

Cooling element for a heat source

The invention concerns a cooling element for the cooling of a heat source, for example an LED module in accordance with the first part of claim 1, as they are used, for example, as LED lights to illuminate interior spaces and in some outdoor areas (e.g. tunnels, gardens, building illumination).

LEDs (light emitting diodes) are often used as light sources. LEDs are electronic semiconductor components. If electricity flows through the diode in the direction of the outlet, light is emitted. Light diodes possess an exponentially increasing current-voltage-characteristic (I-V curve) which, among other things, depends on temperature. The luminous flux is nearly proportional to the operating current. The forward voltage adjusts itself due to constant current through operation, possesses tolerances and is temperature-dependant - it sinks with increasing temperature as with all semiconductor diodes. High temperatures (usually due to high currents) shorten the life span of LED's dramatically.

Typically, multiple light emitting diodes together on one carrier are arranged to one unit colloquially referred to as an "LED" light, which is now also subsequently referred to as an LED. The brightness of an LED grows with power consumption. At a constant semiconductor temperature the increase is roughly proportional. The level of efficiency drops with increasing temperature, and it is for this reason that the light yield drops at the limit of performance depending on the type of cooling. LED's generally have bad thermal stability which is why they must be cooled off for long-time use, so that their lifespan is not dramatically shortened. Heavily populated LED modules, meaning modules which are furnished with many light-emitting diodes, like, for example, the Fortimo DLM Line by Philips, or XLM by Xicato, or BXRA by Bridgelux, and others, are particularly heat sensitive.

The heat produced by the operating current as thermal power loss may not heat up the module above 65°C at the housing measuring point defined in order to be able to ensure the predetermined lumen output (luminous flux unit -> luminosity) and the required lifespan (min. 50,000 operating hours).

In order to achieve this various precautions have already been taken.

Attempts were made to cool using free convection on the LED's extensive housing, or with these thermally connected arrangements with cooling elements (passive cooling), i.e. using diverse lamellae arrangements. Apart from the fact that a lot of space is required for this these relatively heavy metal elements form inefficient cooling elements, particularly in the assembly of a larger number of LEDs in the module or lamp body (DE 10 2007 030 186 B1, DE 20 2008 906 325 U1).

Further, using actively moved elements for cooling (active cooling) is known, for which, in connection with convection elements, motor driven fans, or a oscillating membrane, are used, see "Application guide, Philips Fortimo LED downlight module system (DLM)", Page 18, Abb.: SynJet cooling System von Nuventix." Apart from the fact that these elements also require additional energy to function, they produce very disruptive noises (over 20 db), which can lead to very high resonances, particularly with the arrangements of many lights of this kind on suspended ceilings of larger rooms, in addition vibrations and echo effects occur which can build up to extremely distracting background noise, up to five times amplification. In addition the side lamellae cooling elements provided are not suited for, and also not intended, to enable the necessary reduction in temperature. They only serve to spread the heat. For this reason these lights could only be used to a limited extent until now.

Finally, it is known to use arrangements with heat pipes for heat dissipation. For example, cooling elements with heat pipes, with which one end of the heat pipes is thermally connected with a heat source, while their external sections are equipped with a lamellae-equipped, or lamellae-like, cooling element, are known from DE 10 2007 038 909 A1 and DE 10 2006 045 701 A1. Apart from the fact that this concerns systems that are practically useful only in outdoor applications in motor vehicles and not for lights to be used indoors, therefore not for indoor applications, this concerns cooling threads shaped directly on the pipe casing and ineffective cooling elements, or a lamella package which is applied on heat pipes with various contents and purposes. These cooling elements are not suitable for cooling lights in building spaces. Cooling elements in accordance with the category are known from EP 1903278 A1 and DE 20 2009008456U1, which are, however, not satisfactorily manufacturable and/or sufficiently efficient and space saving - particularly for application in lighting elements.

Therefore, the problem of the invention is to create a space-saving cooling element, in accordance with the category, for effective, silent cooling of lights with a high number of LEDs.

The problem is solved by a cooling element with the characterizing features of Claim 1. Advantageous embodiments may be taken from the dependent claims.

The basic elements in a cooling element according to the invention are: at least one, preferably two, three, or more heat pipes which extend on a common level and for each of which one (first) end section is embedded in one of the base bodies to be connected to the heat source, while on the other (second) end section a cooling body is attached consisting of multiple lamellae. The heat pipes are arranged across the entire length of the base body so that the heat source, or the LED module, lies on the base area of the base body. In doing so, the heat pipes run parallel to each other and to the metal contact surfaces, parallel to the heat source with the hottest zone (hot spot). The lamellae are provided integrally with these on the exterior of the base body. Consequently, one end of the tubes runs very close along the hot base of the LED module across its entire length, so that a very good thermal conduction from the heat source to the heat pipes is ensured. In addition, the lamellae are already being cooled in the area of the base body and the heat source above the base body at the same time, thereby, on the whole, significantly contributing to the heat dissipation.

It is beneficial that the base body lamellae, which can be designed differently, are arranged on the base body in a transverse or longitudinal direction. For the primarily U-shaped base body, surrounding the U-shaped metal housing of the rectangular-shaped LED modules at least partially, offers, to also arrange the lamellae in a U-shape in transverse axial succession. However, it is simpler if the cooling ribs or lamellae are arranged lengthwise or axially for manufacture. Therefore the base body is, as a whole, manufacturable as one piece using extrusion or extrusion moulding.

It can be advantageous if two or three or more heat pipes always running through one common level are used for one cooling element. In this way three heat pipes can be used together, which, for example, have a pipe diameter of 5 mm, whereby the arrangement of the heat pipes is selected in such a way that their first end section is embedded in a form-fitting, and thermally conductive manner, in the base body in the

corresponding opening and in the corresponding axially parallel distance to one another, while they are continued in various forms after their exit from the base body. In this way, for example, a central

heat pipe is extends axially in a straight direction while both side heat pipes extend on their separate ways, and the distance between the heat pipes increases across a relatively short distance, for better heat dissipation, after which they continue even axially parallel in the cooling body so that, overall, a forked arrangement of the heat pipes exists.

The cooling body, which consists primarily of many parallel, distanced lamellae, stretches across the entire second end section of the heat pipes. The lamellae are advantageously designed so that through-holes for the passage of the heat pipes are shaped so that the heat pipes, in press fit, or shrink fit, are firmly in tight, thermally conducting, form-fitting contact with the lamellae, whereby optimum thermally conducting contacts between the heat pipes and the lamellae are ensured.

In order to simply maintain a constant distance between the lamellae various spacers can be used. These, for example, can, in each case, be simple spacer rings on both of the exterior heat pipes. They have spacers rising vertically out of the lamellae, which can be directly cut in, in a tongue-like manner, and vertically bent out by the punching manufacturer.

With an embodiment with only two heat pipes they are similarly shaped as the two external heat pipes of the above-described embodiment with three heat pipes. The first end sections of the heat pipes in the interior of the base body also run parallel to each other, then after exiting the base body diverging and upon entry into the cooling body again parallel to one another so that the shape is roughly like a tuning fork. Here it can be useful to select heat pipes with a somewhat thicker diameter, i.e. with 6 mm, so that overall similar thermal and strength conditions exist as in the embodiment with three pipes with a diameter of 5 mm.

The heat pipes can, in a first embodiment, be embedded, form-locking, in axial or longitudinal holes, in the base body base section, along its entire length, whereby they have no physical contact with the hot zone of the LED module. Through the good conductivity of the base body, particularly the base section, in which the heat pipes are

embedded, the heat absorbed by the base body through its close contact with the hot zone of the module to be cooled off, can be easily transferred to the pipes and active vaporization of the fluid medium found in the heat pipes under absorption of the latent warmth, and with that the dissipation in the following cool zone with condensation and release of the latent warmth takes place.

Usually the heat pipes extend through the thermal absorption plates. However, for some applications it is advantageous if the heat pipes are each placed in a groove which is open to the contact surface of the base body-base element. In doing so, the cross section of the grooves can be designed essentially U-shaped for maximum contact and form fit, with the same groove-base diameter as those of the heat pipes and a groove height according to the thickness of the heat pipes. As a result, full surface contact with the LED module in the base body occurs concurrently with direct contact between the heat pipes and the hot base surface of the LED modules. Therefore a particularly good thermal contact is obtained so that the evaporation of the medium of the heat pipes and with it most efficient heat dissipation can occur.

According to the invention, the base body can have various embodiments. It can be designed as a simple plate, upon or to which, an LED module can be fastened, with good contacts, accordingly. Then the plate comprises vertically extending lamellae on its flat exterior accordingly, which can run lengthwise or crosswise for the course of the heat pipes arranged therein.

However, the base body can also be designed so that it can, at least, partially laterally encompass the heat source, or the LED Module, in a U shape, therefore itself have a U-shape. Therefore, the base body comprises a base body floor section wherein the heat pipes extend partially in corresponding holes, or grooves, as well as two sides vertically thereto. The distance between the base body sides is to be designed so that their inner flanks have a good contact area and therefore lie on the metal flanks of the LED module so that they are thermally conductive. In order to establish this contact the base body sides can also be attached on the side using fasteners on the flanks of the LED module.

Further, the base body sidewalls along the flank of the LED can run shorter or longer.

So, for example, a base body side length of only 0.5 to 15 mm, preferably 8 mm, is conceivable which only serves as a fastening aid. The short base body side design form has the significant advantage that more leeway remains for mounting a light housing to be used, which then encroaches upon or is fastened to the lower part of the LED module.

In a further embodiment the base body, or at least its base body floor section, is relatively thin. The thickness of the base body floor section is less than the diameter of the heat pipes. At the same time grooves with an opening directed to the contact surface for simple insertion of the heat pipes are provided, while the thin material of the base body is guided around these grooves in an arched shape. In addition, the lamellae provided on the front side of the base body protrude vertically from the exterior of the base body floor section so that optimal heat dissipation, with economic material use, exists.

With long U-shaped encompassing base body side walls, and axially extending lamellae, side lamellae can also be provided in addition to the lamellae protruding outward from the base body floor section. For reasons of space these can then also be at least partially angled upwards. Only with very short side walls should side lamellae not be provided, because only a little heat can be absorbed in the short stub base body sides, and therefore dissipated.

Because here the heat source to be cooled, here the LED module, has multiple fastening devices, i.e. holes, in a special arrangement, these should also be provided in the base body floor section. The Fortimo module, for example, provides three anchor holes, arranged in the shape of an isosceles triangle.

It is particularly advantageous if, in addition to the customary three holes (two in the front, one in the centre rear) an additional three holes are provided, which are arranged in a mirror image of the first three, namely a centre hole on the front outer edge and two holes spaced apart from each other on the inside edge of the base body. So the base body can simply be turned by 180° on an LED module and fastened so that the LED module can either be mounted with its electrical connection side facing outward, or inward, across from the entire element. This is particularly the case when using the cooling element not only for the rectangular Fortimo LED modules for example, but

also for the Lexel modules by Philips having the same width, however, approx. double the length. The base body can be placed on the module so that it locks with the outer end of the LED module on the front side, whereby then, for example, the power-connection side of the LED module protrudes over the inner edge of the base body far inwards, in the direction of the cooling body. In this arrangement, the hot zone is found in the module zone facing the electric connection end. With a changed application of the module, with the power connection part facing outward, the thermal conducting base body of the cooling element sits on the then inner zone so that the front side of the base body is flush with the corresponding front side of the LED module.

With an arrangement with an internal power connection of the LED module it is important to ensure that a corresponding inner distance between the base body and the cooling body exists. This can be achieved, among other things, by using the heat pipes reversed, namely with the Crimp-end, unusable for a form-locking contact with the lamellae not protruding far out of the last lamella, but instead with this end laid into the groove of the base housing. In this way the entire lamellae package of the cooling body can be fastened very close to the now outward facing flat end.

With a further embodiment at least one, preferably two support sheets spaced apart from each other provided for the vertical support of the cooling body. As a result, the entire cooling lamellae package of the cooling body is carried through only three heat pipes protruding from the base body. The heat pipes are mostly manufactured out of relatively soft material with good thermal conductivity, like aluminum, or copper, and bend very easily under the weight of the lamellae package, or through improper handling, and are therefore easily damaged.

The support sheets can simply lie flat or linear on the underside, or bottom edge, of the lamellae for support. However, they can also, in a particularly advantageous manner, join in a form-fit corresponding vertical slits in the lamella, so that not only a vertical, but also a good lateral support exists. The support sheet can be designed in various ways, particular its length, whereby its first end can be attached to the sides of the module of the base body, while a second console-type protruding longer end should at least extend across the majority of the length of the cooling body.

It is advantageous if the support sheets are on the top side designed in the length of the corresponding contact facing the lamellae and are angled toward the top, with slope, or incline. There even a slight incline of preferably 5° , or at most 18° , is already extremely effective, because the entire lamellae package with heat pipes then runs angled toward the top directed towards the cooling end, whereby the condensate transport is supported by gravitational force. Using only a slight slope of the heat pipes a significantly faster return of the cooled medium takes place within the heat pipes to the first, hot vaporization end. Thereby, through an extremely simple measure, a remarkably better cooling effect can be achieved, paired with increased strength and safety. For example, for the their application on non-square heat sources, with larger length measurements and reverse layout, i.e. with the electrical power connections of the heat source, or the light housing not facing out, but instead facing in facing the lamellae cooling body, the distance between the base body and the lamellae cooling body can be designed at least 10 mm larger than for square LED modules.

Finally, it is advantageous if at least the lamellae or even all parts of the cooling element are executed in black because black surfaces radiate more heat than white, or bare metal surfaces.

In the following, the invention is explained using embodiments with reference to the drawing, to which it is in no way limited. Therein show:

Fig. 1: a perspective view of a first embodiment of the cooling element from above,

Fig. 2: a perspective view of the embodiment of Fig. 1 from below,

Fig. 3: a perspective view from the front and above a second embodiment with longitudinal lamellae of the base body,

Fig. 4: a view from below of the embodiment according to Fig. 3,

Fig. 5: a forward front view of the embodiment according to Fig. 3 and 4,

Fig. 6: a perspective view from above and behind of a third embodiment with oval cooling lamellae and only a short encompassing cooling body,

Fig. 7: a perspective view from below the embodiment according Fig. 6,

Fig. 8: a perspective view from below the embodiment according to Fig. 6 and 7,

- Fig. 9: a forward front view of the embodiment according to Fig. 6 through 8,
- Fig. 10: a front view of an embodiment similar to that in Fig. 6, however, without base body sides,
- Fig. 11: a front view of an embodiment similar to Fig. 6, however, with thick base body-base body floor section,
- Fig. 12: a front view of a lamella of the cooling body in accordance with the embodiment according to Fig. 6,
- Fig. 13: a side view of the lamellae according to Fig. 12 with the spacer,
- Fig. 14 a schematic side view of the cooling element, placed on a LED module and light housing, designed with angled support braces,
- Fig. 15 a schematic side view of a cooling element, placed on a square LED module,
- Fig. 16 a view similar to Fig. 15, whereby the cooling element is placed on a long LED module, with inward facing power connection;
- Fig. 17 a similar arrangement as in Fig. 16 with long LED module, with outward facing power connection;
- Fig. 18 an embodiment with arrangement of the cooling body above the LED module, in perspective view;
- Fig. 19 the embodiment of Fig. 18 in cross section
- Fig. 20 the embodiment of Fig. 18 in perspective view from behind
- Fig. 21 the embodiment of Fig. 18 in view from front
- Fig. 22 the embodiment of Fig. 18 viewed from the base plate
- Fig. 23 the embodiment of Fig. 18 in view from the back
- Fig. 24 an embodiment of a cooling lamella with adhesive groove
- Fig. 25: a further embodiment of the cooling body in different views
- Fig. 26: an embodiment for cooling lamella bodies for a point light source in perspective view
- Fig. 27: top views of the cooling lamella body from Fig. 26
- Fig. 28: an embodiment of a point light-cooling body with fastener for cooling lamella body from Fig. 26 and 27; and
- Fig. 29 a - c Detail views of a point light-cooling lamella

In Fig. 1 and 2 a first embodiment of the invention is shown, from which it is apparent, that the cooling element 1 according to the invention, consists primarily of three elements, a base body 2, a cooling body 3, and heat pipes 4, 5, and 6. The heat pipes

4, 5, and 6 connect the two bodies 2, 3. The heat pipes initially run inside the base body 2 with, at least, small distance from one another, whereby the first end section of the heat pipes 4, 5, and 6 is embedded in the base body 2, while the second end section extends through the cooling body 3. The base body 2 is, in this embodiment, primarily U-shaped, with a base body floor section 7, and two base body sides 8. Obviously in the base body floor section 7 of the base body 2 three holes 9 separated from one another are provided, in which the first end sections of the heat pipes 4, 5, and 6 run. The LED module 12, which, at the same time, represents the heat source to be cooled off, is, in this case, square (i.e. a Fortimo module by Philips). Its body is comprised of two U-shaped housing parts: a metal housing part 13 and a plastic housing part 14. The metal housing part 13 has an upward facing base body floor section 15, with the hot zone 16 (hot spot) in its centre upon which metal base body sides 17, with corresponding outer contact surfaces extend on the opposite ends. Here, three fastening bores 18 are shown which are arranged in a triangle shape and fasten it to the base body 2. Thereto three threaded holes 19 are arranged in a triangular shape corresponding to the three fastening bores 18, in the LED module 12.

Further it is shown that the cooling element 1 has a relatively long cooling body of cooling body lamellae 20 on its other end. Here, the cooling body lamellae 20 are simple squares and are lined up at spaced at a constant distance from one another on the heat pipes 5, 6.

The heat pipes 4, 5, and 6 are guided across the entire length, parallel to each other, with relatively small space in between in the base body, base body floor section 7 and exit from the inner side of the base body 2 with corresponding distance. Concurrently therewith the middle heat pipe 4 runs in the centre, straight and axially, while both of the outer heat pipes 5 and 6 are first angled diagonally outward, then again run parallel to one another at a corresponding larger distance from one another, so that the shape of a fork with three teeth is achieved. The cooling body lamellae 20 of the cooling body 3 are lined up on the fork teeth section.

In Fig. 2, the LED module 12 to be connected with the base body 2 is shown from above in perspective view as it is laid into base body 2 and screwed to it. Its plastic housing part 14 faces upward and in its floor, or light part 24, three fastening bores 18 can also be identified. The contact surface 15 of the U-shaped metal housing is in assembled state precisely on the contact surface 21 of the base body 2 while the metal base body sides 17 are in thermal contact with the contact surfaces 22 of the base body side 17.

Fig. 3 shows a second embodiment of a cooling element 25. Both base body sides 8 of the U-shaped base body 2 extend vertically relatively far down, until nearly over the entire side length of the LED module to be accommodated. It is particularly noticeable that the cooling ribs or lamellae 10 are not arranged cross-wise but instead lengthwise, or axially. On the top side of the base body floor section 8 vertical, upwardly extending lamellae 10 are provided across the entire length of the base body 2, while, on the base body sides 8, two side lamellae 28 each, protruding diagonally upwards, in order to avoid making the protrusion too expansive are provided. The lengthwise arrangement of the lamellae 28 has the advantage that, with the integral embodiment of the base body 2, according to the invention, the the base body 2 can be extruded in a faster and more economical manner, whereby even the grooves for the heat pipes 4, 5, 6 can also be shaped along with it, and the base body 2 only needs to be cut by a long profile section and the necessary fastening bores 18 made.

As a particularity it should be understood that three heat pipes are no longer provided, but instead only two, namely heat pipes 5 and 6, which correspond to the shape and arrangement of this in Fig. 1, whereby both heat pipes 5 and 6 have a shape similar to a tuning fork with two parallel teeth. What cannot be identified is that a change in the dimensions of the heat pipes has taken place here. Here, the preference is no longer to use three heat pipes with a 5 mm diameter, but instead two heat pipes with a 6 mm diameter so that, despite, the savings of the centre heat pipe, the stability and the thermal budgeting, meaning the heat dissipation, in this case, have largely remained unchanged. Regarding the formation of the cooling body 3 it should be noted that the cooling body lamellae 20, in comparison to those from Fig. 1, no longer exhibit a simple square shape, but instead are curved upward in the centre in a dome shape and, in each case, are angled laterally upward. The height of the cooling body lamellae 20 has remained the same throughout. The width of the lamellae package is only very minimally decreased, at the most by a few millimetres, as a result of the curved and/or angled design. Two punched holes 29 can also be identified, which can be manufactured by a primarily U-shaped punching and bending back one tongue each by 90° (not shown in this view), which serve as spacers 32 between the individual cooling body lamellae 20. Their formation and arrangement can be better taken from Fig. 6 and 13 and is also explained accordingly in connection with these images.

In addition, two slits 30 are introduced vertically from the bottom to the top on the cooling body lamellae 20, whereby here only one of the two slits is shown. The vertical insertion slots each serve to include a support sheet, as seen in Fig. 8 and 14 and is also described in connection with these images.

Fig. 4 shows the cooling element 25 from Fig. 3 in a view from below, whereby it can be seen that in the base body 2 near the axial middle, two grooves 26 are provided, in which the, here on the left, (vaporization) end sections of the heat pipes 5 and 6 are incorporated along their entire length. In this position these pipe ends are, for example, held tight by firmly screwing the corresponding inserted LED module to the base body. The three thread holes 19 serve this purpose. Here it may be seen how the side lamellae 28 protrude laterally angled from the deeply downward drawn base body sides 8 of the base body.

In cooling body 3 two backwards bent spacers 32 can be seen, each of which appear as only an axial line, so that an optical illusion of a line, which could represent a continuous plate, exists.

The front view of the cooling element 25 in Fig. 5 allows to identify the arrangement of the device parts to one another and their extension in horizontal and vertical directions. So, the U-shape of the base body 2, with relatively thin base body floor section 7, is easily recognizable, which is arched around both heat pipes 5, 6 so that each U-shaped groove 26 is available corresponding to the diameter of the heat pipes 5, 6. On the top side of the base body floor section 7 the lengthwise lamellae 10 protrude vertically, and are graded, arched in a cross direction in their vertical length for a more agreeable appearance and more convenient handling. This arch continues up to both side lamellae 28. The rounded form of the cooling body lamellae 20 (20b) is easily recognizable with a centre arch and lateral, upward extending wing parts. Here it may be seen that the cooling body lamellae 20 are primarily equally high throughout.

Fig. 6 through 9 show a third embodiment of the cooling element 35 according to the invention. In particular, from Fig. 6, which shows a perspective view from behind, it can be identified that the base body 2 in its primary elements is put together similarly to the cooling element 25 from Fig. 3. In this embodiment the base body sides 8 are rather short. It is the preferred embodiment for the Fortimo-Moduln, which have a length of only approx. 5 or 8 millimetres. Also, there are not side lamellae provided on these short base body sides 8, but instead the cooling body 2 only has vertically, upwardly extending lamellae 10. Here, the cooling body lamellae 20 (20c) have a particular design. They are no longer just square, or designed as a curved and bent square, as they have no corners at all anymore, but instead a primarily oval, rounded shape. Although the cooling body lamellae 20c are a little shorter than the previously described cooling body lamellae 20a and 20b, they do, however, have a significantly larger height, and width than these, as is particularly evident from the comparison of the front views according to Fig. 5 and 9. There is therefore, with a significantly larger vertically upward heat dissipation surface, no more space required, however, in the width there is significant space saved, whereby the installation and handling are significantly improved. That there are no corners present on the lamellae package of the cooling body, but instead only curves which lie comfortably in the hand and also makes it look better, also adds to these characteristics.

The rear view of the cooling body 3 from Fig. 6 shows how both spacers 32 protrude vertically out of the last lamellae 20c, through which the primarily U-shaped slits in the lamella plate and subsequent bending of the punched out tongues result, whereby the punched holes 29 remain open. In addition, it shows how the outer two ends of both heat pipes 5 and 6 protrude out of the surface of the last lamella 20 c. The relatively far-protruding heat pipe section is the respective crimp end 33 of the pipes which exhibit pinching and therefore are not sufficiently cylindrical in this end area for proper form-fit accommodation of the lamellae.

Fig. 7 illustrates the bottom side of the cooling element 35, whereby the arrangement of the slits 30 and the punched holes 29 to the spacers shown may be seen on the cooling body 2. In addition the embodiment of both heat pipes 5 and 6 is easily recognized, namely the relatively close guidance in the base body floor section 7, which after exiting takes on a outwardly curved arched shape and is then guided with a larger distance parallel to one another in cooling body 3.

Further, the arrangement here of the threaded holes 19 is identified, which serves for the attachment to the LED module. Here, not only are just the three threaded holes 19 planned in a triangle arrangement, but instead, in addition, a mirror image duplication of this arrangement, i.e. six holes. This has the advantage that the LED module can be mounted to the base body in any way, i.e. rotated by 180°, meaning that a choice exists whether the power connection will face outward, or inward.

The particular arrangement of the threaded holes can also be identified in Fig. 8, a view from below. Here the successive arrangement of the spacers 32 can also be recognized, similar to Fig. 4, the guidance and formation of both heat pipes 5 and 6, as well as the arrangement of the support sheets 36 and 37. The latter are, on the one hand, fastened to base body 2 and, on the other hand, reach into the slits 32, which are not shown here, but are, however, as shortly mentioned in the preceding, in connection with Fig. 3, 6, and 7.

Fig. 9 illustrates the already mentioned arrangements and size ratios of the individual parts of the cooling element 35, in particular the cooling body 2 with its relatively thin base body floor section 7, whose arched grooves 26 guide the heat pipes 5 and 6. How

both heat pipes 5 and 6 lie in direct contact with the hot zone 16 of an LED module 12 can also be identified. Further, the cloud-like, oval, grooved design of the cooling body lamellae 20c of cooling body 3, in arrangement and width, as well as height design, is also visible. Also, both slits 30, for the support sheets (not shown), as well as the punched holes 29 of the tongue shaped spacer 32, are visible, from each of which a narrow base body base, or lower connection base, can be seen.

Fig. 10 shows a front view of a base body 2 similar to Fig. 9, in which, however, the base body sides are missing and the straight base body floor section 7 is designed as a plate with cooling ribs.

Fig. 11 shows an additional embodiment of base body 2 in front view with the grooves 26 for both heat pipes 5, 6 as well as the arrangements and direction of the base body lamellae 10. The essential difference is the thickness of the base body floor section 7, similar to the cooling element 1 in Fig. 1. However, here the heat pipes do not run in lengthwise holes, but instead in 15 U-shaped grooves open to the contact surface. Naturally, this embodiment with the thick base body floor section 7 can also be implemented without base body side 8, therefore, primarily as designed as a plate with a smooth bottom side, similar to the embodiment of Fig. 10.

Fig. 12 depicts a lamella 20 of cooling element 35, whose cloud-like, oval design, which is, in the broadest sense, evocative of a peanut with its top and bottom longitudinal, symmetric pinches, or notches. The arrangement of both slits 30 for support sheets, holes 38 in the lamella for guiding the heat pipes, as well as the punched out holes 39, can be seen. This concerns a very simple and cost-effective producible punched part which can be quickly and simply produced in the quantity desired. Furthermore, it should be noted that the holes 38 are spaced from one another, and to the upper and lower edges, so that a ratio of lower height to upper height of preferably approx. 2: 3.5 exists, and sufficiently lower free space width remains to ensure good air circulation despite the great height of the lamellae, as is particularly evident in Fig. 9.

Fig. 13 shows, in side view, the lamella 20c from Fig. 12 and the shape of the spacer 36 bent vertically out of it.

Fig. 14 presents a cooling element 25, 35 implemented in a LED module 12 on a lamp case 39. The longitudinally extending support sheets 36 are fastened on the sides of the body 2 by screws 41. The support sheets 36 have a rising angle of, for example 3° to 5° on the upper edge. This way, on one hand the lamellae package is supported longitudinally, so that the relatively soft and therefore malleable heat pipes 5 and 6 are protected longitudinally and horizontally. On the other hand, because of the angle increase to the back of the lamellae, a positive angle of "warm side" to "cold side" ensues after installation. This allows the reflux of the condensate to be supported by gravitational force and thereby the degree of effectiveness of the device is measurably improved.

The power connection 41 of the LED module 12 points backwards, whereby a cable 42 leads to a connection box 43 of a LED generator 44. Through the slight angulation of the lamellae package some more lower space results, so that the corresponding connections can be formed to the back more easily and without disturbance.

Fig. 15 to 17 show different configuration possibilities for the cooling elements 1, 25, 35, especially of the base body 2 versus the right-angled LED module. Through their arrangement of the power connection to the front in direction of the lamellae package, various special problems or challenges arise...

Fig. 15 shows a configuration similar to Fig. 14, in which a base body 2 rests on a quadratic LED module 12 of the same length. The hot upper zone 16 of the LED module 12 as well as its light zone 24 is in the middle of the LED module 12 and the base body 2. The power connection 40 points to the back of the lamellae of the cooling element 3. Because for this embodiment there is a relatively large distance between the back of the base body 2 and the front lamella of the cooling element 3, there is no space problem and the connection can be handled easily.

In Fig. 16, the configuration of the base body 2 of a device according to the invention, on a relatively long LED module can be seen; the electrical connection faces the back, whereby the hot zone 16 and the light zone 24 are located in the front half of the LED module. Accordingly, the base body 2 is also located on this front side and is aligned with its front side. The inner distance between the base body and the cooling body is so large, that there is sufficient room for the power connection 40 to the first

lamellae of the cooling body. The additional space is achieved through the total lamellae package of the cooling body 3 on the heat pipes being pushed further out. In addition, the heat pipes with the crimp ends are not jutting out to the right, but rather the crimp-ends (that represent a missing length) are situated in the notches of the base body 2, so that the lamellae package can be configured all the way outside on the smooth end 34 of the heat pipes. This allows 10 mm of distance to be gained when the tubes and the cooling body lengths are the same.

Fig. 17 shows the cooling element from Fig. 15, 16 with a rotated, long LED module whose power connection 40 is easily accessible from the front. Because the hot zone 16 is located on the side facing the cooling-frame lamellae, the base body 2 is located on this back zone of the LED module so that both back sides of the base body and the LED module are vertically aligned.

Fig. 18 shows a further embodiment for the cooling element for a heat source for locations where the height of the cooling element is unimportant, but where space must be saved horizontally. These designs are particularly suitable for hanging lights and similar. Here, the heat pipes (for these designs 2 heat pipes are presented) are bent in one level into U-shape so that the cooling body is located above the LED housing. The embodiment is shown in cross-section in Fig. 19 for better understanding.

Fig. 20 to 23 show further views of the embodiment with the cooling bodies above the LED. It is obvious how the heat pipes lead from the base body 2 into the cooling body 3 and how the heat pipes 6,5 feed into notches in the base body 2. The base body 2 is an extruded profile in this design and is easy to manufacture.

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Fig. 24 shows a preferred embodiment of cooling a lamella 20, which enables a particularly strong connection of the cooling body lamellae 20 to the heat pipes. To this end, in addition to the form or press fit between the lamellae 20 and the heat pipe, a deepened peripheral surface area of the entry opening for the heat pipe is provided in the opening 38 area; for example, by deep drawing with a form stamp after cutting the lamellae. The ring-shaped groove 45 formed between heatpipe and lamella opening serves to take in the connection between material helping the connection between the heat pipe and the lamellae – e.g. adhesives, soldering material, or filling materials. Heat-conductive adhesives which are known to the expert in the field are preferred.

Especially suited are adhesives including admixed heat-conductive metals. Through the adhesive layer ring around the heat pipe made in this way, the mechanical and thermal connection of the heat pipe on the lamellae 20 is improved.

Fig. 25 exemplifies a further embodiment of a cooling element 3 with a relatively thick base body floor section, short sidewalls and reception openings 6 for heat pipes in the base body section from different views.

Fig. 26 presents a further embodiment in accordance with the invention for small light sources, such as a spotlight light sources. Spotlight light sources are light sources with a small outer circumference that project light in a targeted fashion. They can often be pivoted in order to follow changing objects, which need to be illuminated in order to highlight them optically. These spotlights have a slim construction above the light source. In this example, a special cooling lamellae body 3 with a small diameter is shown for a spotlight. The cooling body lamellae 20 are bent in a wing-like fashion, so that they have a small diameter when seen from below and so that behind the actual light source, the LED, they are less optically apparent. It is important to maintain appropriate distances between the lamellae – secured by the spacer – in order to make air circulation possible. The bent lamellae wings are currently preferable attached at an angle of 30 to 60 degrees to the heat pipe, preferably between 40 and 50 degrees, in order to make optimal air circulation possible for cooling.

In Fig. 27 views from above and below the cooling lamellae frame 2 of the figure 26 are shown in the direction of the central opening. In the view from above (fig. 27a), the bent lamellae 50 of the base body are clearly visible; at the same time, in the view from below (fig. 27b), the fastening screws for a LED and the bent lamellae 50 can be seen, as well as the minimal optical view of the body.

In Fig. 28 an example of the spotlight base frame 2 for the design of fig. 27 is shown. The fastening above the indentation provided in the lamellae for the heat pipes of the cool lamellae body in Fig. 26 and Fig. 27 is presented and the outline is based on a circular LED. In Fig. 29 detailed views of a spotlight cooling lamella 50 are presented. The central opening for air circulation, the bent spacers, the openings for the heat pipes are clearly visible. A detailed view of the spacer, which here is formed into a support 32a, as well as a heat pipe receiving area with a groove 45 is shown.

Even though the invention was explained in detail with a preferred embodiment, it is in no way limited to this design but is only determined by the protection of the accompanying claims.

Reference List

1. Cooling element, first design.
2. Base body
3. Cooling body
4. Heat pipe
5. Heat pipe
6. Heat pipe
7. Floor section
8. Base body side
9. Hole
10. Lamellae (base body-)
11. Fastening hole, side
12. LED-Module (heat source)
13. Metal housing part
14. Plastic housing part
15. Floor section – contact surface
16. Hot zone (hot-spot)
17. Metal housing part – base body side
18. Fastening hole
19. Threaded hole
20. Lamellae (cooling body)
21. Floor section contact surface
22. Base body contact surface
24. Light zone (-floor)
25. Cooling element, second design
26. Groove
27. Arch
28. Side lamellae
29. Punched hole

- 30. Slit
- 32. Spacer
- 33. Crimp-End of 4, 5
- 34. Smooth end of 4, 5
- 35. Cooling element, third design
- 36. Support sheet
- 37. Support sheet
- 38. Hole
- 39. Lamp housing
- 40. Power connection
- 41. Fastening screw
- 42. Cable
- 43. Connection box
- 44. LED generator
- a Angle

Claims

1. A cooling element for cooling a heat source of an LED module, the cooling element comprising:

- a base body, having a first and a second surface, the first surface of the base body configured to be in thermal and mechanical contact with the heat source and the second surface of the base body having lamellae formed integrally therewith,
- at least one heat pipe,
- at least one cooling body comprising cooling body lamellae,
- wherein the first end of the at least one heat pipe is received within the at least one cooling body and the other end of the at least one heat pipe is received within the entire length of the base body in a form-fit and thermally conducting manner,
- the heat pipes being arranged to run parallel to each other, spaced from another, and parallel to a contact surface between the cooling body and the heat source when the cooling body and the heat source are in thermal and mechanical contact,
- characterized in that shapes of the cooling body lamellae, includes arch shaped, wing shaped, oval shaped, oval shaped with notches in a cloud-like fashion, and/or round shaped; and
- wherein the cooling body lamellae may be bent in order to ensure a smaller visible surface of the cooling body.

2. Cooling element according to claim 1, characterized in that at least two heat pipes are provided that, outside of the base body lead away from each other in the style

of a pitchfork and thereafter run parallel to one another with a larger distance between them, whereby the cooling body is formed by the outer section of the heat pipes having greater distance with cooling body lamellae.

- 5 3. Cooling element according to claim 1, characterized in that three thermoconducting pipes are provided, whereby a straight central heat pipe runs in the middle between two outer, pitchfork-shaped, heat pipes that are bent outwardly in the style of a three-pronged fork, whereby the cooling body is formed through the part with parallel section areas of the heat pipes having cooling body lamellae.

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4. Cooling element according to claim 1, characterized in that the heat pipes are received in holes along the whole length of the base body or are set in a groove that is open to the contact surface between the base body and the heat source, so that there is good contact between the heat pipes and the contact surface of the heat source.

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5. Cooling element according to claim 1, characterized in that the base body is a plate with exterior base body lamellae extending from the contact surface.

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6. Cooling element according to claim 5, characterized in that the plate of the base body is thinner than the diameter of the heat pipe and is arched around the heat pipe through grooves.

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7. Cooling element according to claim 4, characterized in that the base body with base body section and base body sides at least partially wraps around the heat source in a U-form, whereby the base body sides offer support.

8. Cooling element according to claim 4, characterized in that the base body lamellae run perpendicular or parallel to the base body.

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9. Cooling element according to the claims 6 or 7, characterized in that on the base body sides axially aligned base body lamellae are provided in addition to the lamellae extending upwards from the floor section as side lamellae.

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10. Cooling element according to at least one of the previous claims, characterized in that in the base body floor section thread holes are provided to fasten to the heat source that correspond with the holes in the heat source, whereby

optionally additional fastening holes are provided in the base body – mirrored to the first – so that turning the entire cooling element by 180 degrees to the heating source is possible.

5 11. Cooling element according to at least one of the preceding claims, characterized in that the bent cooling body lamellae are attached at an angle of 30 to 60 degrees to the heat pipe, preferably between 40 to 50 degrees in order to make optimal air circulation possible.

10 12. Cooling element according to claim 1, characterized in that the cooling lamellae of the cooling body in press or shrink fit on the heat pipes at a predetermined distance from one another, whereby spacers are provided between the cooling lamellae.

15 13. Cooling element according to claim 10, characterized in that the spacers are punched out from the lamellae sheet tongues, bent away from the lamella main level.

20 14. Cooling element according to at least one of the previous claims, characterized in that on the lower side of the cooling body lamellae, at least one slit running from top to bottom or leading inside is provided to take accommodate vertical support sheets.

15. Cooling element according to claim 1, characterized in that the cooling element is configured above the base body, whereby the heat pipes on the cooling element connected to the thermal conducting tubes are bent upwards in a U-shape.

25 16. Cooling element according to one of the previous claims, characterized in that the openings for the heat pipes of the cooling body cooling lamellae comprise a step-like deep drawn area in their circumference, so that after passing through the heat pipe, adhesives can collect in the groove formed between the heat pipe and the cooling body lamella.

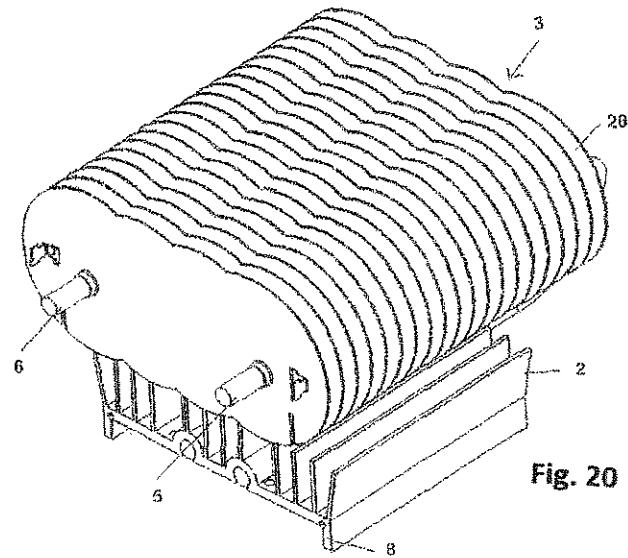


Fig. 20

(57) Abstract: The invention relates to a cooling element for a heat source, especially LED modules fitted with many components, said device comprising a base body (2) that is in thermal and mechanical contact with the body of the heat source (12), at least one heat pipe (4, 5, 6) having an end section that is inserted into the base body (2) in a form-fitting and thermoconducting manner, and at least one cooling body (3) comprising cooling body lamellae (20) on the other end section of the heat pipe. The invention is characterised in that the heat pipes (4, 5, 6) extend over the entire length of the base body (2) such that a hot zone (16, 34) of the heat source (12) lies on a contact surface (21) of the base body (2), the heat pipes extend parallel to each other and parallel to the contact surface of the heat source with the hottest zone (16, 34), and the base body (2) is fixed to the body of the heat source (12), base body lamellae (10) being provided on the outer side of the base body (2), formed as a single component thereon or connected thereto.

(57) Abstract:

[Continued on next page]