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(71) Applicant: **SCHREDER S.A.** [BE/BE]; Rue du Lusambo 67, 1190 Brussels (BE).

(72) Inventors: **BECKSE, Imre**; Petnehazy utca 55. III/302, 1135 Budapest (HU). **OLAH, Gyula**; Rozsnyay utca 31, 1139 Budapest (HU). **HORVATH, Csaba**; Rezsu str 119, 1029 Budapest (HU).

(74) Agent: **ARNOLD & SIEDSMA**; Bezuidenhoutseweg 57, 2594 AC THE HAGUE (NL).

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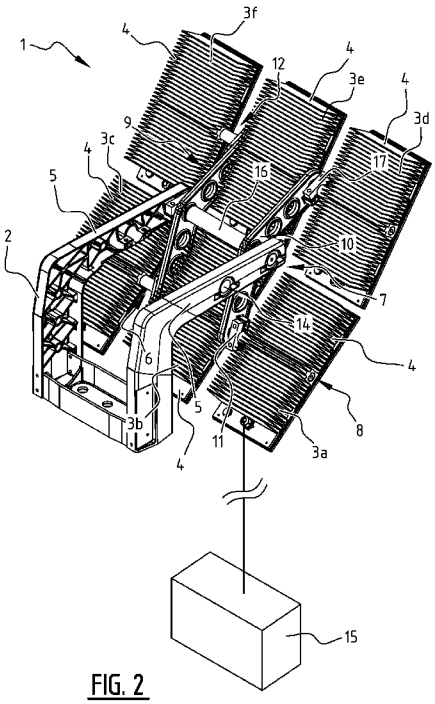

FIG. 2

(57) **Abstract:** Lighting apparatus comprising a frame having multiple module mounting positions and comprising a number of lighting modules adapted to be mounted in the mounting positions, wherein the frame comprises a support structure with two arms and comprises a mounting shaft, wherein distal ends of the two arms are spaced apart and each provided with a respective arm opening, wherein each lighting module comprises a hole for receiving the mounting shaft, such that, when the mounting shaft is arranged through the respective arm openings, a first shaft segment extending between the respective arm openings forms a central mounting position of said multiple module mounting positions and second and third shaft segments at opposite ends of the shaft form respective outer mounting positions of said multiple module mounting positions.

WO 2022/064005 A1

Lighting apparatus with modular frame

FIELD OF INVENTION

The field of the invention relates to a lighting apparatus, in particular for lighting sports fields, said apparatus being provided with a plurality of lighting modules.

The field of the invention further relates to a functional module usable in such lighting apparatus, for example a lighting module for obtaining a desired light beam for lighting at least a part of a sports field or other large areas or surfaces.

BACKGROUND

Car parks, buildings, sports fields and other large areas are generally illuminated with a light beam that has been designed specifically for this purpose. In order to obtain a desired light distribution that meets the requirements, a composite light beam is usually provided. Several composite lighting modules with a specific light distribution are used in order to devise a lighting plan that meets predetermined requirements in respect of illuminance and uniformity. For the purpose of said light beam, individual lighting modules may be connected together via a support structure and then fastened as a whole to or on a lighting pole or roof/wall structure. After fastening, the lighting modules are aligned if necessary. Two, three, four, six or more lighting modules are used per support structure.

The individual lighting modules now no longer comprise conventional light sources such as gas-discharge lamps, but are provided with light-emitting diode, LED, light sources. Each lighting modules comprises a LED light source, which is generally built up from a plurality of LED elements in an at least substantially rectangular arrangement. This rectangular arrangement may result in a corresponding, substantially symmetrical light beam. The light beam as comprised in the lighting plan may be obtained by arranging several of these rectangular lighting modules in different directions.

An effective lighting plan is designed so that the composite light beam is directed as much as possible onto the area to be illuminated. That is, the sports field, car park, or whatever area is to be lighted, is illuminated and no light nuisance can arise, or light nuisance is limited as far as possible. Light nuisance may be defined, in the context of the invention, as light that shines or is directed onto spots where that is not desired. In the case of sports fields and the like, light nuisance may arise if light shines on parts outside the sports field. This may also affect the direct environment around the sports field. As a rule, light nuisance means nuisance from light for

humans, animals or plants as a result of light pollution. This light pollution may be divided into three classes. Sky glow is the phenomenon whereby the air seems to glow because light is reflected on dust particles and water vapour in the air. Owing to this reflection, a kind of uplighting dome light is visible, and few if any stars can be seen. This phenomenon mainly occurs in large towns and districts with horticulture under glass. Then there is so-called light trespass. Light trespass means unwanted lighting. This is the lighting that goes beyond the area to be illuminated and thus causes nuisance to nearby residents and/or flora and fauna. In fact this too can be broken down into two components. On the one hand this is the unwanted lighting of for example a facade, and on the other hand direct view of the light source from a nearby position, resulting in a high-intensity point of light. Specific examples of light trespass are neighbours who experience nuisance from street lighting located nearby or at a distance, garden lighting, greenhouse lighting, sports field lighting and lighting of car parks or other large areas. Finally there is glare. Glare or dazzle occurs in particular in road traffic. It is excessively intense lighting that has a dazzling effect for humans and animals and greatly increases the likelihood of traffic accidents.

Sports fields, car parks and other large areas are, in the case of LED-based fixtures, generally illuminated with composite lighting modules. These comprise a set of generally two, three, four or six lighting modules, which can be fixed to a lighting structure. A tennis court is often illuminated by means of two, three or four of these composite lighting modules whereas a football field generally comprises six composite lighting modules.

Each of the composite lighting modules is configured in relation to the application. That means that the individual lighting modules of the system are installed individually with a degree of freedom. The aim of the installation is to direct as much as possible of the finally assembled light beam onto the area to be illuminated, giving a more or less uniform illuminance on the area in accordance with the applicable standards.

In the known composite lighting modules, however, optimally orienting the different lighting modules is highly complex and therefore the light beam cannot be formed optimally. As a result, light is wasted because it partly arrives on a spot where it is not wanted. Moreover, it contributes to light pollution. This may result in certain light nuisance guidelines being exceeded.

EP3594560 describes a lighting fixture system for a sports field wherein multiple LED modules may be individually oriented. The setup of the lighting fixture system however makes it cumbersome for an operator to precisely orient the lighting modules. In particular, because the lighting fixture system is typically installed high above the area to be lit, the slightest

change in angular position of a LED module has a large influence on where the light beam arrives at the ground surface.

SUMMARY

It is an object of embodiments of the invention to provide a modular lighting apparatus wherein the lighting modules can more easily be positioned, oriented and fixated to provide a lighting apparatus wherein a wide, or specific or application-oriented light distribution may be achieved, and the light nuisance or light pollution is less than the currently known lighting fixture systems.

To this end, the invention provides a lighting apparatus comprising a frame having multiple module mounting positions and comprising a number of lighting modules adapted to be mounted in the mounting positions, wherein the frame comprises a support structure with two arms and comprises a mounting shaft, wherein distal ends of the two arms are spaced apart and each provided with a respective arm opening, wherein each lighting module comprises a hole for receiving the mounting shaft, such that, when the mounting shaft is arranged through the respective arm openings, a first shaft segment extending between the respective arm openings forms a central mounting position of said multiple module mounting positions and second and third shaft segments at opposite ends of the shaft form respective outer mounting positions of said multiple module mounting positions.

The modularity of the lighting apparatus of the invention is provided by the frame having multiple module mounting positions. This enables an operator or light designer to choose the number of lighting modules, and to position the chosen number of lighting modules in the frame in an optimal way. The lighting modules are provided with a hole for receiving a mounting shaft. The setup with the two arms allows to mount at least one lighting module in the center mounting position, and to mount further lighting modules in outer mounting positions. In the light of the foregoing, it will be clear that the term central mounting position is not intended to be limiting to a single mounting position, and includes a pair of central mounting positions or more than two central mounting positions. Because these lighting modules are mounted on a mounting shaft, preferably a single mounting shaft, they can be oriented together by rotating the shaft. Because these lighting modules are mounted on a mounting shaft, preferably a single mounting shaft, they may be mounted substantially parallel, meaning that the light beams generated by the different lighting modules arrive at the ground surface at substantially the same spot. The designer or installer of the lighting apparatus may adjust the maximum intensity of the light on this spot by adding or removing lighting modules. In this way, an optimal light intensity can be achieved by

adding or removing lighting modules in the module mounting positions while the light direction may be adjusted by rotating the mounting shaft. It will be clear that the location and orientation of the support structure of the lighting apparatus also influences the direction in which the light beam is oriented.

Preferably, the lighting apparatus additionally comprises an extension frame to be arranged in between the distal ends of the two arms and the mounting shaft, the extension frame comprising a connection section adapted to be connected to the arms via the respective openings and comprises first respective frame openings adapted for the mounting shaft to be arranged such that when the mounting shaft is arranged through the first respective frame openings, the first shaft segment extends between the first respective frame openings and forms the central mounting position and the second and the third shaft segments form said respective outer mounting positions.

The extension frame provides the possibility of mounting the shaft at a distance from the distal ends of the arms. This further increases the flexibility for the designer or installer of the lighting apparatus. In a first state or setup of the lighting apparatus, the mounting shaft is directly connected to the arms by extending through the respective arm openings which are provided in the arms. In a second state or setup of the lighting apparatus, the mounting shaft is indirectly connect to the arms, via the extension frame. The extension frame is directly connected to the arms and the mounting shaft is connected to the extension frame by extending through the first respective frame openings. Having these different states or setups increases the flexibility for the designer or installer.

Preferably, the extension frame comprises second respective frame openings adapted for arranging a further mounting shaft such that, when the further mounting shaft is arranged through the second respective frame openings, the further mounting shaft extends substantially parallel to, and at a distance from said mounting shaft when it is arranged through the first further respective openings, and a first further shaft segment extending between the second respective frame openings forms a further central mounting position of said multiple module mounting positions and second and third further shaft segments at opposite ends of the further shaft form respective further outer mounting positions of said multiple module mounting positions.

By providing second respective frame openings at the extension frame and by providing a further mounting shaft, the number of module mounting positions increases, preferably doubles. The mounting shaft and the further mounting shaft are, when both mounted to the extension frame respectively through the first respective frame openings and second respective frame openings, spaced apart such that lighting modules may be mounted to both mounting shafts. In other words, having two mounting shafts at a distance from each other, two rows of lighting

modules may be provided. The orientation of the lighting modules in a row may be changed by rotating the respective mounting shaft. The two rows of lighting modules may therefore be such that the first row illuminates a first spot of the area and the second row illuminates a second spot of the area, the first spot and second spot having a predetermined optimal relative orientation. For example, the first spot may be adjacent to the second spot with a minimal overlap. An additional advantage of the use of the extension frame is that the extension frame may be rotated with respect to the arms to rotate the combination of first row and second row of lighting modules without changing the relative orientation of the rows with respect to each other. This has proven to significantly facilitate the positioning, orienting and fixating to provide a lighting apparatus wherein a wide, or specific or application-oriented light distribution is achieved.

Preferably, the extension frame is curved with, for each of said arms, two frame arms extending in different directions at both sides of a curve, wherein the connection section is formed at the curve and wherein the first respective frame openings and second respective frame openings are formed at respective distal ends of the two frame arms. A curved frame has proven to be a preferred element for branching the distal ends of each arm. The curved frame allows to position lighting modules in a convenient and usable way particularly to position, orient and fixate lighting modules to provide a lighting apparatus wherein a wide, or specific or application-oriented light distribution may be achieved.

Preferably, each mounting shaft is significantly longer than a distance between said respective openings such that the outer mounting positions are located outside of the respective openings. In other words, mounting positions are located at both sides of both arms. This provides a compact setup particularly of the frame of the lighting apparatus. One of the advantages is that the absence of a wide frame covering the lighting modules allows to mount these lighting apparatuses even with space restrictions.

Preferably, the support structure comprises a substantially horizontal connection surface at a proximal end. The horizontal connection surface facilitates mounting the lighting apparatus on top of a supporting surface. The support structure may be mounted on top of a roof or on top of a pole of mast.

Preferably, the arms have a proximal section which is substantially upright and have a distal section which is substantially lying. Such shape of the arms with a proximal upright and a distal lying section allows to uphold the lighting modules towards the area to be illuminated. In many specific or application-oriented light distribution situations, such shape of the arms is advantageous.

Preferably, adjacent to the respective arm openings, secondary respective arm openings are provided which provide an alternative arrangement position for the mounting shaft

and optionally for the extension frame. Providing an alternative arrangement position for the mounting shaft and/or for the extension frame increases the modularity of the lighting apparatus.

Preferably, each mounting shaft and each hole is compatible in shape to limit rotation of the mounting shaft inside the hole. Compatible shapes for hole and mounting shaft facilitates mounting multiple lighting modules parallel to each other. By rotating the shaft with respect to the frame or arms, all lighting modules connected to that shaft will equally rotate so that the light beam generated by the combination of these lighting modules may be kept unchanged while directing the beam.

Preferably, each lighting module is provided with fixation means to fixate the lighting module onto the mounting shaft thereby preventing rotation and sliding of the mounting shaft inside the hole. Preferably, the support structure and optionally the extension frame comprise shaft fixation means at the location of the respective openings for preventing rotation and sliding of the mounting shaft inside the openings. Via the fixation means and the shaft fixation means, the position of the individual lighting modules with respect to the mounting shaft as well as the position of the mounting shaft with respect to the frame may be fixed.

Preferably, the lighting modules have a rectangular frontal surface with shorter and longer sides, the longer sides being oriented transverse to the mounting shaft. Tests and simulations have shown that the upright orientation of the lighting modules in the lighting apparatus is beneficial for the layout of the apparatus and for the distribution of the light.

Preferably, each lighting module comprises an array of LEDs and preferably also a driver which is arranged on the support structure or arranged externally from the lighting apparatus. Preferably, high power LEDs are provided. A LED is known for outputting light and generating heat. The specific setup of the lighting apparatus of the invention allows to efficiently dissipate heat via the back of the lighting modules. These lighting modules are not enclosed or covered by the frame so that heat can optimally exchanged between the lighting modules and the surrounding air.

The invention further relates to a functional module comprising a heat sink having a base with multiple cooling fins, the base being provided with a through hole adapted for arranging a mounting shaft through the heat sink. Functional modules which generate heat may be provided with a heat sink. The sole function of the heat sink is typically to dissipate heat to the environment or to facilitate transmission of heat. This is often obtained by creating cooling fins which provide an increased surface area for heat to be transferred to the environment. The cooling fins are provided on a base which base is in direct contact with the functional module. In this way, the functional module transfers heat to the base, which base further transfers the heat to the cooling fins where the heat may be transferred to surrounding air. By providing a through hole in

the base, the heat sink facilitates mounting of the functional module. In other words, no extra elements or connectors must be provided for mounting the functional module, which significantly simplifies the functional module design. This allows to manufacture the functional module with the heat sink in a cost-efficient manner.

Preferably, the cooling fins extend substantially parallel to the through hole. Preferably, the base comprises a thickening and the through hole is located in the thickening. Preferably, the heat sink is formed in one piece preferably by extrusion. This allows to manufacture the functional module with the heat sink in a cost-efficient manner.

Preferably, the base is further provided with at least one electrical connector for providing power and optionally providing operational signals to the functional module. Providing the connector at the heat sink allows to connect the functional module to one side of the heat sink and to electrically connect the functional module via the back side, where the heat sink is provided. This has proven to be efficient in manufacturing and efficient for an operator or installer. The frontal surface may be maximized and the heat dissipation from the functional module may be optimized.

Preferably, the through hole has a shape in cross section that deviates at least partially from a round shape. Having a through hole with a shape that is not round, allows to insert a corresponding shaft thereby preventing rotation of the shaft inside the hole. In this way, the angular position of the functional module with respect to the mounting shaft may be fixed and predetermined.

Preferably, the functional module comprises an array of LEDs, preferably high power LEDs. Particularly when the functional module is a LED lighting module, it is advantageous to maximize the frontal surface, for maximal light output, and optimize the heat dissipation. By providing the through hole in the heat sink, and optionally by providing the electrical connector in the heat sink, the frontal surface of the heat sink may be maximized for mounting LEDs while optimizing dissipation of heat via the back side.

The invention further relates to a set of a functional modules according to the invention and a mounting shaft adapted to extend through the through hole. Preferably, the functional module is provided with fixation means to fixate the mounting shaft in the through hole preventing rotation and sliding of the mounting shaft inside the hole. Preferably, the mounting shaft shows a cross-sectional shape which corresponds to the shape of the through hole to limit a rotation of the mounting shaft inside the through hole.

The invention further relates to a lighting apparatus according to the invention, wherein each lighting module is a functional module according to the invention. In other words, the functional module may be fixed to a frame as disclosed for the lighting apparatus and/or that

the lighting apparatus can comprise the combination of at least one lighting module and at least one other functional module. Yet other embodiments of the invention relate to an apparatus comprising only functional modules which are not lighting modules.

BRIEF DESCRIPTION OF THE FIGURES

The invention will now be described in more details with respect to the drawings illustrating some preferred embodiments of the invention. In the drawings:

figure 1 shows an embodiment of the lighting apparatus of the invention in a first state;

figure 2 shows an embodiment of the lighting apparatus of the invention in a second state;

figure 3 shows a side view of the lighting apparatus of figure 2;

figure 4 shows a cross-section of a functional module of an embodiment of the invention;

figure 5 shows an embodiment of fixation means usable in the lighting apparatus of the invention; and

figure 6 shows a cross section of a set of a lighting module and a mounting shaft.

In the drawings a same reference number has been allocated to a same or analogous element.

DESCRIPTION OF EMBODIMENTS

Figure 1 shows a lighting apparatus 1 in a first state or set-up. The first state or set-up of the lighting apparatus 1 relates to the set-up where only a single mounting shaft 6 is provided. In this first set-up, the mounting shaft 6 is arranged through arm openings 7. The arm openings 7 are provided in distal ends of arms 5. The arms 5 form part of a frame 2 further comprising a base with a substantially horizontal connection surface 13. Via the substantial horizontal connection surface 13, the lighting apparatus 1 can be mounted on a support structure. The lighting apparatus may for example be mounted on a pole or mast or on top of a roof. Since the lighting apparatus is primarily intended for illuminating sport fields, the skilled person understands that the support structure may be the roof of a stand of an arena. Alternatively, four or more poles or masts may be built around a field, and a lighting apparatus is provided on top of each pole or mast. The skilled person will understand that the lighting apparatus is not limited to a frame with a horizontal connection surface 13. The frame 2 could alternatively be shaped for

connection to a vertical structure such as a vertical wall. Further alternative, the frame comprises both a horizontal and a vertical connection surface.

From the connection surface 13, preferably two arms 5 extend substantially parallel to each other and preferably at a substantially constant distance from one another. These arms 5 have a first section that is preferably upright, which first section connects to the connection surface 13, and these arms have a second section that extends substantially horizontally. The second sections form the distal ends of the arms 5, being the ends of the arms 5 that lay opposite to the connecting surface 13. At these distal ends, the arms 5 are provided with the arm openings 7. In the embodiment of figure 1, the distance between the arms 5 is such that one lighting module 4 fits between the arms 5. It will be clear that other embodiments may fit two or more lighting modules 4 next to each other in between the arms 5. The arms 5 may additionally be provided with secondary openings 14. The secondary openings 14 are provided in the arms 5 at a distance from the arm openings 7. The secondary arm openings 14 provide an alternative mounting position for the mounting shaft 6 or, as will be explained hereunder, an alternative mounting position for the extension frame.

The frame 2 further comprises at least one mounting shaft 6. In figure 1, a single mounting shaft 6 is arranged through the arm openings 7 provided at the distal ends of the arms 5. The mounting shaft 6 is significantly longer than the distance between the arms 5. In particular, the mounting shaft 6 has a length being at least twice the distance between the arms 5. Most preferably, the mounting shaft 6 has a length which is about three times the distance between the arms 5. Each lighting module 4 is provided with a hole, preferably a through hole 8. The mounting shaft 6 and through hole 8 have a compatible shape and dimensions such that the mounting shaft can be slid into the through hole.

When the mounting shaft 6 is arranged through the arm openings 7, multiple sections can be distinguished on the mounting shaft 6 where lighting modules 4 may be positioned. These potential positions of lighting modules 4 are referred to as multiple module mounting positons 3. In figure 1, three module mounting positions 3a, 3b, 3c are provided, and a lighting module 4 is mounted in each of these module mounting positions 3. It is noted that it is not required to mount a lighting module in each module mounting position 3, and that one or more module mounting positions 3 may be left empty, depending on the circumstances and requirements.

When the mounting shaft 6 has a length that is significantly longer than the distance between the arms 5, arranging the mounting shaft 6 through openings 7 has the effect that outer ends of the mounting shaft extend beyond the boundaries of the combination of arms 5. In addition to the central module mounting position 3b, at least two outer module lighting positions

are provided at both sides of the combination of arms. In figure 1, these mounting positions are mounting positions 3a and 3c. It will be clear that, depending on the length of the mounting shaft 6, the width of the lighting modules 4 and the distance between the arms 5, the number of lighting modules mountable in each section of the mounting shaft may be different.

Figure 2 shows a second state or second set-up of the lighting module 1 of the invention. The second state or second set-up is characterized by having two separate mounting shafts 6 and 12. The mounting shafts 6 and 12 are indirectly mounted to the arms 5 via an extension frame 9. The extension frame 9 branches the distal end of each arm 5 so that the combination of the arms 5 and extension frame 9 have two separated distal ends for each arm 5. This allows one mounting shaft 6 to be connected at a first of the distal ends and a further mounting shaft 12 to be connected to a second of the distal ends. The mounting shaft preferably lies at a distance from and parallel to the further mounting shaft. This distance is determined by the shape of the extension frame 9, and is preferably chosen to allow multiple lighting modules to be mounted on the two mounting shafts without interference. This means that when a lighting module is mounted on the mounting shaft; this mounting module cannot come into physical contact with another lighting module mounted on the further mounting shaft in normal operating conditions of the lighting apparatus 1. By providing two mounting shafts 6 and 12, the number of module mounting positions 3 in the second state or set-up of the lighting apparatus is increased compared to the first state or set-up of the lighting apparatus.

The extension frame 9 has a connection section 10, where the extension frame 9 may be connected to the arm openings 7. It will be clear that the extension frame 9 may also be connected to the secondary openings 14. The extension frame may be formed as a single structure, or may be formed as a separate element for each arm. When connected to the arms 5, a stability enhancing shaft 16 preferably interconnects, together with the extension frame 9, the two distal ends of the arms 5. This stability enhancing shaft 16 may also ensure that the extension frame 9 behaves as a single structure even when the extension frame is formed by separate elements. Behaving as a single structure means that a rotation of the extension frame 9 at a first arm has the same effect for the extension frame 9 at the second arm.

At the connection section 10, the extension frame comprises, for each arm 5, two extension arms extending preferably in different directions towards two distal ends. The extension frame 9 comprises, for each of the arms 5, a first frame opening 11 and a second frame opening 17. The mounting shaft 6 may be arranged through the first frame openings 11 and the further mounting shaft 12 may be arranged through the second frame openings 17. The distance between the first frame openings 11 is preferably substantially equal to the distance between the arms openings 7. The distance between the second frame openings 17 is also preferably substantially

equal to the distance between the arm openings 7. As a result, a lighting module 4 can be fitted between the first frame openings 11, in mounting position 3b and another lighting module may be fitted between the second frame openings 17, indicated in figure 2 with mounting position 3e. Analogue to what is described above in relation to figure 1, each end of the mounting shafts 6 and 12 also provide outer module mounting positions 3a, 3c, 3d and 3f.

Although the extension frame 9 shown in the figures comprises for each arm 5 two extension arms, this is not necessary. The extension frame 9 may also comprise, for each arm 5, a single extension arm which allows to mount a single mounting shaft 6 at a distance from the distal ends of the arms 5. In such embodiment, the extension frame 9 should not comprise a curve. Even in an embodiment where the extension frame 9 does comprise, as is shown in figure 3, two extension arms for each arm 5, it is not necessary to provide the a curve between the two extension arms.

Based on the description of the figures 1 and 2, the skilled person will understand that the lighting apparatus 1 of the invention is highly modular. By not using the extension frame 9, a first number of lighting modules 4 may be mounted. The example of figure 1, one or two or three lighting modules 4 can be mounted in respective module mounting positions 3a, 3b, 3c. When the extension frame is connected to the arms 5, four or five or six lighting modules 4 may be mounted in module mounting positions 3a-3f. Identical or different lighting modules 4 may be used. The mounting shaft 6 may be identical to or different from the further mounting shaft 12. This shows that with a limited number of different elements, a multitude of different configurations of the lighting apparatus can be made. In figure 1, the driver 15 for the lighting modules is mounted to the frame 2. Figure 2 schematically illustrates another embodiment wherein the driver 15 is mounted externally.

Figure 3 shows a side view of the lighting apparatus of figure 2. The side view shows that the arm openings 7 are located at a distance from the secondary arm openings 14. Figure 3 also shows the first mounting shaft 6 located at a distance from the second mounting shaft 12. The distance is such that upper lighting module 4 cannot collide with a lower lighting module 4. Therefore the distance between the first frame openings 11 and the second frame openings 17 is preferably larger than a height of the lighting module 4.

Figure 3 also shows a detail of the connection between the lighting module 4 and the second mounting shaft 12. It will be clear based on the description above that the connection between the first mounting shaft 6 and a lighting module 4 is highly similar or even identical. The lighting module 4 comprises an array of LEDs 19, preferably high power LEDs, which are typically arranged on a printed circuit board PCB. The front side of the PCB is provided with the array of LEDs 19 while the back side of the PCB is connected to a heat sink.

The heat sink is formed as a thermally conductive metal body. The thermally conductive metal body comprises a plate like portion which forms the base 20 of the heat sink. The thermally conductive metal body comprises at least one cooling fin 21 and comprises a hole 8. The hole 8 extends in the transverse direction W of the metal body, parallel to the cooling fins 21. A plurality of cooling fins 21 extends away from the base 20. Preferably, the metal body is an extruded body extruded in one piece in the transverse direction W. Preferably, the metal body is made from aluminium. The metal body may be anodized to improve the corrosion resistance.

The base 20 functions as a mounting surface for a single support substrate or two or more support substrates, depending on e.g. the length L and the width W of the metal body and the required application. The support substrate is arranged against the frontal surface of the base 20, which frontal surface is located opposite the cooling fins 21. Preferably, the support substrate extends over a width perpendicular to the longitudinal direction L which is at least 80%, more preferably at least 90% of the width w of the base 20, and even more preferably over substantially the entire width W of the base 20. It is noted that in other embodiments there may be provided multiple support substrates, depending on e.g. the length L of the metal body and the required application. Also, it is possible to arrange two or more support substrates next to each other seen in the width direction perpendicular on the longitudinal direction L.

Preferably, the hole 8 is formed through the complete metal body, in the width direction W of the base 20, parallel to the direction of the cooling fins 21 and in a width direction perpendicular on the longitudinal direction L. The hole 8, seen in a cross section perpendicular on the width direction W, may have substantially any one of the following shapes: circular (not preferred), a polygon or closed shape having at least three vertices touching a virtual inner circle, a closed shape having at least three curved or straight segments contacting a virtual inner circle. Preferably, the hole has a cross sectional shape which is largely circular but with at least one flat section, as is shown in figure 3. The flat section is preferably provided perpendicular to the base 20 and directed to the back of the heat sink. The mounting shafts 6 and 12 have a corresponding cross sectional shape, being cylindrical with at least one flat section. The direct result of the corresponding non-circular shapes of the hole 8 and shaft 6 and 12 is that the shaft 6 and 12 will be able to slide in the hole, but will not be able to rotate inside the hole 8. Therefore the angular orientation of the heat sink and the mounting shaft 6 and 12 is predetermined and fixed once the mounting shaft 6, 12 is inserted into the hole 8 of the heat sink. The width W may be e.g. between 100 and 200 mm. Preferably the width W may be e.g. between 150 mm and 180 mm. The length L may be e.g. between 200 mm and 500 mm, preferably between 250 mm and 300 mm.

Figure 4 shows a detailed cross-section of an example of a functional module. In the description above, the heat sink is described as connected to LEDs 19 to form a lighting

module. According to an exemplary embodiment, the light source comprises a plurality of LEDs, preferably arranged on a LED support, such as a PCB. The LEDs may be arranged in an array of multiple columns and rows. According to a preferred embodiment, one or more optical elements are associated with the light source. The one or more optical elements may comprise a plurality of lens elements associated with the plurality of LEDs, e.g. grouped in a lens plate. However, also other types of optical elements may be additionally or alternatively present, such as reflectors, backlights, prisms, collimators, diffusors, and the like. In the context of the invention, a lens element may include any transmissive optical element that focuses or disperses light by means of refraction. It may also include any one of the following: a reflective portion, a backlight portion, a prismatic portion, a collimator portion, a diffusor portion. For example, a lens element may have a lens portion with a concave or convex surface facing a LED, or more generally a lens portion with a flat or curved surface facing the LED, and optionally a collimator portion integrally formed with said lens portion, said collimator portion being configured for collimating light transmitted through said lens portion. Also, a lens element may be provided with a reflective portion or surface or with a diffusive portion.

According to an exemplary embodiment, the light source may comprise a plurality of first light elements such as LEDs and one or more associated first optical elements configured to output a first light beam having a first color temperature according to a first intensity distribution within a first solid angle, and a plurality of second light elements such as LEDs and one or more associated second optical elements configured to output a second light beam having a second color temperature according to a second intensity distribution within a second solid angle. The second intensity distribution may be different from the first intensity distribution. Also, the second color temperature may be different from the first color temperature. Exemplary embodiments of such light sources are disclosed in Dutch patent application with application number NL2024571 in the name of the applicant which in included herein by reference.

According to an exemplary embodiment, the light source may comprise RGB and/or RGBW and/or RGBA LEDs and associated control circuitry for controlling the color emitted by the light source.

The lighting modules 4 preferably comprise a light source. Preferably the light source further comprises one or more optical elements associated with the plurality of light emitting elements. Preferably, the one or more optical elements comprise a plurality of lens elements associated with the plurality of light emitting element. Optionally, the plurality of lens elements may be integrated in one or more optical lens plates arranged above the one or more carriers on which the light emitting elements are mounted. Indeed, lens elements may be typically encountered in outdoor luminaire heads, although other types of optical elements may be

additionally or alternatively present in such luminaires heads, such as reflectors, backlights, prisms, collimators, diffusors, and the like. In the context of the invention, a lens element may include any transmissive optical element that focuses or disperses light by means of refraction. It may also include any one of the following: a reflective portion, a backlight portion, a prismatic portion, a collimator portion, a diffusor portion. For example, a lens element may have a lens portion with a concave or convex surface facing a light source, or more generally a lens portion with a flat or curved surface facing the light source, and optionally a collimator portion integrally formed with said lens portion, said collimator portion being configured for collimating light transmitted through said lens portion. Also, a lens element may be provided with a reflective portion or surface or with a diffusive portion or surface. In some embodiments the one or more optical elements, such as one or more lens elements integrated in a lens plate, can form the transparent or translucent portion.

However, instead of connecting LED's to the heat sink, other functional modules may be connected to the heat sink for mounting in a module mounting position of the lighting apparatus. In the lighting apparatus, at least one module is a lighting module. Other functional modules may also be mounted to the one or more shafts 6, 12. Examples of other functional circuitry which may be included in the functional module in addition to or instead of the lighting module, are any one or more of the following:

- power management circuitry comprising e.g. one or more of: a power meter, a fuse, a line protection, a circuit breaker, an electrical connection for multiple power lines, a clock, an astroclock, a power supply module, an PLC, a computer, a communication module, display circuitry, etc.; preferably the power management circuitry is configured to manage the provision of power to one or more lamp posts, preferably at least three lamp post, e.g. more than ten lamp posts. In such embodiments power connection cables pass from the functional module through the support pole to other lamp posts, e.g. underground.

- telecommunication circuitry for wired or wireless communication, which can comprise at least one of: an optical fiber connection, a fiber to copper interface, a fiber patch panel, a modem, a router, a switch, a patch panel, a network video recorder (NVR), a computer;

- audio system management circuitry which can comprise at least one of: an amplifier, a transformer, a media player (connected to network or not), electrical connections for multiple loudspeaker lines, a computer;

- WiFi circuitry, wherein an antenna for receiving WiFi signals may be integrated either in the functional module or in a separate antenna module as in the exemplary embodiment of the lamp post with a base station module;

- charger circuitry, e.g. phone/computer/tablet charger circuitry or vehicle charger circuitry or UAV charger circuitry (e.g. drone charger circuitry);

- an environmental sensor such as a sound sensor, a microphone, a voice recorder, a detector of CO2, NOx, smoke, or any other pollutant sensor, or an image sensor, etc., and the associated circuitry;

- a human interface device (HID) and the associated circuitry, e.g. a camera, a loudspeaker, a button, a display, etc.

- a signaling device, e.g. a light ring capable of performing signaling;

- a mechanical and/or electrical plug-in device, e.g. a universal plug-in module, e.g. a mechanical device to fix a flag, a waste bin, etc.; a socket plug-in device.

Figure 4 further shows that the base 20 of the heat sink comprises a thickening 22 in a central zone of the base 20. The opening 8 is provided in this thickening 22. Because the cooling fins 21 and the thickening 22 and the through hole 8 all extend in a single direction, being the width direction of the heat sink, the heat sink may be manufactured by extrusion. One end of the heat sink is preferably provided with a connector 23. The connector 23 is typically formed in the heat sink after the extrusion process. For providing the connector 23, one end of the heat sink, the left end in figure 4, is not provided with cooling fins 21 so that a flat surface segment is provided at the back end of the heat sink. Via a protrusion to the front end of the heat sink, electrical connections can be lead through the heat sink from the back side where the connector is provided to the front side where the function element is provided. Although figure 4 shows a preferred embodiment, it will be clear that other possibilities exist. The invention is not limited to the preferred embodiment. For example, it is possible to manufacture die casted heat sinks. In such die casted heat sinks, it is not required that different aspects such as cooling fins and through holes extend in a single direction. For example, the through hole may be formed transverse to the cooling fins. Further alternatively, the cooling fins may be formed as diamond shaped protrusions, thereby deviating visually from the shown cooling fins.

Figure 5 shows a part of the elements of the lighting apparatus of figure 2. Figure 5 illustrates and shows in more detail how the shafts 6 and 12 may be connected to distal ends of the extension frame 9, and on how the extension frame 9 is connected to the arms 5. Figure 5 shows that the extension frame 9 comprises shaft fixation means 24 adjacent to each of the frame openings 11, 17. The fixation means may be formed as a clamping means wherein a movable part and a fixed part, the fixed part being indicated with reference number 24a in the lower part of figure 5, between which the shaft may be squeezed. By squeezing the shaft, rotation of the shaft is prevented based on friction. A similar fixation means 24 is provided at the distal ends of the arms 5, adjacent to the arm openings 7. The stability enhancing shaft 16, which extends together with

the extension frame 9 between the arms 5, may be fixated with respect to the arms 5 using the arm fixation means. The angular position of the stability enhancing shaft 16 with respect to the extension frame 9 is preferably predetermined, for example by providing a non circular hole in the extension frame 9 which is compatible with a non-circular cross-sectional shape of the stability enhancing shaft 16. The skilled person will realize that other possibilities exist to fixate an angular position of a shaft with respect to a frame or arm. The embodiment described above is therefore not limited to the shown and described fixation means.

Figure 5 shows that when the extension frame 9 is mounted to the arms 5 using the stability enhancing shaft 16, and when the mounting shafts 6 and 12 are mounted through openings of the extension frame 9, lighting modules may be oriented by rotation around three axes of rotation R1, R2 and R3. Each of the mounting shafts 6 and 12 and the stability enhancing shaft 16 may be rotated by loosening the fixation means 24, and may be fixated using the fixation means 24. As described above, the angular orientation of the lighting modules 4 with respect to the mounting shafts is predetermined. Therefore rotating the mounting shafts automatically induces a corresponding rotation of the lighting modules 4. By rotating the mounting shafts 6 and 12, the lower and upper row of lighting modules 4, connected to these respective shafts, may be individually rotated with respect to each other, see R1 and R3. This allows to orient the relative beams of the upper and lower rows of lighting modules 4 with respect to each other. The combination of lighting modules 4 may be rotated by rotating the extension frame 9 with respect to the arms 5, see R2. This allows to orient the combination of beams into the preferred direction.

Figure 5 shows an end piece 25 covering the end of the mounting shaft 12. It will be clear for the skilled person that each end of each mounting shaft 6, 12, may be provided with such end piece 25 to prevent unintentional loosening of a lighting module 4.

Figure 6 shows another aspect of the lighting module 4. Figure 6 shows a cross section of a lighting module 4, similar to figure 4, at the location of a module fixation opening 26. The heat sink is preferably provided with a tapped opening through the thickening transverse to and towards the flat segment of the hole 8. Such tapped opening allows a screw to be inserted to clamp the heat sink onto the shaft 6. This prevents sliding of the mounting shaft 6 inside the hole. Such screw in the module fixation opening 26 would also further limit a rotation of the mounting shaft 6 in the hole 8 which, due to manufacturing tolerances may be possible to a limited extent. The opening, preferably in combination with the screw is called module fixation means 26. The end pieces 25 shown in figure 5 provide an additional stop which prevents the lighting module 4 from accidently or unintentionally slide off a mounting shaft 6, 12.

Whilst the principles of the invention have been set out above in connection with specific embodiments, it is to be understood that this description is merely made by way of

example and not as a limitation of the scope of protection which is determined by the appended claims.

5

Claims

1. Lighting apparatus (1) comprising a frame (2) having multiple module mounting positions (3) and comprising a number of lighting modules (4) adapted to be mounted in the mounting positions, wherein the frame comprises a support structure with two arms (5) and comprises a mounting shaft (6), wherein distal ends of the two arms are spaced apart and each provided with a respective arm opening (7), wherein each lighting module comprises a hole (8) for receiving the mounting shaft (6), such that, when the mounting shaft is arranged through the respective arm openings, a first shaft segment extending between the respective arm openings forms a central mounting position (3b) of said multiple module mounting positions and second and third shaft segments at opposite ends of the shaft form respective outer mounting positions (3a, 3c) of said multiple module mounting positions.

2. The lighting apparatus according to claim 1, additionally comprising an extension frame (9) to be arranged in between the distal ends of the two arms and the mounting shaft (6), the extension frame comprising a connection section (10) adapted to be connected to the arms (5) via the respective openings (7) and comprising first respective frame openings (11) adapted for the mounting shaft (6) to be arranged such that when the mounting shaft is arranged through the first respective frame openings, the first shaft segment extends between the first respective frame openings and forms the central mounting position and the second and the third shaft segments form said respective outer mounting positions.

3. The lighting apparatus according to claim 2, wherein the extension frame (9) comprises second respective frame openings (17) adapted for arranging a further mounting shaft (12) such that, when the further mounting shaft is arranged through the second respective frame openings (17), the further mounting shaft extends substantially parallel to, and at a distance from said mounting shaft when it is arranged through the first further respective openings, and a first further shaft segment extending between the second respective frame openings forms a further central mounting position of said multiple module mounting positions and second and third further shaft segments at opposite ends of the further shaft form respective further outer mounting positions of said multiple module mounting positions.

4. The lighting apparatus according to the previous claim, wherein the extension frame (9) is curved with, for each of said arms (5), two frame arms extending in different directions at both sides of a curve, wherein the connection section (10) is formed at the curve and

wherein the first respective frame openings (11) and second respective frame openings (17) are formed at respective distal ends of the two frame arms.

5. The lighting apparatus according to any one of the previous claims, wherein each mounting shaft is significantly longer than a distance between said respective openings such that the outer mounting positions are located outside of the respective openings.

6. The lighting apparatus according to any one of the previous claims, wherein the support structure comprises a substantially horizontal connection surface (13) at a proximal end.

7. The lighting apparatus according to any one of the previous claims, wherein the arms have a proximal section which is substantially upright and have a distal section which is substantially lying.

8. The lighting apparatus according to any one of the previous claims, wherein adjacent to the respective arm openings (7), secondary respective arm openings (14) are provided which provide an alternative arrangement position for the mounting shaft and optionally for the extension frame.

9. The lighting apparatus according to any one of the previous claims, wherein each mounting shaft and each hole (8) is compatible in shape to limit rotation of the mounting shaft inside the hole.

10. The lighting apparatus according to any one of the previous claims, wherein each lighting module is provided with module fixation means (26) to fixate the lighting module onto the mounting shaft thereby preventing rotation and sliding of the mounting shaft inside the hole.

11. The lighting apparatus according to any one of the previous claims, wherein the support structure and optionally the extension frame comprise shaft fixation means (24) at the location of the respective openings for preventing rotation and sliding of the mounting shaft inside the openings.

12. The lighting apparatus according to any one of the previous claims, wherein the lighting modules have a rectangular frontal surface with shorter and longer sides, the longer sides being oriented transverse to the mounting shaft.

13. The lighting apparatus according to any one of the previous claims, wherein each lighting module comprises an array of LEDs.

14. The lighting apparatus according to the previous claim, wherein a driver for the LEDs is arranged on the support structure or arranged externally from the lighting apparatus.

15. The lighting apparatus according to any one of the previous claims, wherein each lighting module has a base and wherein the hole receiving the mounting shaft is a through-hole extending between opposite sides of the base.

16. The lighting apparatus according to the previous claim, wherein the base is formed in one piece, preferably by extrusion.

17. The lighting apparatus according to claim 15 or 16, wherein the base is provided with cooling fins.

18. Functional module comprising a heat sink having a base with multiple cooling fins, the base being provided with a through hole adapted for arranging a mounting shaft through the heat sink.

19. Functional module according to the previous claim, wherein the functional module a substantially rectangular frontal surface with shorter and longer sides, the longer sides being oriented transverse to the through hole.

20. Functional module according to one of the claims 18-19, wherein the cooling fins extend substantially parallel to the through hole.

21. Functional module according to one of the claims 18-20, wherein the base is further provided with at least one electrical connector (23) for providing power and/or providing operational signals to the functional module.

22. Functional module according to any one of the claims 18-21, wherein the heat sink is formed in one piece preferably by extrusion.

23. Functional module according to any one of the claims 18-22, wherein the base comprises a thickening (22) and wherein the through hole is located in the thickening.

24. Functional module according to any one of the claims 18-23, wherein the through hole has a shape in cross section that deviates at least partially from a round shape.

25. Functional module according to any one of the previous claims 18-24, wherein the functional module comprises an array of LEDs.

26. Set of a functional module according to any one of the claims 18-25 and a mounting shaft adapted to extend through the through hole.

27. Set according to the previous claim, wherein the mounting shaft shows a cross-sectional shape which corresponds to the shape of the through hole to limit a rotation of the mounting shaft inside the through hole.

28. Set of one of the previous claims 26 or 27, wherein the functional module is provided with module fixation means (26) to fixate the mounting shaft in the through hole preventing rotation and sliding of the mounting shaft inside the hole.

29. The lighting apparatus according to any one of the previous claims 1-17, wherein each lighting module is a functional module according to claim 25.

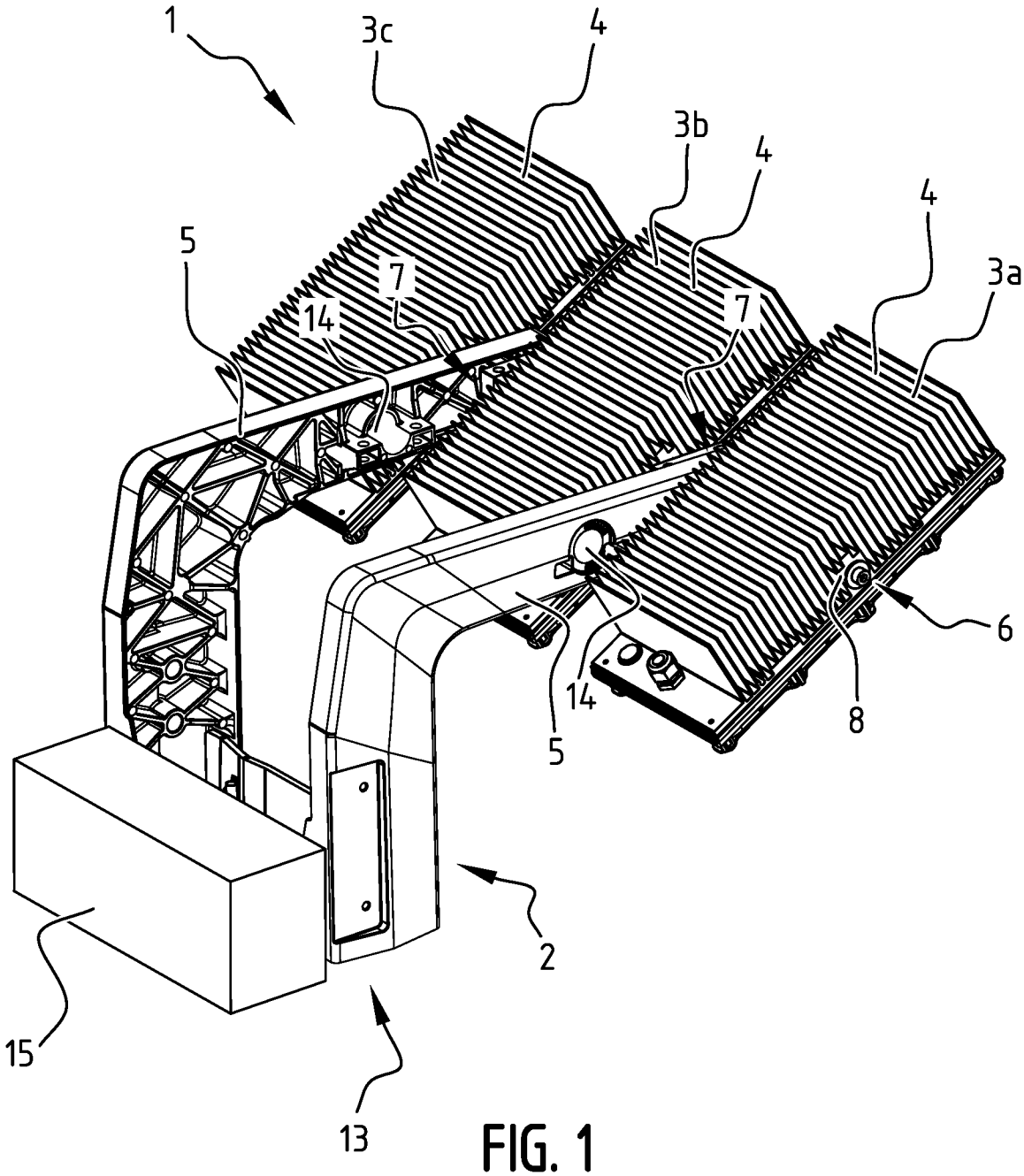

FIG. 1

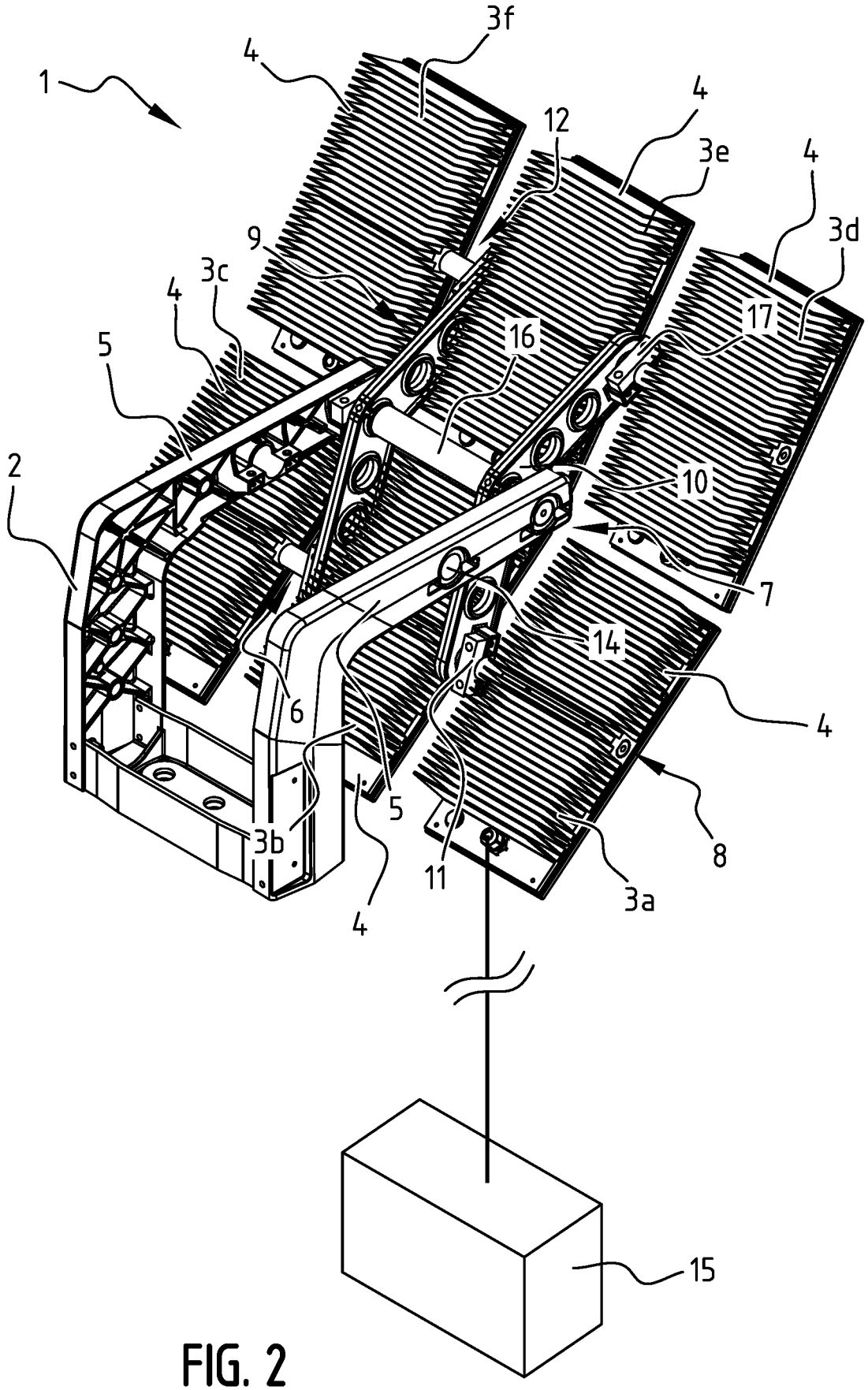

FIG. 2

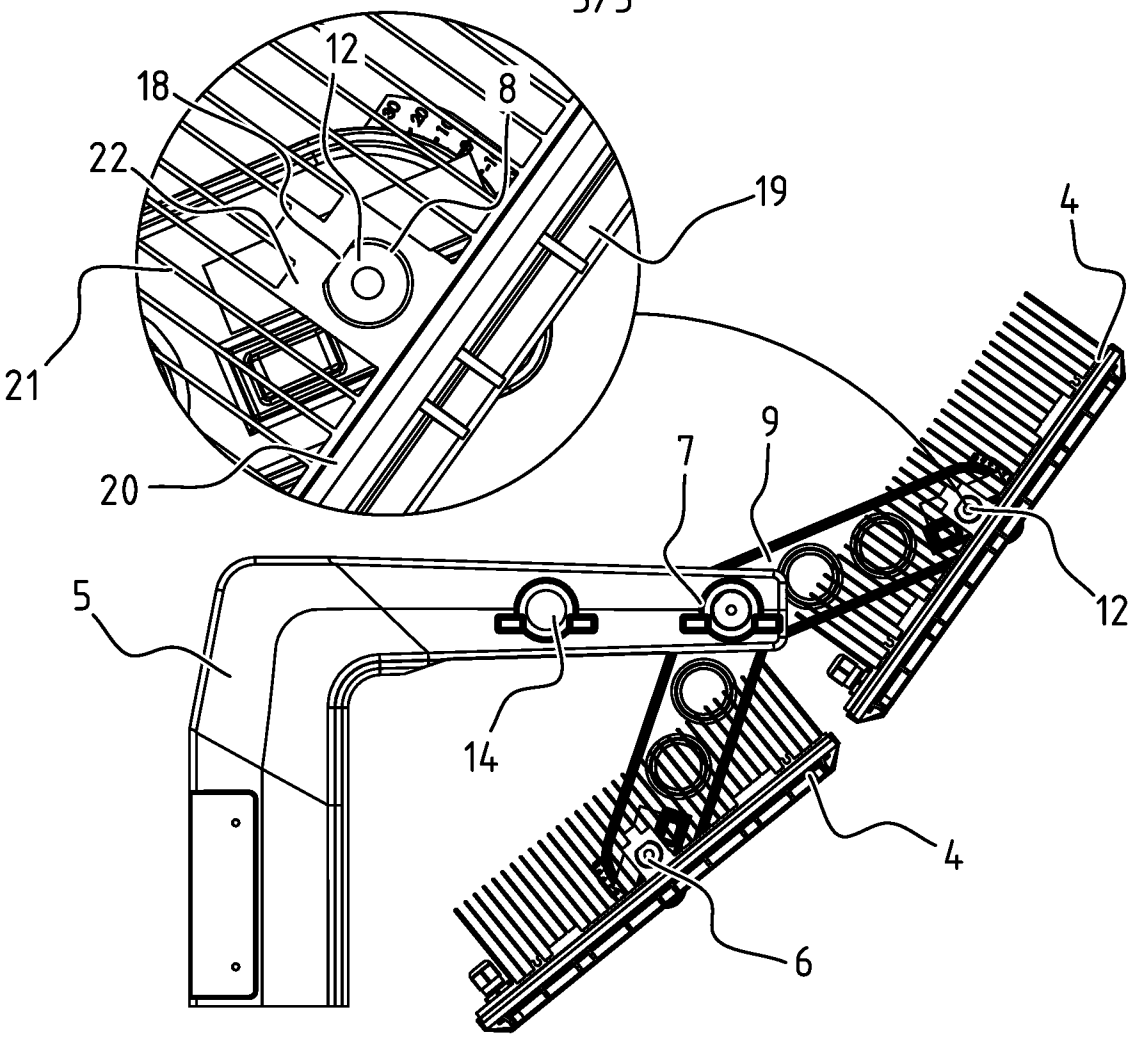

FIG. 3

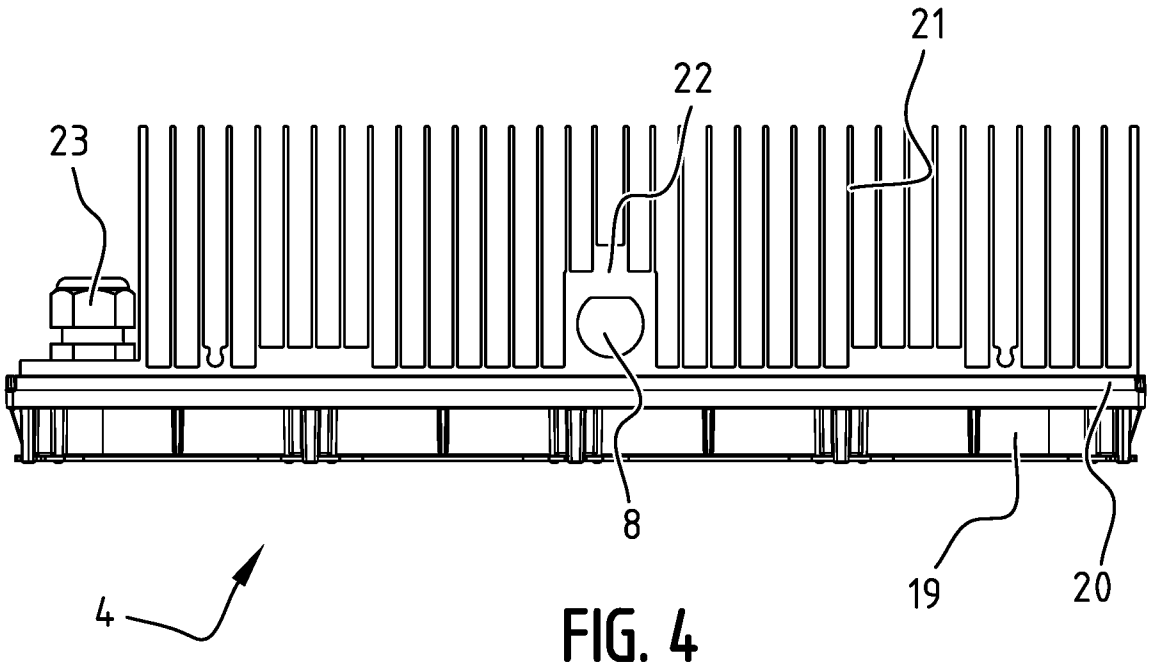

FIG. 4

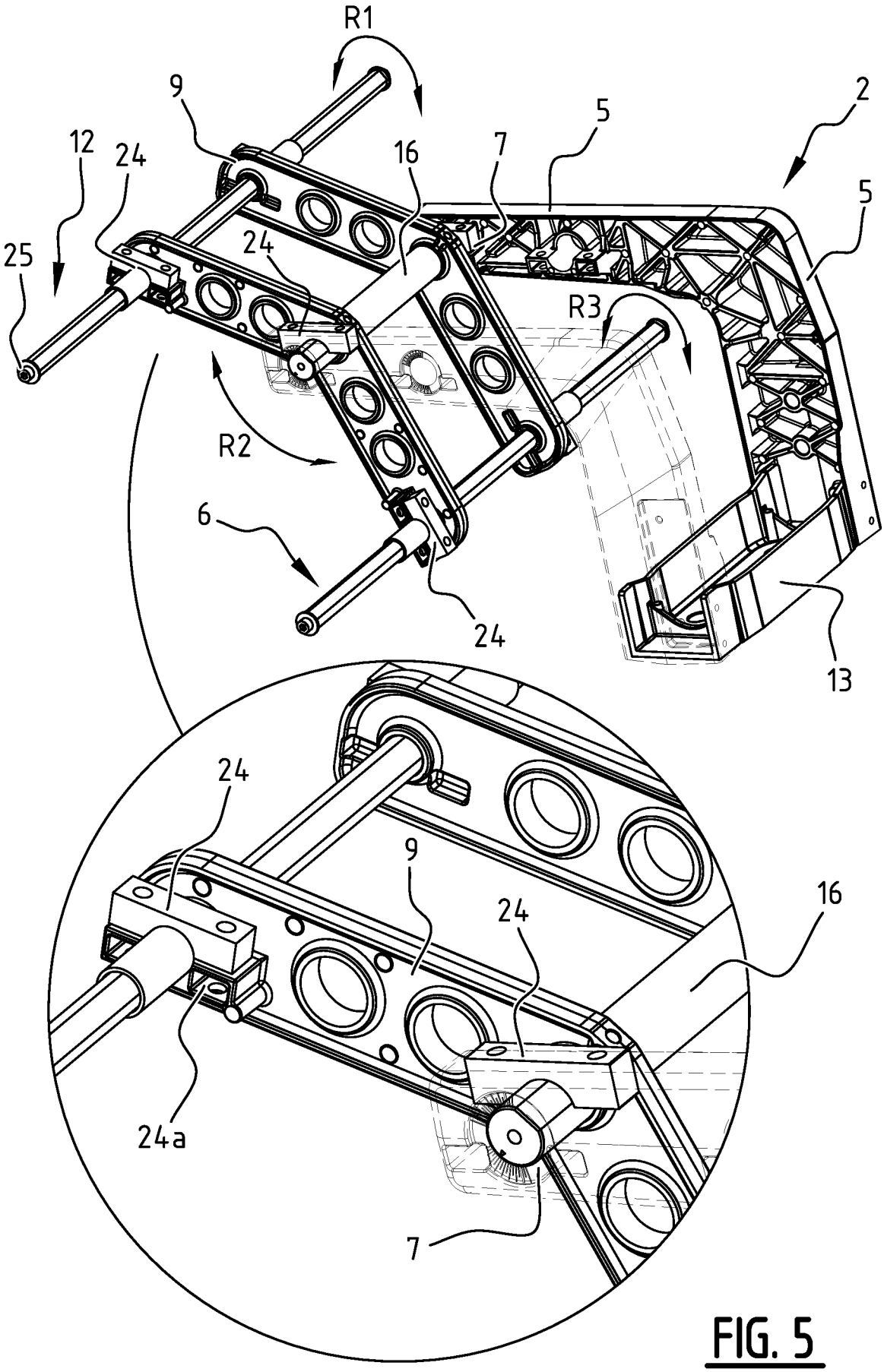

FIG. 5

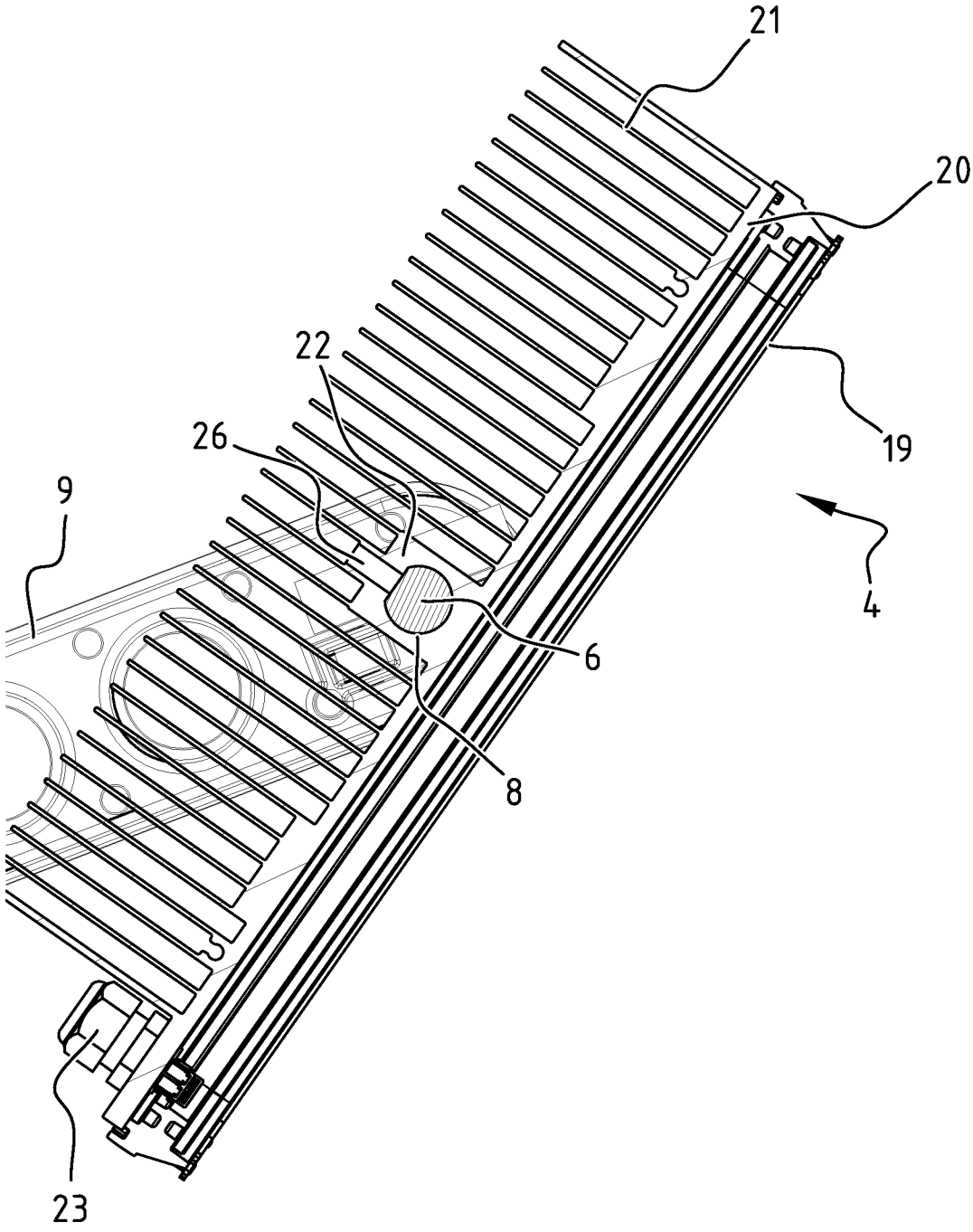

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/076403

A. CLASSIFICATION OF SUBJECT MATTER
INV. F21S2/00 F21V21/116 F21V21/14 F21V29/76
ADD. F21W131/105

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F21S F21V F21W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 3 167646 U (TATEYAMA KOSAN KK [JP]) 12 May 2011 (2011-05-12) figures 1-6	1-7,9-29

X	CN 106 051 649 A (SHENZHEN AGC LIGHTING TECH CO LTD) 26 October 2016 (2016-10-26)	18-28
A	figures 1-6	1-17,29

X	DE 10 2011 052322 A1 (SAILER ROLAND [DE]) 7 February 2013 (2013-02-07)	1,5-7, 9-15, 17-29
Y	figures 1-3	8

Y	CN 207 514 671 U (ZHONGSHAN YADE LIANGCAI LIGHTING CO LTD) 19 June 2018 (2018-06-19)	8
A	figure 1	1-7,9-29

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 December 2021	09/12/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dinkla, Remko

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2021/076403

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 3167646 U	12-05-2011	NONE	
CN 106051649 A	26-10-2016	NONE	
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CN 207514671 U	19-06-2018	NONE	