial curve. Hence, a comparably simple form with good flow properties can be provided.

[0020] At least one of the two extension sections or both of which may taper into a rounded tip preferably at a distal end of the respective extension section most distant from the central section. This rounded tip allows for an optimized fluid flow, e.g., so as to allow fluid (e.g. air) to flow closely around the pin fin.

[0021] The two extension sections may be identical. Hence, production may be facilitated and fluid flow be improved; irrespective of the flowing direction of a cooling fluid. Alternatively, the two extension sections may also be different, preferably at least different in shape and/or size. This may allow for an optimized layout of the pin fin in respect of fluid flow, drag area, heat dissipation ability, and other factors like weight etc.

[0022] The pin fins may be symmetric with respect to a symmetry plane, respectively. Hence, production can be further facilitated and fluid flow be improved.

[0023] The symmetry planes of at least some or all of the pin fins may preferably be parallel with respect to each other. Hence, the overall layout of the heat sink allows for an improved fluid flow particularly if a main flowing direction can be anticipated, while still benefitting from the reduced drag area in all possible flowing directions.

[0024] The cross-sectional configuration or cross section may be mirror-symmetric with respect to a symmetry line. This layout allows for an easy production of the heat sink while further allowing for the pin fins having good flowing abilities in all flowing directions.

[0025] Preferably, the central section or its first outer contour or the defined geometrical shape, and/or preferably the respective extension sections or their respective second outer contours or the combined geometrical shape may be mirror-symmetric with respect to a symmetry line. This layout also allows for an easy production of the heat sink while further allowing for the pin fins having good flowing abilities in all flowing directions.

[0026] The symmetry lines of at least some or all of the pin fins can preferably be parallel with respect to each other. Hence, fluid flow of the overall heat sink can be improved while keeping low the drag area irrespective of the flowing direction of the fluid.

[0027] The pin fins each may have a height along the protruding direction of 10 to 100 mm, preferably 12 to 60.. Hence, the pin fins can have a comparably large exchange surface for a sufficient transfer of heat, while still allowing for a quite rigid layout to sufficiently withstand drag forces from a fluid flowing around the pin fins, thus resulting in a good durability and sufficiently long product life. The pin fins can thus also be optimized according to the required needs, e.g. dependent on different factors like place of operation (e.g. temperatures, wind, etc.), materials used, operation temperatures (e.g. operation point of lighting device, etc.).

[0028] The pin fins closer to a center of the top surface or base plate may be higher (i.e. extend further from the top surface in the protruding direction) than the pin fins closer to an edge of the top surface or base plate. Hence, the pin fins can be optimized with respect to their operational load or requirements. Usually, the pin fins at the edge of the heat sink are less engaged in the heat dissipation work than the pin fins in the center of the heat sink. By considering this in the height of the pin fins, the overall weight of the heat sink can be reduced without affecting the cooling efficiency. This, in turn, results in a supporting arrangement for the supporting the heat sink be reduced in size which thus results in much reduced production, assembly and maintenance costs.

[0029] The pin fins preferably taper with increased distance to the top surface (i.e. with increased distance from the top surface). Hence, production of the heat sink can be facilitated, e.g. for demoulding a moulded heat sink. Moreover, the drag area at a section most distanced from the base panel and thus from the support of the pin fin can be reduced so that durability of the heat sink can be increased.

[0030] Each of the pin fins or the respective combined geometrical shapes may have a length (i.e. an overall length; L) measured in its cross-section along the extension direction. The length preferably is at least 6mm, or at least 8mm, or at least 10mm, or at least 12mm, or at least 15mm, or at least 18mm, or at least 20mm. Hence, the pin fins allow for a sufficient heat dissipation while having a reduced drag area, which results in overall improved cooling abilities.

[0031] Each of the pin fins may further have a (maximum) width measured in its cross-section and orthogonal to the extension direction and preferably being the maximum width or the diameter of the central section. A ratio of the length of the respective pin fin to its width (i.e. L:W) is from 1,2:1 to 4:1, or from 1,5:1 to 3:1, or about 2:1. Hence, heat dissipation can be improved while the drag area can be kept low to reduce the drag forces irrespective of the flowing direction of a cooling fluid. Still, the defined ratio allows for a longitudinal layout further supporting natural convection in case of no or limited external fluid flow.

[0032] Preferably, each of the pin fins is distanced to each of its neighboring pin fins by at least 6mm, or at least 8mm, or at least 10mm, or at least 12mm. Hence, sufficient heat dissipation can be achieved while allowing for an improved fluid flow at a comparably low drag area. Also, any stationary fluid around the pin fins can be avoided as being entrained by the fluid consequently freely flowing around the pin fins thus increasing the heat dissipation ability.

[0033] The pin fins may preferably be distributed, more preferred evenly distributed, over the top surface. Hence, production is facilitated and fluid flow be improved.

[0034] The pin fins may preferably be arranged in staggered rows or in equally aligned rows. In staggered rows, there can be provided a high number of pin fins per square millimetre while heat dissipation is improved. In case of the pin fins being arranged in equally aligned rows, production can be facilitated and fluid flow be improved particularly in case of high or strong fluid flows.

[0035] The pitch between two neighboring pin fins of the same row preferably is at least 15mm, or at least 20mm, or at least 25mm, or at least 30mm. The pitch may preferably be identical for each of the pin fins and/or in each of the rows; while it may also differ as desired. A defined minimum pitch allows for an improved fluid flow and thus increased heat dissipation ability.

[0036] The protruding directions of at least some or all of the pin fins may preferably extend orthogonally to the top surface or the bottom surface, respectively. Hence, production of the heat sink can be facilitated and heat dissipation be improved.

[0037] The protruding directions of at least some or all of the pin fins may preferably be parallel with respect to each other. Hence, production can be facilitated, fluid flow be improved and drag forces be reduced; irrespective of the flowing direction of the cooling fluid.

[0038] The mounting section may preferably be designed for mounting the light source with a surface contact or flat contact. Hence, the heat transfer by thermal conduction can be maximised.

[0039] The bottom surface or the mounting section may extend in a plane. Hence, production of the heat sink can be facilitated. Also, the attachment of a light source can be facilitated and efficient heat dissipation can be obtained.

[0040] The top surface may extend in a plane. Hence, the layout of the heat sink can be facilitated, thus making the production process less complex. Also, this layout allows for a smooth fluid flow to thus increase heat dissipation.

[0041] The top surface and the bottom surface are or extend preferably parallel to each other. Hence, the production of the base panel is facilitated and a uniform heat dissipation can be obtained.

[0042] The base panel and the pin fins may preferably be integrally formed. Hence, production of the heat sink can be facilitated and heat dissipation be improved.

[0043] The heat sink and preferably the base panel and/or the pin fins are preferably made of a material having a good thermal conductivity. In particular, the heat sink and preferably the base panel and/or the pin fins may comprise a material selected from the group consisting of aluminium, magnesium, copper, gold, silver, and an alloy comprising one or more of the aforementioned materials. Hence, a good heat transfer, as desired, can be provided.

[0044] According to another aspect, the present invention is directed to a lighting device - like a floodlight - comprising a heat sink according to the present invention as well as a light source being mounted to the mounting section such that heat from the light source when being operated is transferred via the base panel to the pin fins by thermal conduction.

[0045] Hence, the advantages as already described for the heat sink apply alike for its use in a lighting device. Therefore, even in an environment with unforeseeable cooling flow directions, sufficient cooling of the lighting device and particularly of the light source can be obtained, thus increasing life time of such a light source even in the mentioned environments. Due to the reduced drag area, the lighting arrangement is less affected by drag forces, which positively affects the durability and thus lifetime of the lighting device.

[0046] The light source preferably is in surface contact or flat contact with the mounting section. Hence, heat transfer can be maximised.

[0047] The light source preferably is an LED-module. This type of light source usually requires a good heat dissipation because temperature severely affects its life span. Moreover, this type of light source can usually be efficiently operated so that operational costs can be minimized.

[0048] The LED-module may have at least one or a plurality of LEDs. Preferably, each of the LEDs can be associated to one of the pin fins. More preferred, each of the LEDs can be positioned opposite to one of the pin fins with respect to the base panel. Hence, effective heat transfer from the light source to the heat sink and further into the pin fins for heat dissipation can be improved. This may further result in the base plate be made thinner as it does not need to contribute much for the heat transfer or dissipation, which in turn results in a reduction in weight of the lighting device.

[0049] According to another aspect, the present invention is directed to lighting arrangement - like a floodlight arrangement - comprising at least one lighting device according to the present invention as well as a supporting arrangement for supporting (i.e. carrying, mounting, etc.) the lighting device. These types of lighting arrangement are usually highly affected by strong fluid flows (e.g. wind) so that the advantages as described herein above are likewise valid.

[0050] The supporting arrangement may preferably comprise a support structure, like a mounting frame, and/or a pole for supporting the lighting device preferably in an adjustable or pivotable manner. Hence, the lighting device can be securely mounted, while, preferably, a light emitting direction of the light sources can be adjusted as desired, thus increasing flexibility of the lighting arrangement.

[0051] Further features, details and advantages of the present invention will now be described in relation to the embodiments of the enclosed figures.

FIG 1 shows a perspective top view of a heat sink according to a first embodiment of the present invention,

FIG 2 shows a perspective bottom view of the heat sink according to FIG 1,

FIG 3 shows a top view of the heat sink according to FIG 1,

FIG 4 shows a cross-sectional side view along a line IV-IV of the heat sink of FIG 3,

FIG 5 shows a perspective view of a detail of FIG 1,

FIG 6 shows a perspective view of a lighting arrangement according to an embodiment of the present invention with pivotable lighting devices, and

FIG 7 shows a perspective view of the lighting arrangement of FIG 6 with differently oriented lighting devices.

[0052] The figures show different views of embodiments of a heat sink 1 for a lighting device 100 of the present invention.

[0053] The heat sink 1 comprises a base panel 2 having a top surface 20 and a bottom surface 21. The top surface 20 preferably extends in a plane as illustrated in FIGs 2, 4 and 5. The bottom surface 21 may preferably also extend in a plane as illustrated in FIGs 2 and 4. As illustrated in FIG 4, the top surface 20 and the bottom surface 21 are preferably parallel with respect to each other.

[0054] The heat sink 1 further comprises a plurality of pin fins 3 each extending outwardly from the top surface 20 in a protruding direction 4. The protruding directions 4 of at least some or all of the pin fins 3 preferably extend orthogonally to the top surface 20 or the bottom surface 21, respectively. This is exemplarily illustrated in FIG 4.

[0055] The protruding directions 4 of at least some or all of the pin fins 3 are preferably parallel with respect to each other. FIGs 1, 4 and 5 show an embodiment in which the protruding directions 4 of all pin fins 3 are parallel to each other.

[0056] As exemplarily shown in FIGs 1 and 3, the pin fins 3 are preferably distributed over the top surface 20. As illustrated in FIG 3, the pin fins 3 are even more preferred evenly distributed over the top surface 20.

[0057] As illustrated in all figures, the pin fins 3 are preferably arranged in staggered rows. However, it may also be possible that the pin fins 3 are arranged in equally aligned rows or in any other way arranged in a defined or undefined manner or even arbitrarily distributed over the top surface 20.

[0058] A pitch C between two neighboring pin fins 3 of the same row preferably is at least 15mm, or at least 20mm, or at least 25mm, or at least 30mm. As exemplarily illustrated in FIGs 1, 3 and 5, the pitch C can be about 25mm. As exemplarily illustrated in FIGs 1 and 3, the pitch C may be identical for each of the pin fins 3 and/or in each of the rows. However, it may also differ, if need be.

[0059] Each of the pin fins 3 may have a defined minimum distance to each of its neighbouring pin fins 3. For instance, each of the pin fins may be distanced to each of its neighboring pin fins 3 by at least 6mm, or at least 8mm, or at least 10mm, or at least 12mm. As exemplarily illustrated in FIGs 1 and 3, the minimum distance between the pin fins 3 can be about 9mm, respectively.

[0060] The pin fins 3 each may have a height H along the protruding direction 4 (see, e.g., FIGs 4 and 5) of 10 to 100 mm, preferably 12 to 60 mm. As exemplarily illustrated in FIGs 1 and 5, the height H can be about 50mm.

[0061] The pin fins 3 all may have the same height H. However, it may also be possible that the pin fins 3 have different heights H. In a preferred embodiment, for instance, the pin fins 3 closer to a center of the top surface 20 or base plate 2 can be higher than the pin fins 3 closer to an edge of the top surface 20 or base plate 2 to allow for a reduction in weight of the heat sink 1 without affecting the heat dissipation ability.

[0062] As illustrated in FIGs 1, 4 and 5, the pin fins 3 may taper with increased distance to the top surface 20 (i.e. with increased distance from the top surface 20). The pin fins 3 may taper continuously or gradually. They may taper over its entire height or only along part of their height.

[0063] The bottom surface 21 comprises a mounting section 22 for mounting a light source 200 so as to transfer heat from the light source 200 via the base panel 2 to the pin fins 3 by thermal conduction (see, e.g., FIGs 2 and 4 in combination with FIGs 6 and 7).

[0064] The heat sink 1 and preferably the base panel 2 and/or the pin fins 3 may be made from a material having a good heat transfer ability. Preferably, the heat sink 1, more preferred the base panel 2 and/or the pin fins 3, may comprise a material selected from the group consisting of aluminium, magnesium, copper, gold, silver, and an alloy comprising one or more of the aforementioned materials.

[0065] The base panel 2 and the pin fins 3 are preferably integrally formed, as can be clearly derived from FIG 4 as well as the other figures.

[0066] The mounting section 22 preferably is designed for mounting the light source 200 with a surface contact or flat contact. This is preferably easily achieved by the mounting section 22 extending in a plane, as can be derived from FIGs 2 and 4.

[0067] The pin fins 3 each have a cross-sectional configuration Q, when viewed along (i.e. in or opposite to) the extension direction 4, with a central section 30 and two extension sections 31. As can be clearly derived from the embodiment of Fig. 5, the central section 30 is structurally distinct over the extension sections 31, respectively; i.e. the respective sections 30, 31 are each as such recognizable.

[0068] As can be seen in Fig. 5, the central section 30 may have a first outer contour Cc and the extension sections 31 each have a second outer contour C_E. Preferably, the first outer contour Cc is geometrically distinct to the second outer contour or contours C_E, respectively.

[0069] With particular reference to Fig. 5, the central section 30 and the extension sections 31, preferably their outer contours Cc, C_E, may preferably meet in a structural transition area T (here, two of the four transition areas T of the respective pin fin 3 are referenced in Fig. 5), respectively, which is thus (i.e. structurally or geometrically) recognizable.

[0070] The transition areas T may preferably be defined at transition points of the first outer contour Cc with the second outer contours C_E, respectively, as shown in the embodiment of Fig. 5.

[0071] The two extension sections 31 or their second outer contours C_E, by virtual extension of their shapes towards each other, may preferably have a combined geometrical shape G_E, preferably an oval shape, as exemplarily shown by the dotted line in Fig. 5.

[0072] The extension sections 31 each extend along an extension direction 5 from opposite sides of the central section 30. The extension sections 31 each extend such that they taper with increased distance from the central section 30. This is exemplarily illustrated in FIG 5 and also derivable from FIGs 1 and 3.

[0073] The extension sections 31 each may have an arcuate form or a parabolic form or a form of a polynomial curve, each exemplarily illustrated in FIG 5.

[0074] At least one of the two extension sections 31 or, as exemplarily illustrated in the shown embodiment, e.g., of Fig. 1, 3 and 5, both extension sections 31 may taper into a rounded tip 32 preferably at a distal end of the respective extension section 31 most distant from the central section 30.

[0075] As also exemplarily illustrated in FIG 5, the two extension sections 31 can be identical, while they may also be different, e.g., in shape and/or size.

[0076] As illustrated in FIG 5, the central section 30 or its first outer contour Cc, by virtual extension of its shape, may have a defined geometrical shape Gc, as exemplarily shown by the dashed line in Fig. 5. The defined geometrical shape may be a rotationally symmetric shape, as illustrated in Fig. 5. However, the central section 30 or its first outer contour Cc, by virtual extension of its shape, may also have another defined geometrical shape Gc, like a cyclically symmetric shape or even a non-symmetric shape. The first outer contour Cc of the central section 30, by virtual extension of its shape, according to the shown embodiment of FIG 5 here has a circular shape, while the defined geometrical shape may also be oval, polygonal, square, or rectangular or even be any other symmetrical or non-symmetrical shape.

[0077] As illustrated in Fig. 5, the central section 30 or its first outer contour Cc itself may also preferably have a cyclically symmetric shape.

[0078] As illustrated in Fig. 5, in a direction orthogonal to the extension direction 5 (i.e. within the cross-section or plane spanned by the cross-sectional configuration Q being oriented orthogonally to the protruding direction 4; as this feature defines the central and extension sections 30, 31 which all extend, by definition, in the cross-sectional configuration Q), the central section 30, preferably its defined geometrical shape Gc, extends beyond the respective extension sections 31, preferably their combined geometrical shape G_E, preferably on opposite sides with respect to the direction orthogonal to the extension direction 5.

[0079] When measured in a direction orthogonal to the extension direction 5 (i.e. within the cross-section or plane spanned by the cross-sectional configuration Q being oriented orthogonally to the protruding direction 4; as this feature refers to or defines the central and extension sections 30, 31 which all extend, by definition, in the cross-sectional configuration Q), a maximum width Wc of the central section 30, preferably of the first outer contour Cc or the defined geometrical shape Gc, may be larger than a maximum width W_E of the respective extension sections 31, preferably of the respective second outer contours C_E or the combined geometrical shape G_E. Preferably, a ratio of the maximum width Wc of the central section 30 to the maximum width W_E of the respective extension sections 31 of the respective pin fin 3 is from 1:1,2 to 1:4, or from 1:1,5 to 1:3, or about 1:2.

[0080] The pin fins 3 are preferably symmetric with respect to a symmetric plane P, as exemplarily illustrated in FIG 5. The symmetric planes P of at least some or - as illustrated in the shown embodiment - all of the pin fins 3 are preferably parallel with respect to each other and thus are all oriented in the same direction, as can also be gathered from FIGs 1 and 3.

[0081] The cross-sectional configuration Q or cross section, preferably the central section 30 or its first outer contour Cc or the defined geometrical shape Gc and/or preferably the respective extension sections 31 or their respective second outer contours Cc or the combined geometrical shape G_E, may preferably be mirror-symmetric with respect to a symmetry line Y. Preferably, the symmetry lines Y of at least some or - as exemplarily shown in FIG 5 - all of the pin fins 3 are preferably parallel with respect to each other and thus symmetric on both sides to thus allow for a smooth and regular fluid flow irrespective of the flowing direction of a fluid flowing around the pin fins 3.

[0082] As exemplarily illustrated in Fig. 5, each of the pin fins 3 or the respective combined geometrical shapes G_E may have a length L measured in its cross-section along the extension direction 5. The length L may be, for instance, at least 6mm, or at least 8mm, or at least 10mm, or at least 12mm, or at least 15mm, or at least 18mm, or at least 20mm. As exemplarily illustrated in Fig. 1 and 5, the length L can be about 12mm.

[0083] As exemplarily illustrated in Fig. 5, each of the pin fins 3 may further have a (maximum) width W measured in its cross-section and orthogonal to the extension direction 5. In the shown embodiment of the central section 30 being circular, the (maximum) width W may be identical to the maximum width Wc or the diameter D of the central section 30. A ratio of the length L of the respective pin fin 3 to its width W - i.e. L:W - preferably is from 1,2:1 to 4:1, or from 1,5:1 to 3:1, or - as exemplarily illustrated in Fig. 5 - about 2:1.

[0084] When measured in a direction orthogonal to the extension direction 5, the width of the central section 30, preferably of the first outer contour Cc or the defined geometrical shape Gc, may taper, preferably continuously or discontinuously, towards the respective extension sections 31. As can be derived from FIG. 5, the central section 30 or its first outer contour Cc or the defined geometrical shape Gc taper towards the respective extension sections 31 - i.e. towards opposite sides - in the form of an arc, respectively.

[0085] As can be clearly derived from FIGs 1, 3 and 5, the heat sink 1 according to the present invention has a quite high exchange area to volume ratio while permitting a good fluid flow from every direction. Moreover, the streamlined shape of the pin fins 3 allows for a reduction in the pressure losses while improving the fluid flow. The well balanced shape of the pin fins 3 allows for a fluid flow in every flowing direction with a low drag area and thus limited drag forces to be applied while having good cooling abilities.

[0086] The present invention is also directed to a lighting device 100 comprising the heat sink 1 according to the present invention as well as a light source 200 being mounted to the mounting section 22 such that heat from the light source 200 when being operated is transferred via the base panel 2 to the pin fins 3 by thermal conduction. This is exemplarily illustrated in FIGs 6 and 7.

[0087] The light source 200 may be in surface contact or flat contact with the mounting section 22. Therefore, the mounting section 22 preferably extends in a plane. The light source 200 can, for instance, be an LED-module having at least one or a plurality of LEDs, e.g., provided on a printed circuit board. In a preferred embodiment, each of the LEDs can be associated to one of the pin fins 3, e.g. by each of the LEDs being positioned opposite to one of the pin fins 3 with respect to the base panel 2. The printed circuit board preferably extends in a plane and can thus be easily attached in a flat contact to the plane mounting section 22 of the shown embodiment of FIG 2 and 4. The light source 200 can thus be mounted to the mounting surface 22 by being directly mounted thereon. With the LEDs being associated to a pin fin 3, respectively, a most efficient heat transfer to the pin fins 3 and heat dissipation from the heat sink 1 can be obtained. It may also be possible that the light source 200 is not directly mounted on or attached onto the mounting section 22. In this case, the light source 200 may also be mounted to the mounting surface 22 via a mounting element allowing for heat transfer by thermal conduction from the light source 200 to the base panel 2 and thus further to the pin fins 3, around which then a fluid (like air) can flow for effectively dissipating the heat. This is particularly advantageous if the lighting device 100 is a floodlight, which is usually mounted at a raised position. Due to the layout of the pin fins 3, low drag forces act on the lighting device 100 irrespective of the flow direction while still allowing for a good heat dissipation due to the high exchange area to volume ratio compared to known pin protrusions.

[0088] The present invention may further be directed to a lighting arrangement 10 comprising at least one lighting device 100 according to the invention as well as a supporting arrangement 300 for supporting or carrying the lighting device 100. In case of the lighting device 100 being a floodlight, the lighting arrangement 10 is a floodlight arrangement, as exemplarily illustrated in FIGs 6 and 7.

[0089] The supporting arrangement 300 may comprise a support structure 310, like a frame. The frame may comprise a plurality of elements or may be integral. As illustrated in FIGs 6 and 7, a device frame 311 of the frame comprises two lateral carriers between which there are supported (i.e. mounted) three lighting devices 100. In the shown embodiment, the lighting devices 100 are each preferably supported or mounted in an adjustable or pivotable manner to thus allow for adjustment of a light emitting direction of each of the lighting devices 100. As illustrated in FIG 7, the lighting devices 100 are each rotatable or pivotable about a rotational axis X. This is exemplarily illustrated by the three double-arrows in FIG 7. The rotational axes X preferably extend parallel to each other.

[0090] The frame 310 may further comprise a mounting frame 312 for mounting the lighting device(s) 100 to a mounting surface, like a wall or a pole. The pole may also be part of the supporting arrangement 300. The mounting frame 312 may carry the two lateral carriers 311 preferably in a pivotable manner about a further rotational axis Y, which is exemplarily illustrated by the double-arrow in FIG 6.

[0091] The present invention is not limited to the embodiments as described herein above as long as being covered by the appended claims.

Claims

1. Heat sink (1) for a lighting device (100), comprising:

   a base panel (2) having a top surface (20) and a bottom surface (21),
   a plurality of pin fins (3) each extending outwardly from the top surface (20) in a protruding direction (4),
   wherein the bottom surface (21) comprises a mounting section (22) for mounting a light source (200) so as to transfer heat from the light source (200) via the base panel (2) to the pin fins (3) by thermal conduction,
   wherein the pin fins (3) each have a cross-sectional configuration (Q), when viewed along the protruding direction (4), with a central section (30) and two extension sections (31) extending along an extension direction (5) from opposite sides of the central section (30) so as to taper with increased distance from the central section (30).

2. Heat sink (1) according to claim 1, wherein the central section (30) is structurally distinct over the extension sections (31), respectively, and/or
   wherein the central section (30) has a first outer contour (Cc) and the extension sections (31) each have a second outer contour (C_E), wherein preferably the first outer contour (Cc) is geometrically distinct to the second outer contour or contours (C_E), respectively.

3. Heat sink (1) according to any of the preceding claims, wherein the central section (30) and the extension sections (31), preferably their outer contours (Cc, C_E), meet in a structural transition area (T), respectively,
   wherein the transition areas (T) are preferably defined at transition points of the first outer contour (Cc) with the second outer contours (C_E), respectively.

4. Heat sink (1) according to any of the preceding claims, wherein the two extension sections (31) or their second outer contours (C_E), by virtual extension of their shapes towards each other, have a combined geometrical shape (G_E), preferably an oval shape, and/or

wherein the central section (30) or its first outer contour (Cc), by virtual extension of its shape, has a defined geometrical shape (Gc), preferably a cyclically or rotationally symmetric shape, and/or a circular, oval, polygonal, square, or rectangular shape, and/or
wherein the central section (30) or its first outer contour (Cc) has a cyclically symmetric shape.

5. Heat sink (1) according to any of the preceding claims, wherein, in a direction orthogonal to the extension direction (5), the central section (30), preferably its defined geometrical shape (Gc), extends beyond the respective extension sections (31), preferably their combined geometrical shape (G_E), preferably on opposite sides with respect to the direction orthogonal to the extension direction (5).

6. Heat sink (1) according to any of the preceding claims, wherein, measured in a direction orthogonal to the extension direction (5), a maximum width (Wc) of the central section (30), preferably of the first outer contour (Cc) or the defined geometrical shape (Gc), is larger than a maximum width (W_E) of the respective extension sections (31), preferably of the respective second outer contours (C_E) or the combined geometrical shape (G_E),

wherein preferably a ratio of the maximum width (Wc) of the central section (30) to the maximum width (W_E) of the respective extension sections (31) of the respective pin fin (3) is from 1:1,2 to 1:4, or from 1:1,5 to 1:3, or about 1:2, and/or
wherein, measured in a direction orthogonal to the extension direction (5), a width (W) of the central section (30), preferably of the first outer contour (Cc) or the defined geometrical shape (Gc), tapers, preferably continuously or discontinuously, towards the respective extension sections (31).

7. Heat sink (1) according to any of the preceding claims, wherein the two extension sections (31) each have an arcuate form or a parabolic form or a form of a polynomial curve, and/or

wherein at least one of the two extension sections (31) tapers into a rounded tip (32) preferably at a distal end of the respective extension section (31) most distant from the central section (30), and/or
wherein the two extension sections (31) are identical or different, preferably at least different in shape and/or size.

8. Heat sink (1) according to any of the preceding claims, wherein the pin fins (3) are symmetric with respect to a symmetry plane (P), respectively,

wherein preferably the symmetry planes (P) of at least some or all of the pin fins (3) are parallel with respect to each other, and/or
wherein the cross-sectional configuration (Q), preferably the central section (30) or its first outer contour (Cc) or the defined geometrical shape (Gc) and/or preferably the respective extension sections (31) or their respective second outer contours (Cc) or the combined geometrical shape (G_E) is mirror-symmetric with respect to a symmetry line (Y), wherein preferably the symmetry lines (Y) of at least some or all of the pin fins (3) are parallel with respect to each other.

9. Heat sink (1) according to any of the preceding claims, wherein the pin fins (3) each have a height (H) along the protruding direction (4) of 10 to 100 mm, preferably 12 to 60 mm, and/or

wherein the pin fins (3) closer to a center of the top surface (20) are higher than the pin fins (3) closer to an edge of the top surface (20), and/or
wherein the pin fins (3) taper with increased distance to the top surface (20).

10. Heat sink (1) according to any of the preceding claims, wherein each of the pin fins (3) or the combined geometrical shapes (G_E) has a length (L) measured in its cross-section along the extension direction (5), wherein the length (L) preferably is at least 6mm or at least 8mm or at least 10mm or at least 12mm or at least 15mm or at least 18mm or at least 20mm, and
wherein preferably each of the pin fins (3) further has a width (W) measured in its cross-section and orthogonal to the extension direction (5) and preferably being the maximum width (Wc) or the diameter (D) of the central section (30), wherein a ratio of the length (L) of the respective pin fin (3) to its width (W) is from 1,2:1 to 4:1, or from 1,5:1 to 3:1, or about 2:1.

11. Heat sink (1) according to any of the preceding claims, wherein each of the pin fins (3) is distanced to each of its neighboring pin fins (3) by at least 6mm or at least 8mm or at least 10mm or at least 12mm, and/or

wherein the pin fins (3) are distributed, preferably evenly distributed, over the top surface (20), and/or
wherein the pin fins (3) are arranged in staggered rows or in equally aligned rows, wherein the pitch (C) between two neighboring pin fins (3) of the same row preferably is at least 15mm or at least 20mm or at least 25mm or at least 30mm, wherein the pitch (C) preferably is identical for each of the pin fins (3) and/or in each of the rows.

12. Heat sink (1) according to any of the preceding claims, wherein the protruding directions (4) of at least some or all of the pin fins (3) extend orthogonally to the top surface (20) or the bottom surface (21), respectively, and/or
wherein the protruding directions (4) of at least some or all of the pin fins (3) are parallel with respect to each other.

13. Heat sink (1) according to any of the preceding claims, wherein the mounting section (22) is designed for mounting the light source (200) with a surface contact or flat contact, and/or

wherein the bottom surface (21) or the mounting section (22) extends in a plane, and/or
wherein the top surface (20) extends in a plane, preferably parallel to the bottom surface (21).

14. Heat sink (1) according to any of the preceding claims, wherein the base panel (2) and the pin fins (3) are integrally formed, and/or
wherein the heat sink (1), preferably the base panel (2) and/or the pin fins (3), comprise a material selected from the group consisting of aluminum, magnesium, copper, gold, silver, and an alloy comprising one or more of the aforementioned materials.

15. Lighting device (100), like a floodlight, comprising a heat sink (1) according to any of the preceding claims as well as a light source (200) being mounted to the mounting section (22) such that heat from the light source (200) when being operated is transferred via the base panel (2) to the pin fins (3) by thermal conduction,

wherein preferably the light source (200) is in surface contact or flat contact with the mounting section (22), and/or
wherein preferably the light source (200) comprises an LED-module with at least one or a plurality of LEDs, wherein more preferred each of the LEDs is associated to one of the pin fins (3), wherein even more preferred each of the LEDs is positioned opposite to one of the pin fins (3) with respect to the base panel (2).

16. Lighting arrangement (10), like a floodlight arrangement, comprising at least one lighting device (100) according to claim 15 as well as a supporting arrangement (300) for supporting the lighting device (100), wherein the supporting arrangement (300) preferably comprises a support structure (310) and/or a pole (320) for supporting the lighting device (100) preferably in an adjustable or pivotable manner.

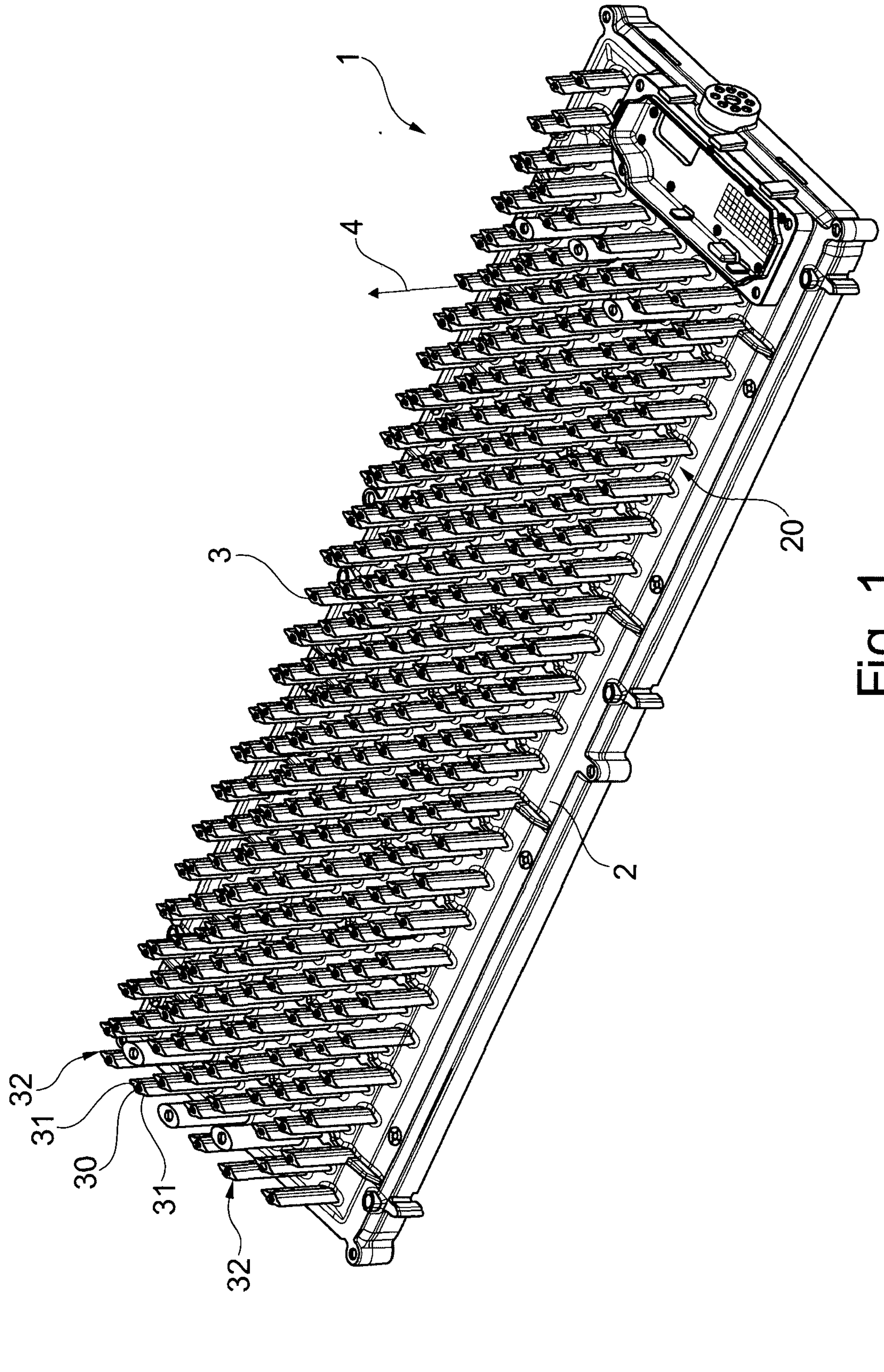

Fig. 1

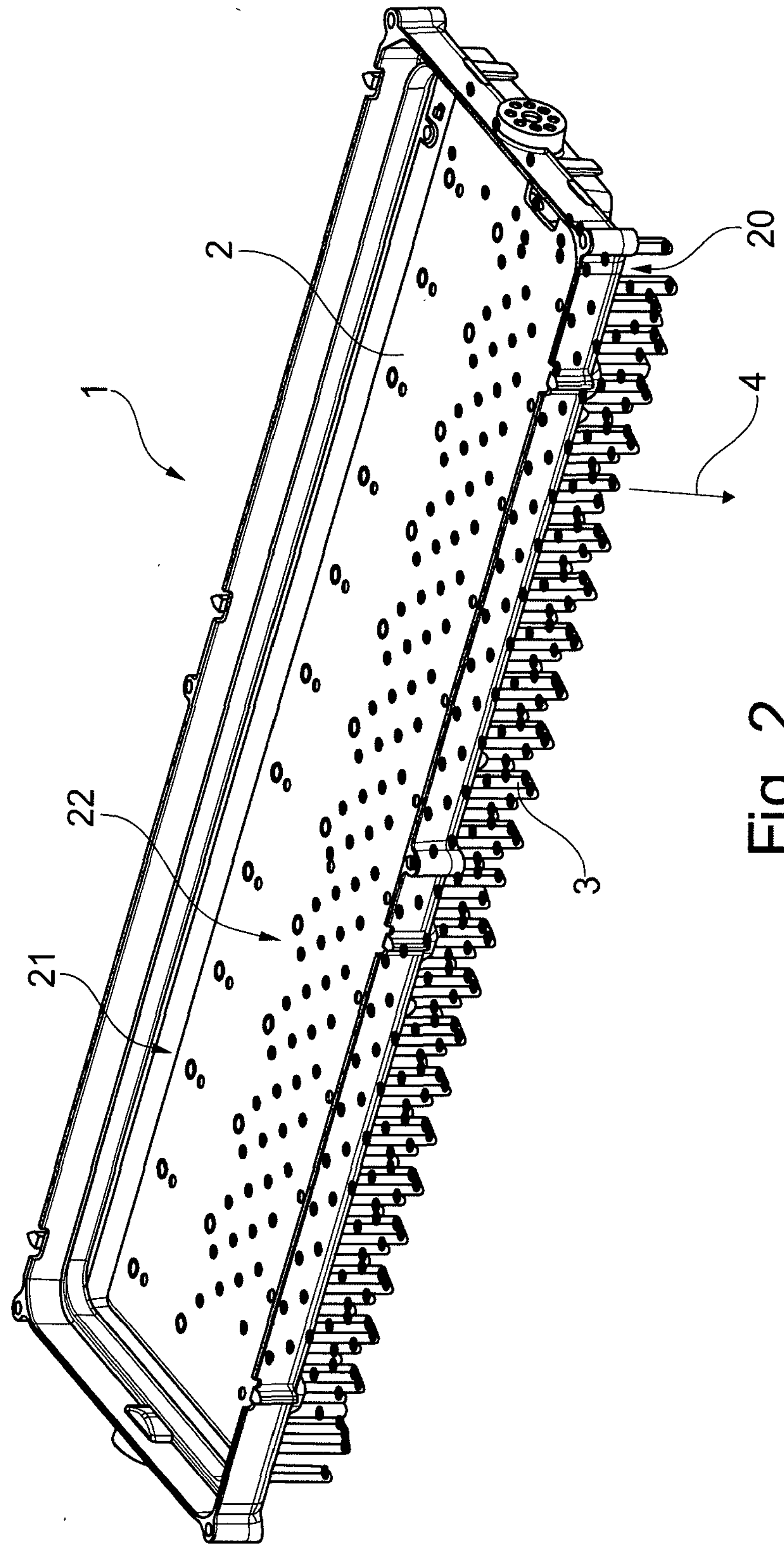

Fig. 2

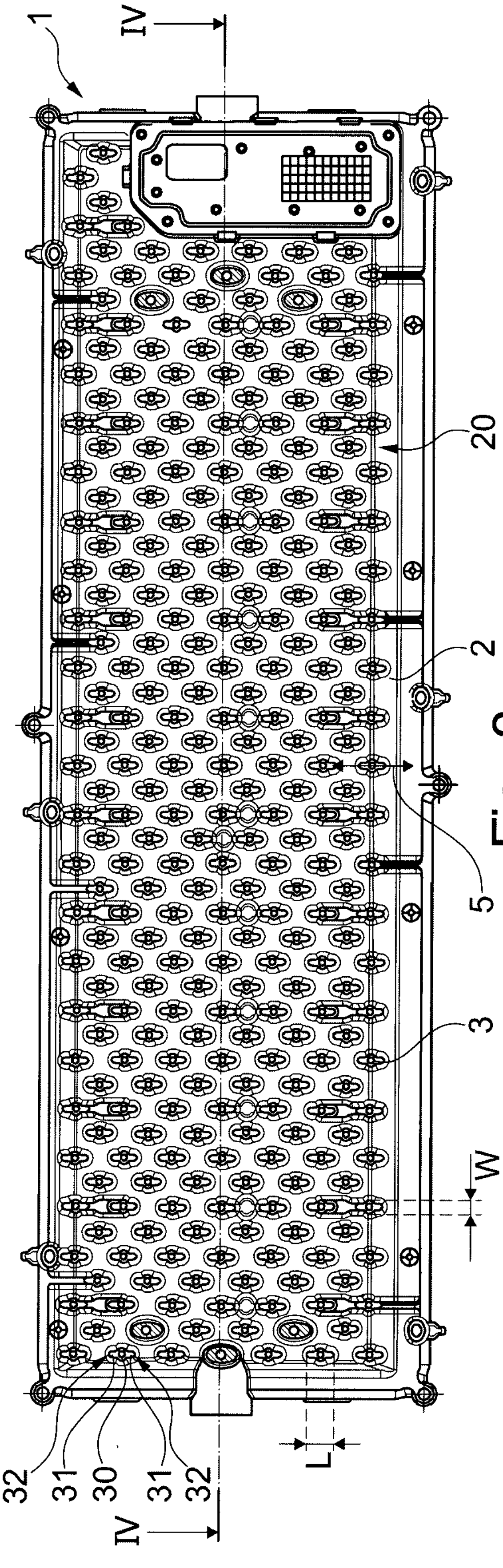

Fig. 3

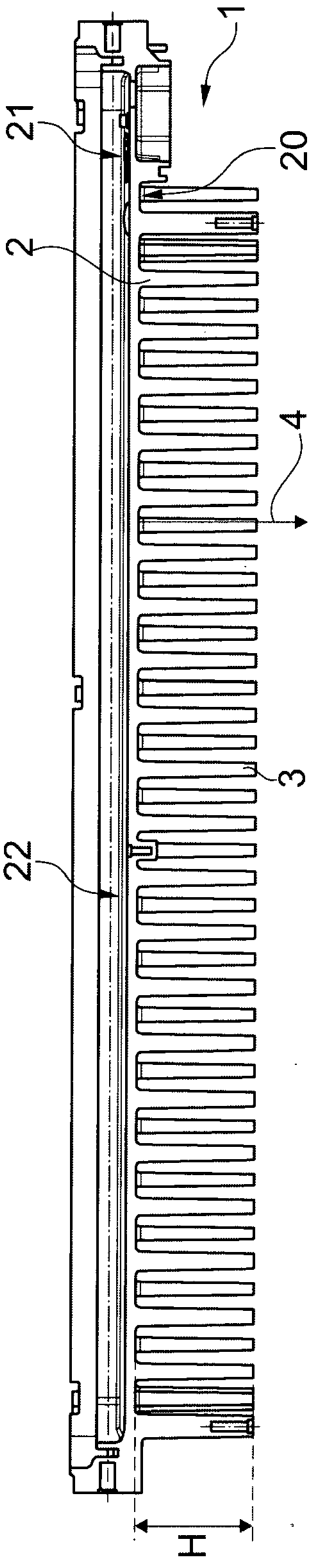

Fig. 4

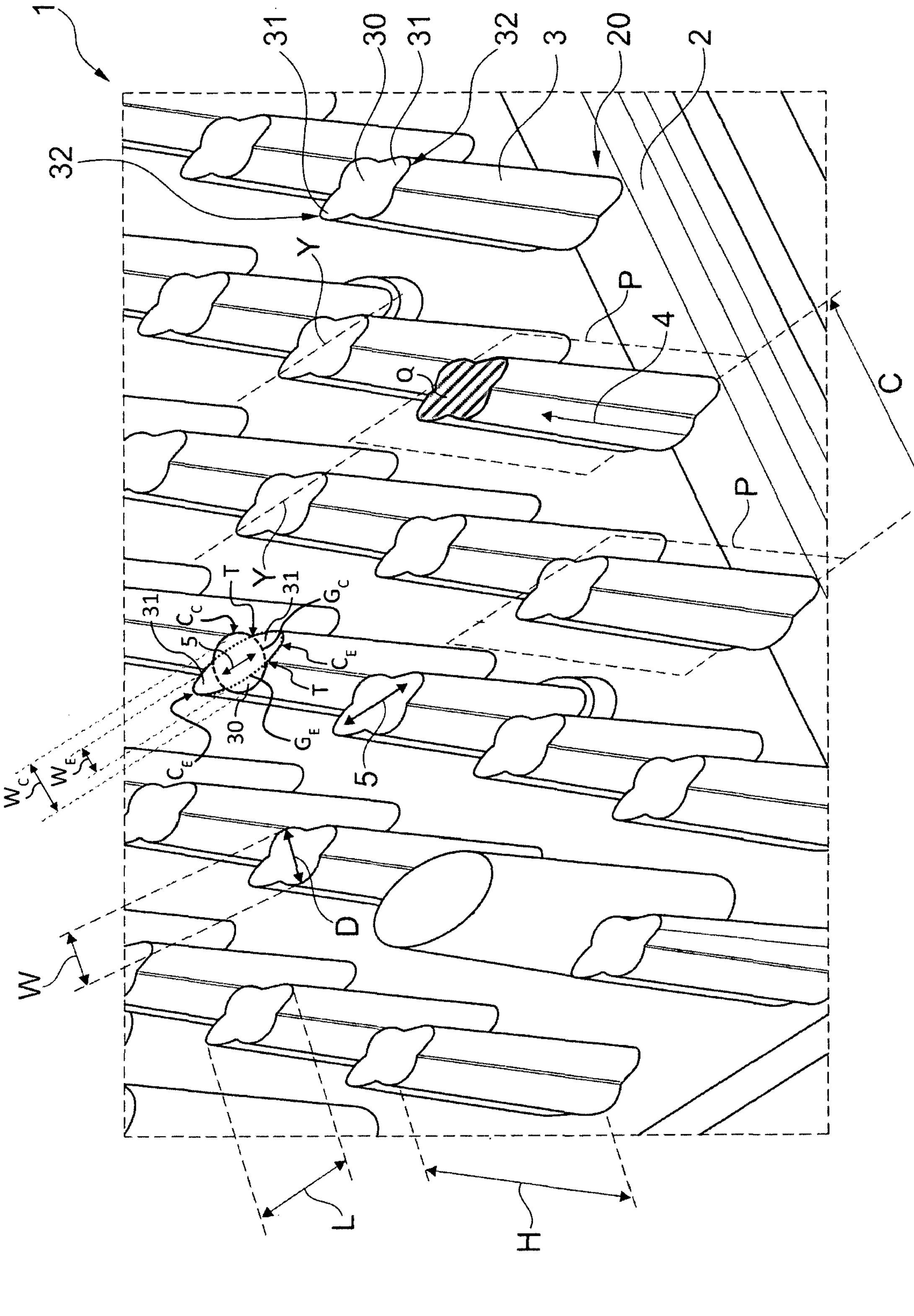

Fig. 5

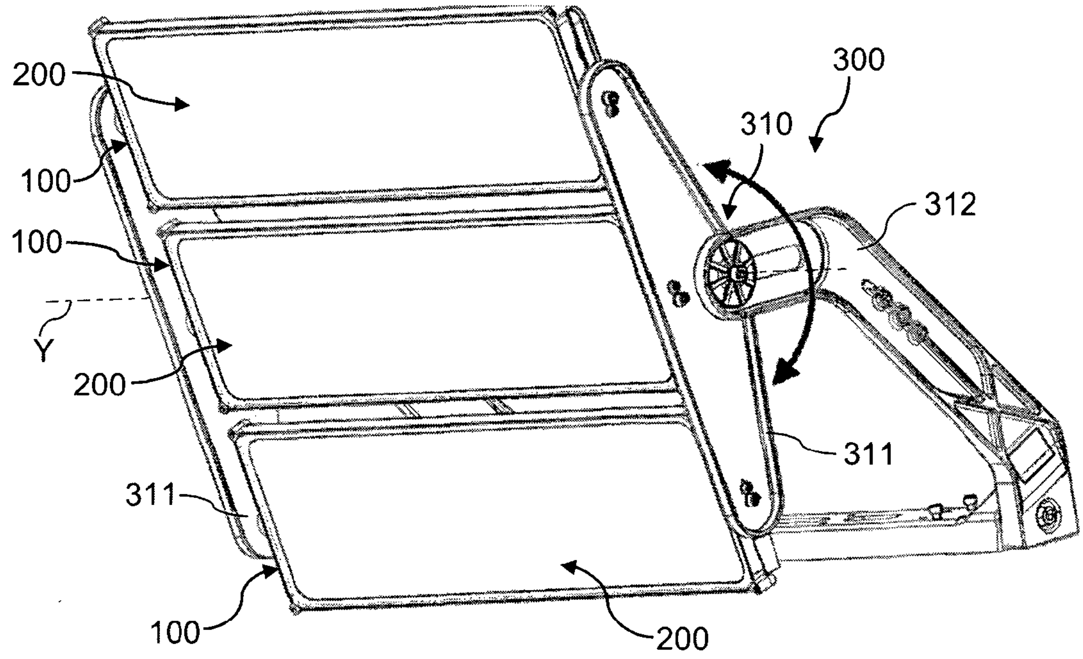
300
310
312
200
100
100
Y
200
311
311
100
200

Fig. 6

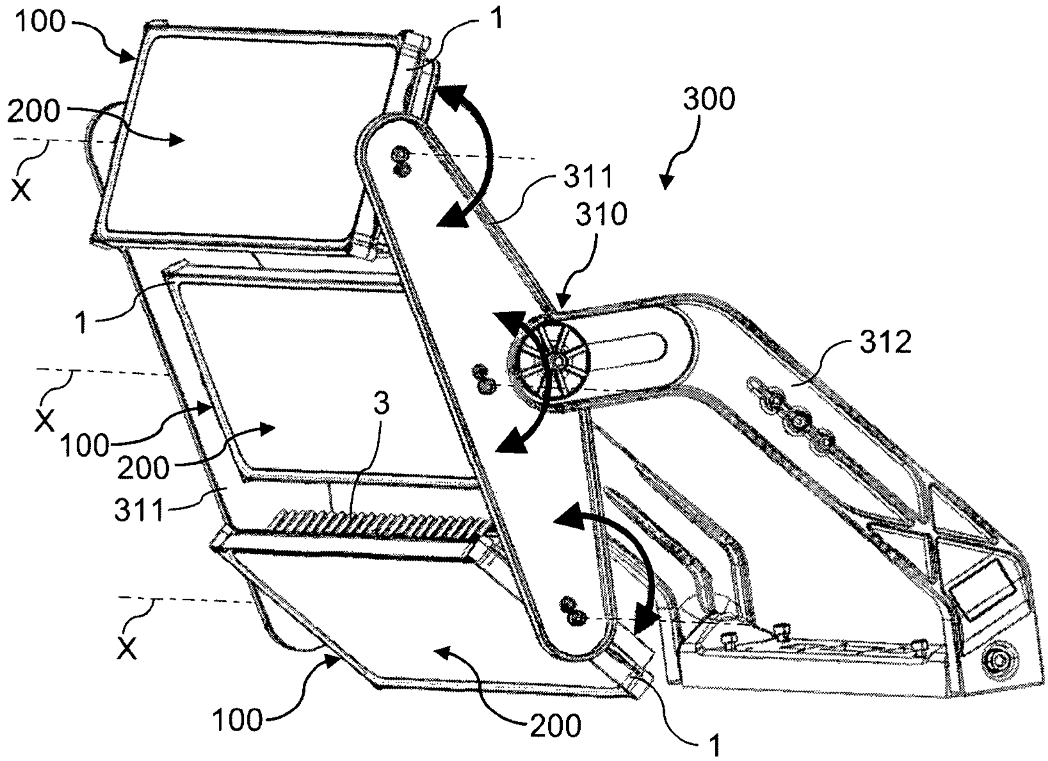
100
1
200
X
300
311
310
1
312
X
100
3
200
311
X
100
200
1

Fig. 7

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Application Number
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	5 October 2022	Menn, Patrick

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EUROPEAN SEARCH REPORT

Application Number
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