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(54) COOLING DEVICE AND COOLING METHOD FOR LIGHTING MODULES

(57) The present invention describes a cooling device (100) for lighting modules, in particular LED lighting modules. Said cooling device (100) at least comprises a fluid jet generating unit (104), wherein the fluid jet generating unit (104) comprises a housing (202) and a fluid jet generating means (209) arranged in said housing (202) for generating fluid jets, wherein the housing (202) comprises at least two separated outlets (220, 222) for outputting said fluid jets, wherein the outlets (220, 222) are fluidly connected to said fluid jet generating means (209), and a heat-dissipating unit (102) attached to the housing (104) of said fluid jet generating unit (104), wherein the heat-dissipating unit (102) comprises at least one heat-dissipating element (103) having an outer surface (220) and an inner surface (224), wherein the heat-dissipating element (103) comprises at least one fluid communication element (108), in particular a plurality of holes or slits, for establishing a fluid communication between fluid adjacent the inner surface (224) and fluid adjacent the outer surface (220) for eliminating pressure differences between fluid adjacent the inner surface (224) and fluid adjacent the outer surface (220), wherein a first one of said outlets (222) is located adjacent the inner surface (224) of the heat-dissipating element and a second one of said outlets (218) is located adjacent the outer surface (220) of said heat-dissipating element (103) for causing pressure differences between fluid adjacent the inner surface (224) and fluid adjacent the outer surface (220).

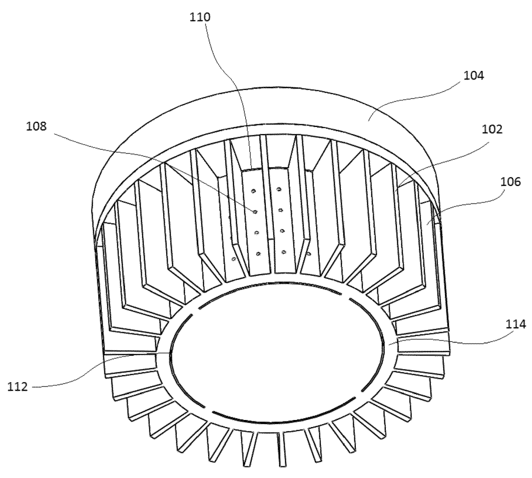

Fig. 1

Description

Field of the Invention

[0001] Effective thermal management is one of the biggest engineering problems in relation to LED lighting products. The life and performance of LED chips decreases rapidly at increased junction temperatures. For this reason effective thermal management in LED lighting is a crucial aspect of their productivity and reliability. This invention relates to the cooling of high-brightness LED lights using an active cooling method. The invention consists of a new heat sink design and a synthetic jet mechanism that has been integrated into this.

Background of the Invention

[0002] LED lighting products are generally cooled in one of two ways, active or passive cooling. In the passive method, finned heat sinks manufactured from metals with high thermal conductivity are attached to the LED chips which are the source of the generated heat. By enlarging the heat transfer area in this way and increasing heat transfer, the temperature of the LED junctions is reduced. This method is the most commonly used one, since it is stable and doesn't consume any energy. However, where passive cooling is used in high power LED lighting, as the dimensions of the heat sinks increase, there is a parallel, adverse increase in product weight. Consequently, increasing dimensions and weight diminish the functionality of these products which is a disadvantage. However, using an active method, air flow is provided to the LED by a fan or blower device that operates using an additional external energy source and cooling is achieved by forced convection. Since the active method utilizes additional energy, the energy efficiency of the LED lighting is reduced. In practice, these two methods are generally used in combination. Documents US2014319239A1, US2007139938A1 and US2014254093A1 describe such disadvantageous subject matters.

[0003] US2014319239A1 discloses a device which includes a thermally conductive base having first and second major surfaces, a die attached to said first major surface of said base, a heat pipe having a first end which is attached to said second major surface of said base, a plurality of heat fins attached to a second end of said heat pipe, and at least one synthetic jet ejector disposed between said base and said plurality of heat fins.

[0004] US2007139938A1 discloses a lamp system comprising a housing, a plurality of LEDs, a heat sink connected to the housing and in thermal communication with the plurality of LEDs, a flexible blade connected to the housing and having a free end spaced from a surface of the heat sink, the blade being moveable to generate a fluid current to cool the heat sink, an electronic actuator operatively associated with the blade for providing a force to oscillate the blade and a circuitry connected to the LEDs and the electronic actuator, the circuitry configured to receive source power from a source to deliver a first power to the electronic actuator and a second power to the plurality of LEDs.

[0005] US2014254093A1 discloses a further cooling system. This cooling system also has the drawback that the resulting dimensions and weight of the cooling device are high.

Object of the Invention

[0006] The main object of the present invention is to provide a cooling device for light emitting units, in particular high power LED lighting modules, that overcome the drawbacks of existing cooling devices.

[0007] Another aim of the present invention is to provide a cooling device that has smaller dimensions and less weight compared to the existing cooling devices.

[0008] Another aim of the present invention is to provide a cooling device that has is more efficient in terms of energy consumption compared to the existing cooling devices.

Description of the Invention

[0009] The object of the present invention is solved by a cooling device for lighting modules, in particular LED lighting modules, according to claim 1. Said cooling device at least comprises a fluid jet generating unit, wherein the fluid jet generating unit comprises a housing and a fluid jet generating means arranged in said housing for generating fluid jets, wherein the housing comprises at least two separated outlets for outputting said fluid jets, wherein the outlets are fluidly connected to said fluid jet generating means. The cooling device further comprises a heat-dissipating unit attached to the housing of said fluid jet generating unit, wherein the heat-dissipating unit comprises at least one heat-dissipating element having an outer surface and an inner surface. According to the invention the heat-dissipating element comprises at least one fluid communication element, in particular a plurality of holes or slits, for establishing a fluid communication between fluid adjacent the inner surface and fluid adjacent the outer surface for eliminating pressure differences between fluid adjacent the inner surface and fluid adjacent the outer surface, and a first one of said outlets is located adjacent the inner surface of the heat-dissipating element and a second one of said outlets is located adjacent the outer surface of said heat-dissipating element for causing pressure differences between fluid adjacent the inner surface and fluid adjacent the outer surface. The term fluid comprises all gases, for example like inert gases or mixtures of gases, and/or liquids, wherein air is a preferred fluid.

[0010] Thus, a new active cooling device respectively a cooling system for high power LED lighting products has been developed. The cooling system comprises a heat-dissipating unit respectively a finned aluminium heat sink, communication elements respectively holes/slits opened in the heat sink and a fluid jet generating unit respectively a synthetic jet mechanism. This synthetic jet mechanism preferably operates using the piezo electric effect. In particular, air flow is supplied simultaneously to both the inner and the outer surfaces of the heat-dissipating unit from the fluid jet generating unit. One preferred feature of the design is that the different air velocities at the inner and outer surfaces of the heat sink create a pressure difference between the fluid adjacent to the surfaces. Under the effect of this pressure difference, the air flow adjacent to the outer surface is preferably sucked towards the inner surface through the holes/slits on the heat sink. Thus the thermal boundary layer on the outer surface where the fins are located becomes thinner and a significant improvement in heat transfer is achieved.

[0011] Advantageous embodiments may be configured according to any claim and/or the following specification parts.

[0012] According to a preferred embodiment of the present invention the fluid jet generating means comprises at least two actuators, wherein a first one of said actuators is connected to the first one of said outlets and a second one of said actuators is connected to the second one of said outlets. This solution is beneficial since at least two different fluid jets can be generated. Such fluid jets can be generated independently or dependently from each other just as necessary. Due to the design of the invented cooling device the fluid jets can be generated in such a manner that pressure differences are generated which cause an increase in fluid flow on the outer surface and therefore an increase in cooling efficiency.

[0013] According to a further preferred embodiment of the present invention at least one of said actuators comprises a flexible member, in particular a diaphragm, wherein the flexible member is coupled to a piezo electric element for deflecting said flexible member back and forth. Thus, the fluid jet generating means preferably comprises or consists of two flexible members, in particular diaphragms, preferably made of plastic or metal, in particular brass, two piezo electric materials or elements affixed to these flexible members and a housing for these. The housing contains two fluid chambers, in particular air chambers, and two fluid vents, in particular air vents. When the piezo electric elements are stimulated with an electric signal varying over time, vibration is generated in the flexible members. As a result of this movement, the volume of the fluid chambers in the housing changes and simultaneously fluid flow from the outlet channels is achieved.

[0014] According to a further preferred embodiment of the present invention a fluid chamber is provided between each of the flexible members and the respective outlet, wherein each fluid chamber provides a fluid connection between one of the actuators and the respective outlet wherein each of the flexible members has a circular shape and extends in an undeflected state in a plane, wherein the fluid connection extends in an inclined manner, in particular orthogonal, to said plane..

[0015] According to a further preferred embodiment of the present invention the heat-dissipating element comprises an at least partially hollow and tube-like main body, wherein the tube-like main body extends from the fluid jet generation unit in its length direction away from the fluid jet generation unit, wherein the inner wall of the heat-dissipating main body has the inner surface and the outer wall of the heat-dissipating main body has at least partially the outer surface and fins are located on the outside surface of said tube-like main body or build as part of the main body and therefore providing at least partially the outside surface of said tube-like main body, wherein the fins are at least partially and preferred mainly orientated in the length direction of the main body. Wherein the term tube-like main body preferably defines an at least partially hollow body and preferably a hollow body having a main clearance hole. A particular feature of this design is that air flow from one of the outlet channels goes to the inner surface of the heat sink, while the other goes to the outer surface where the fins or further heat-dissipating elements are located.

[0016] According to a further preferred embodiment of the present invention the main body consists of a material or an alloy or a material combination at least having a heat conductivity greater than 14 W/mK and preferably greater than 40 W/mK or 50 W/mK or 60 W/mK or 70 W/mK or 80 W/mK or 100 W/mK or 130 W/mK or 160 W/mK or 170 W/mK or 200 W/mK or 230 W/mK or 270 W/mK or 300 W/mK or 400 W/mK or 425 W/mK, wherein the material, alloy or material combination preferably comprises at least one or two or more than two of the materials: steel, iron, nickel, tungsten, zinc, brass, aluminium, gold, silver or copper. This solution is beneficial since the active cooling due to the fluid jets is supported by passive cooling properties of the material of the heat-dissipation element.

[0017] According to a further preferred embodiment of the present invention a control unit for actuating the piezo electric elements is provided, wherein the frequency of each piezo electric element is individually adjustable by providing respective electric signals, wherein each piezo electric element is actuated with a frequency of at least 2 Hz and prefereably with a frequency of at least 10 Hz and most preferably with a frequency of at least 50 Hz. The actuators respectively the piezo electric elements can be actuated at a frequency between 2 and 500 Hz, preferably at a frequency between 10 and 400 Hz or most preferred between 20 and 200 Hz, like between 50 and 150 Hz or between 80 and 120 Hz. Alternatively the frequency can be higher than 2 Hz, in particular higher than 20, 35, 50, 80, 120, 250, 200, 400 or 500 Hz. Due to differences in the electric signals that stimulate the piezo electric materials or elements and/or in the size of the fluid chambers in the housing and/or in the flexible members dimensions and/or in the profiles of the fluid outlet channels, the velocity of the air flow to the outer surface of the heat-dissipating unit is lower than that to the inner surface. This creates a pressure difference between the fluid adjacent to the two surfaces. Because of this pressure difference and with the help of the communication elements, in particular the holes/slits on the heat-dissipating unit respectively the heat sink, fluid respectively air is sucked from the outer surface to the inner surface and the thermal boundary layer on the outer surface, which has a larger surface area, becomes thinner, resulting in a significant improvement in the total cooling effect.

[0018] The present invention is further directed to a lighting system. Said lighting system comprises a light source and a cooling device according to any of the before mentioned claims, wherein the cooling device is coupled with the light source in such a manner that the cooling device cools the light source during operation respectively removes heat from the light source.

[0019] The present invention is also directed to a method for cooling a light source. Said method comprises at least the steps: Providing a device or system according to any of the before mentioned claims; Generating fluid jets with the fluid jet generating unit and outputting the fluid jets through the outlets, wherein the fluid jets outputted through the first outlet differ in at least one parameter from the fluid jets outputted through the second outlet, wherein a pressure difference is caused by the differing fluid jets in such a manner that fluid is sucked from the outside through at least one communication element to the inside of the heat-dissipating element.

[0020] This invention therefore sets forth a process that applies the passive and active method together for use in lighting products, in particularly high power LED lighting products. For this purpose, a synthetic jet mechanism that operates with piezoelectric activation was designed for the active section. For the passive section a heat sink that thins the thermal boundary layer on the fin side and is more effective that its counterparts was designed. In summary, a new cooler was designed that combines the active and passive methods and consumes less energy and has smaller dimensions than conventional cooling systems.

[0021] According to a further preferred embodiment of the present invention the fluid jet differences are caused by differences in the electric signals that stimulate the individual piezo electric element and/or differences in the size of the individual fluid chambers and/or differences in the sizes of the individual flexible members and/or differences in the profiles of the individual outlets.

Brief Description of the Drawings

[0022]

Figure 1. Finned heat sink and synthetic jet cooling system

Figure 2. Cross sectional view of the cooling system, showing inner features of the finned heat sink and the synthetic jet cooling system

Figure 3. Drawing of the air channels included in the cover of the synthetic jet mechanism as already introduced in fig. 1 and 2.

Figure 4. Cross sectional view of the synthetic jet mechanism and the fined heat sink during air discharge.

Figure 5. Cross sectional view of the synthetic jet mechanism and the fined heat sink during air suction.

Figure 6. Picture of the cooling system according to any of fig. 1-5 in a disassembled arrangement.

Figure 7 An arrangement according to Fig. 1, wherein a light source is arranged at the cooling device.

Figure 8 An further arrangement according to Fig. 1, wherein multiple light sources are arranged at the cooling device.

Detailed Description of the Invention

[0023] In this section the invention is explained in detail. In figure 1 the cooling system 100 design is shown. The cooling system 100 consists of a heat dissipating unit 102 that can alternatively be named a heat sink 102 and a synthetic jet mechanism 104, which can be named alternatively a fluid jet generating unit 104.

[0024] The heat sink 102 contains fins 106 in order to increase the surface area and holes/slots 108 to absorb air. The synthetic jet mechanism 104 contains air outlet openings 110 and the heat sink 102 contains air vents 112. The fins 106 can be alternatively named as further heat-dissipating elements, wherein said heat dissipating elements 106 or fins are attached to a tube like main body 300 (cf. fig. 6). According to a preferred embodiment a plurality of fins 106 is provided, in particular more than 10 fins or more than 15 fins or more than 20 fins. The fins 106 preferably separate rows of communication elements 108 respectively holes or slits, wherein said communication elements 108 are part of the tube like main body 300 or are manufactured inside said tube like main body 300. The communication elements 108 are preferably shaped as cylindrical holes, wherein alternative shapes are also possible. Preferably comprises each row of communication elements 108 at least two holes and/or slits and preferably at least three holes and/or slits or at least four holes and/or slits or at least five holes and/or slits or at least ten holes and/or slits.

[0025] The LED chip which generates the heat is connected to the lower surface 114 of the heat sink 102.

[0026] Figure 2 shows a cross section of the cooling system 100. The synthetic jet mechanism 104 in the cooling system 100 includes a top cover 202 and a bottom cover 204. Two diaphragms 206 made of brass have been placed inside the mechanism 104. Piezo ceramic disks 208 have been affixed to the diaphragms. Thus an upper air chamber 210 is formed between the diaphragms 206 and the top cover 202. The upper air chamber 210 can be alternatively named as second fluid chamber. Similarly a lower air chamber 212 is formed between the diaphragms 206 and the bottom cover 204. Said lower air chamber 212 can be alternatively named as first fluid chamber. The synthetic jet mechanism 104 has an upper air channel 214 connected to the upper air chamber 210 respectively a second fluid channel and a lower air channel 216 respectively a first fluid channel connected to the lower air chamber 212. The upper air channel 214 provides air flow to the outer surface 220 of the heat sink 102 with the help of the upper air vents 218 in the bottom cover 204. The upper air vents 218 can be alternatively named second one of the outlets and the lower air vents can be alternatively named first one of the outlets.

[0027] The lower air channel 216 provides air flow to the inner surface 224 of the heat sink 102 with the help of the lower air vents 222 in the bottom cover 204. The air flow flowing from the inner surface 224 is discharged through the air vents 112 on the lower surface 114 of the heat sink 102. The air vents 112 can be alternatively named outlets and are preferably designed as slits. An at least partially circumferential shape of the air vents 112 is preferred, wherein the air vents 112 can be shaped as a plurality of holes functionally connected to each other.

[0028] Figure 3 shows the bottom cover 204 of the synthetic jet mechanism 104. An upper air vent 218 and lower air vent 222 has been included in the lower surface 226 of the cover 204.

[0029] Figure 4 shows the status when negative electrical tension is applied to the piezo ceramic disks 208 in the synthetic jet mechanism 104. As a result of the electrical tension applied to the piezo disks 208 the diaphragms 206 move outwards. Thus the volume of air in the upper air chamber 210 and the lower air chamber 212 is reduced and it is forced to flow from the upper air channel 214 and the lower air channel 216. An air flow 228 from the upper air vent 218 in the bottom cover 204 of the mechanism 104 to the outer surface 220 of the heat sink 102 occurs. Another air flow 230 occurs from the lower air vent 222 in the bottom cover 204 of the mechanism 104 to the inner surface 224 of the heat sink 102. Due to differences in the electric signals that stimulate the piezoelectric disks 208 and/or in the size of the air chambers 210-212 in the mechanism 104 and/or in diaphragm 206 dimensions and/or in the profiles of the air outlet vents 218-222, air flow 228 velocity at the outer surface 220 is lower than air flow 230 velocity at the inner surface 224. Thus a pressure difference between the outer surface 220 and the inner surface 224 is created and a portion 232 of the outer air flow 228 is sucked through the holes/slits 108 on the heat sink 102 towards the inner surface 224. In this way, momentum and the thermal boundary layer on the outer surface 220 where the fins 106 are located thins out and heat transfer is improved.

[0030] Figure 5 shows the status when positive electrical tension is applied to the piezo ceramic disks 208 in the synthetic jet mechanism 104. As a result of the electrical tension applied to the piezo disks 208 the diaphragms 206 move inwards. In this way air volume in the upper air chamber 210 and the lower air chamber 212 is increased, and an amount of air 234 is sucked inwards through the upper air vent 218 in the bottom cover 204 of the mechanism 104. Since the frequency of the electric current applied is high, the air flows 228-230 on the outer and inner surfaces 220-224 which are very close to the air vents 218-222 are not affected by this suction and in effect a continuous air flow is achieved. The air flow 230 to the inner surface 224 is discharged through the air vents 112 on the lower surface 114 of the heat sink 102. The lower surface 114 can be alternatively named coupling surface since said surface is preferably coupled to a light source, in particular a LED light source. The heat of said light source is preferably conducted through the tube like main body 300 to the fins 106.

[0031] Figure 6 is a picture of the disassembled cooling system 100. The system 100 consists of a heat sink 102 and a synthetic jet mechanism 104. The synthetic jet mechanism 104 consists of a top cover 202 respectively a housing, a bottom cover 204 and two diaphragms 206. Piezo ceramic disks 208 are fixed to the diaphragms 206 respectively a flexible member. The diaphragms 206 are affixed to the niches 302 found inside the bottom cover 204. The heat sink 102 has fins 106 and holes/slits 108 that allow air absorption.

[0032] Fig. 7 shows a light source 116a coupled to the cooling device 100 of the present invention. The light source 116a is preferably a LED light source. The light source 116a preferably has a shape similar to a disc or a circular plate. The light source 116a is attached to the lower surface 114 of the cooling device 100. Preferably air vents 112 are surrounding light source 116a in circumferential direction. Light source 116a emits light on one side and is coupled with the lower surface 114 of the cooling device 100 with the other side. Due to the vents 112 air ejected by the upper and lower air chambers 210, 212 is ejected from the tube like main body 300.

[0033] The light source 116a emits heat which is conducted through the material of lower plate 114 to the heat dissipating element 103. Due to the inventive air jet mechanism of the present cooling device 100 heat is in particular dissipated from the tube like main body 300. Since the jet mechanism of the present cooling device 100 increases air flow on the inner and outer surface 224, 220 of the tube like main body 300 the cooling effect is significantly increased compared to state of the art cooling devices.

[0034] Fig. 8 shows an arrangement similar to the arrangement of Fig. 7, but instead of just one light source 116a a plurality of light sources 116b is arranged on the lower surface 114 of the cooling device 100. The plurality of light sources 116b preferably comprises at least two light sources 116b or at least three light sources 116b or at least four light sources 116b or at least eight light sources 116b. Preferaby at least one of said light sources 116 or the majority of said light sources 116b or all of said light sources 116 are LED light sources. It is also possible that the light sources 116b emit different light respectively light of different wavelengths or colors. Preferably at least one light source 116b emits green light and preferably at least one further light source emits red light and preferably at least one further light source emits blue light.

[0035] Thus, the present invention concerns a cooling device 100 for lighting modules, in particular LED lighting modules. Said cooling device 100 at least comprises a fluid jet generating unit 104, wherein the fluid jet generating unit 104 comprises a housing 202 and a fluid jet generating means 209 arranged in said housing 202 for generating fluid jets, wherein the housing 202 comprises at least two separated outlets 220, 222 for outputting said fluid jets, wherein the outlets 220, 222 are fluidly connected to said fluid jet generating means 209, and a heat-dissipating unit 102 attached to the housing 104 of said fluid jet generating unit 104, wherein the heat-dissipating unit 102 comprises at least one heat-dissipating element 103 having an outer surface 220 and an inner surface 224, wherein the heat-dissipating element 103 comprises at least one fluid communication element 108, in particular a plurality of holes or slits, for establishing a fluid communication between fluid adjacent the inner surface 224 and fluid adjacent the outer surface 220 for eliminating pressure differences between fluid adjacent the inner surface 224 and fluid adjacent the outer surface 220, wherein a first one of said outlets 222 is located adjacent the inner surface 224 of the heat-dissipating element and a second one of said outlets 218 is located adjacent the outer surface 220 of said heat-dissipating element 103 for causing pressure differences between fluid adjacent the inner surface 224 and fluid adjacent the outer surface 220.

List of reference numbers

100	Cooling device or cooling system	212	lower air chamber or first fluid chamber
102	heat-dissipating unit or heat sink		
103	heat-dissipating element	214	upper air channel or second fluid channel
104	fluid jet generating unit or synthetic jet mechanism	216	lower air channel or first fluid channel
106	fins or further heat-dissipating element	218	upper air vents or second one of the outlets
108	communication elements or holes or slits	220	outer surface
110	outlet opening	222	lower air vents or first one of the outlets
112	air vent or outlets	224	inner surface
114	lower surface or coupling surface	226	lower surface of cover
116a	light source	228	air flow
116b	multiple light sources	230	another air flow
202	top cover or housing	232	portion of the outer air flow
204	bottom cover	234	amount of air
206	flexible member or diaphragm	240	first actuator
208	piezo electric element	242	second actuator
209	fluid jet generation means	300	tube like main body
210	upper air chamber or second fluid chamber	302	niches

Claims

1. Cooling device (100) for lighting modules, in particular LED lighting modules,
at least comprising
a fluid jet generating unit (104)
wherein the fluid jet generating unit (104) comprises a housing (202) and
a fluid jet generating means (209) arranged in said housing (202) for generating fluid jets,
wherein the housing (202) comprises at least two separated outlets (220, 222) for outputting said fluid jets,
wherein the outlets (220, 222) are fluidly connected to said fluid jet generating means (209),
and
a heat-dissipating unit (102) attached to the housing (104) of said fluid jet generating unit (104),
wherein the heat-dissipating unit (102) comprises at least one heat-dissipating element (103) having an outer surface (220) and an inner surface (224),
wherein the heat-dissipating element (103) comprises at least one fluid communication element (108), in particular

a plurality of holes or slits, for establishing a fluid communication between fluid adjacent the inner surface (224) and fluid adjacent the outer surface (220) for eliminating pressure differences between fluid adjacent the inner surface (224) and fluid adjacent the outer surface (220),
wherein a first one of said outlets (222) is located adjacent the inner surface (224) of the heat-dissipating element and a second one of said outlets (218) is located adjacent the outer surface (220) of said heat-dissipating element (103) for causing pressure differences between fluid adjacent the inner surface (224) and fluid adjacent the outer surface (220).

2. Cooling device according to claim 1,
characterized in that
the fluid jet generating means (209) comprises at least two actuators (240, 242),
wherein a first one of said actuators (240) is connected to the first one of said outlets (222) and a second one of said actuators (242) is connected to the second one of said outlets (218).

3. Cooling device according to claim 2,
characterized in that
at least one of said actuators (240, 242) comprises a flexible member (206), in particular a diaphragm,
wherein the flexible member (206) is coupled to a piezo electric element (208) for deflecting said flexible member (206) back and forth.

4. Cooling device according to claim 3,
characterized in that
a fluid chamber (210, 212) is provided between each of the flexible members (206) and the respective outlet (218, 222),
wherein each fluid chamber (210, 212) provides a fluid connection between one of the actuators (240, 242) and the respective outlet (218, 222),
wherein each of the flexible members (206) has a circular shape and extends in an undeflected state in a plane,
wherein the fluid connection extends in an inclined manner, in particular orthogonal, to said plane.

5. Cooling device according to at least one of the claims 1 to 4,
characterized in that
the heat-dissipating element (103) comprises an at least partially hollow and tube-like main body,
wherein the tube-like main body extends from the fluid jet generation unit (104) in its length direction away from the fluid jet generation unit (104),
wherein the inner wall of the heat-dissipating main body has the inner surface (224) and the outer wall of the heat-dissipating main body has at least partially the outer surface (220)
and
wherein fins (106) are located on the outside surface (220) of said tube-like main body,
wherein the fins (106) are at least partially and preferred mainly orientated in the length direction of the main body.

6. Cooling device according to claim 5,
characterized in that
the main body consists of a material or an alloy or a material combination at least having a heat conductivity greater than 14 W/mK and preferably greater than 40 W/mK or 50 W/mK or 60 W/mK or 70 W/mK or 80 W/mK or 100 W/mK or 130 W/mK or 160 W/mK or 170 W/mK or 200 W/mK or 230 W/mK or 270 W/mK or 300 W/mK or 400 W/mK or 425 W/mK,
wherein the material, alloy or material combination preferably comprises at least one or two or more than two of the materials: steel, iron, nickel, tungsten, zinc, brass, aluminum, gold, silver or copper.

7. Cooling device according to at least one of the claims 1 to 6,
further comprising
a control unit for actuating the piezo electric elements (208),
wherein the frequency of each piezo electric element (208) is individually adjustable by providing respective electric signals, wherein each piezo electric element is actuated with a frequency of at least 2 Hz and prefereably with a frequency of at least 10 Hz and most preferably with a frequency of at least 50 Hz.

8. Lighting system,
comprising

a light source and
a cooling device (100) according to any of the before mentioned claims,
wherein the light source is coupled to a coupling surface (114) of the cooling device (100) in such a manner that the cooling device cools (100) the light source during operation.

9. Method for cooling a light source,
comprising the steps:

- providing a cooling device (100) or system according to any of the before mentioned claims,
- generating fluid jets with the fluid jet generating unit (104) and outputting the fluid jets through the outlets (218, 222),

  o wherein the fluid jets outputted through the first outlet (222) differ in at least one parameter from the fluid jets outputted through the second outlet (218),

    ▪ wherein a pressure difference is caused by the differing fluid jets in such a manner that fluid is sucked from the outside of the heat-dissipating element (103) through at least one communication element (108) to the inside of the heat-dissipating element (103).

10. Method according to claim 9,
characterized in that
the fluid jet differences are caused by

- differences in the electric signals that stimulate the individual piezo electric element (208) and/or
- differences in the size of the individual fluid chambers (210, 212) and/or
- differences in the sizes of the individual flexible members (206) and/or
- differences in the profiles of the individual outlets (218, 222).

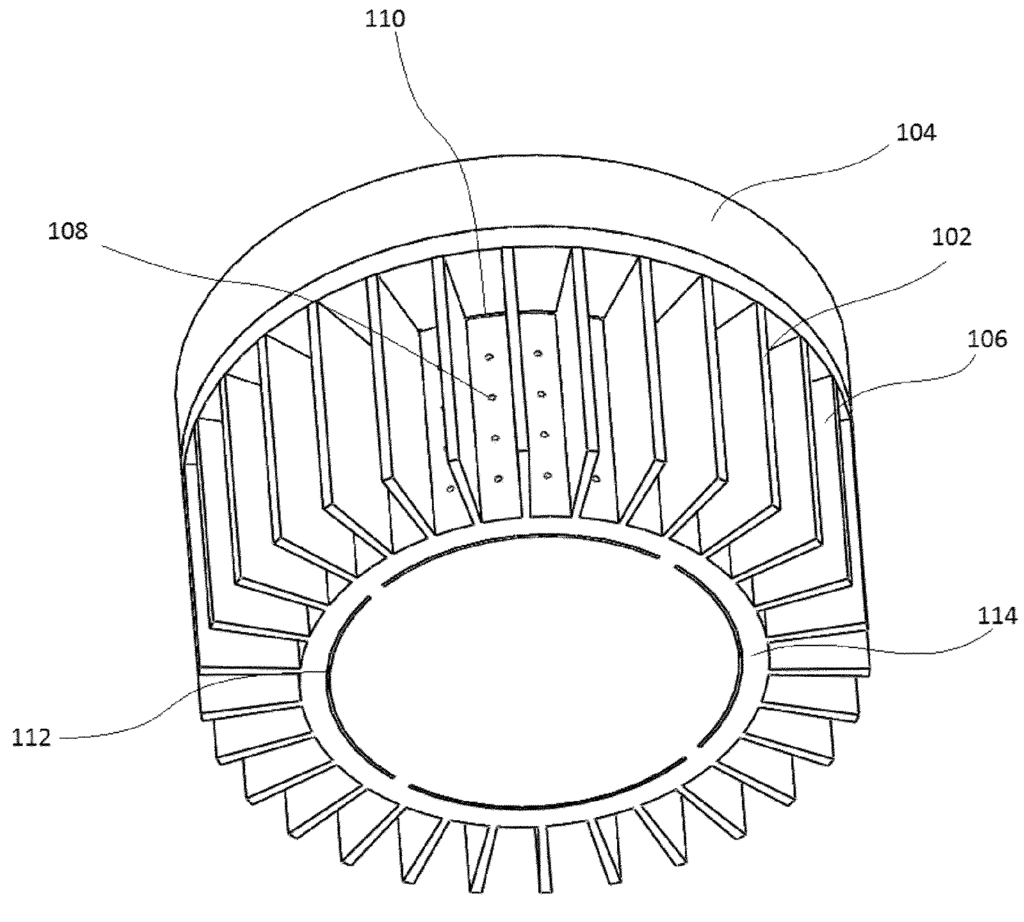

Fig. 1

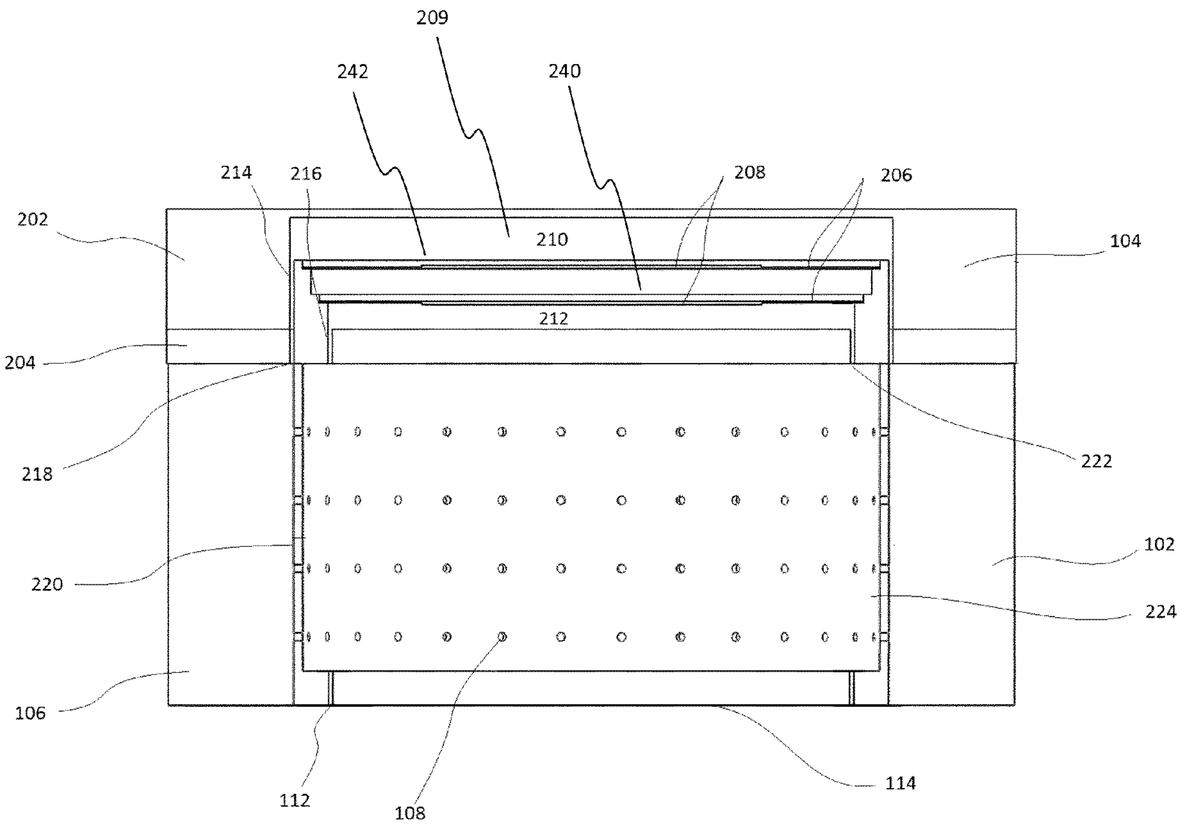
209
242
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Fig. 2

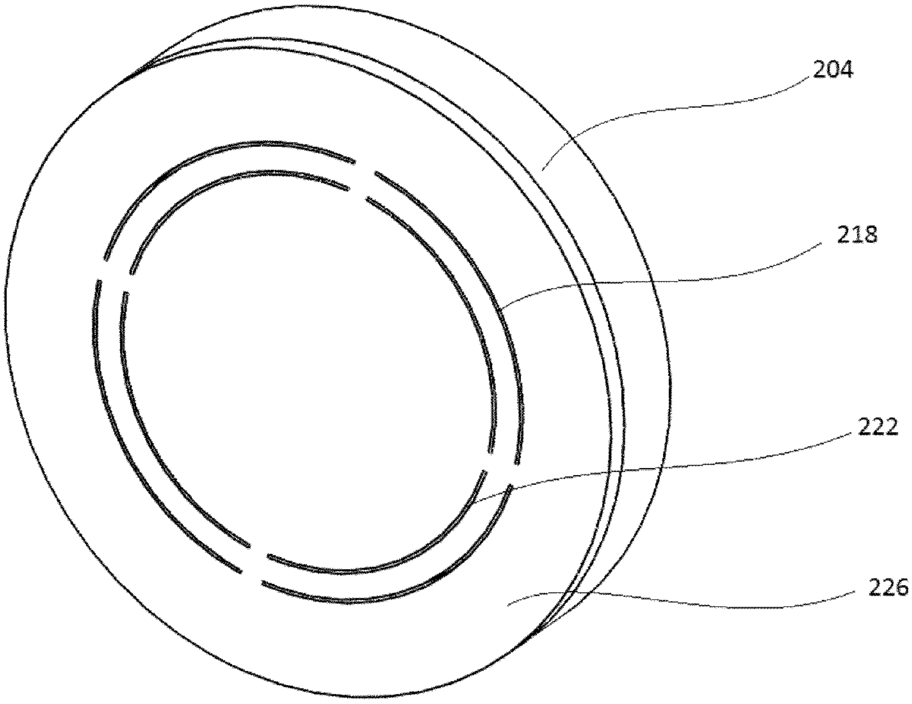

Fig. 3

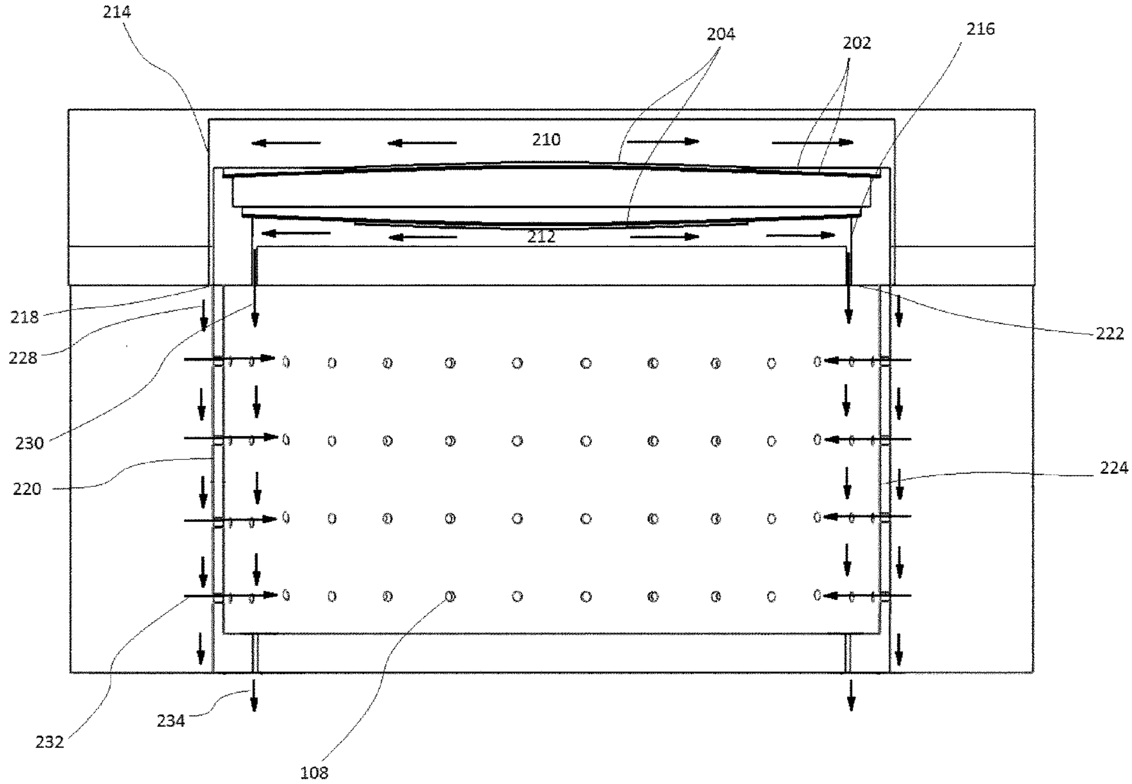

Fig. 4

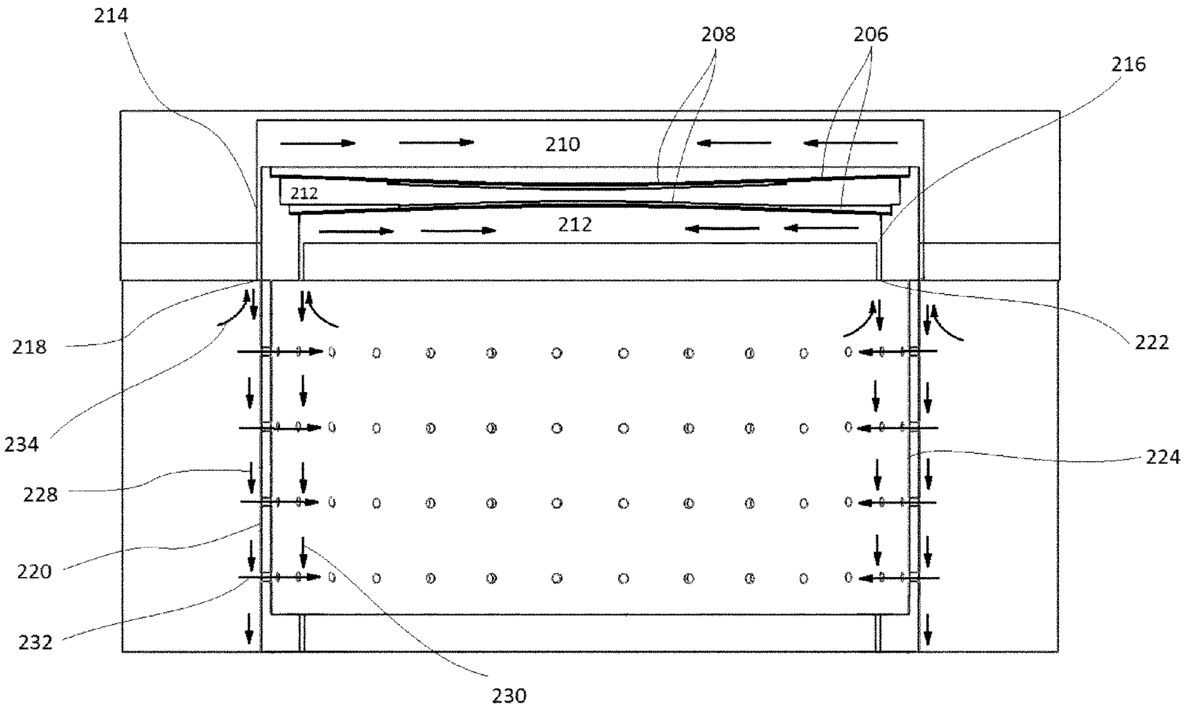

Fig. 5

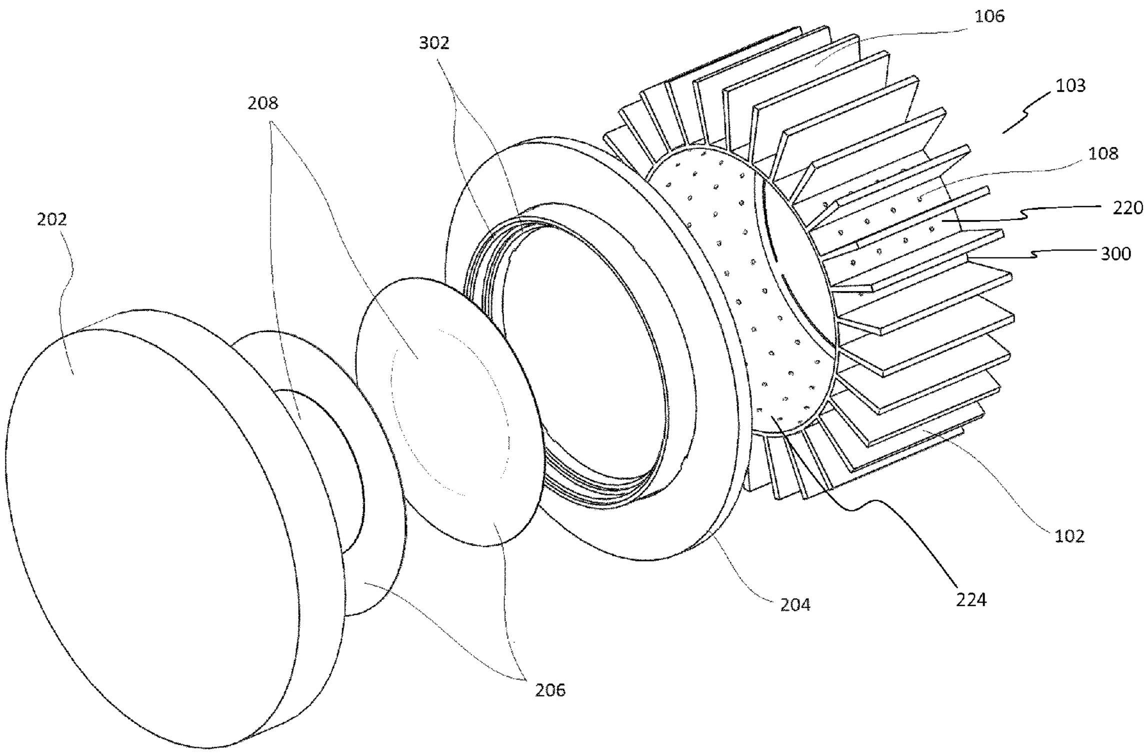

Fig. 6

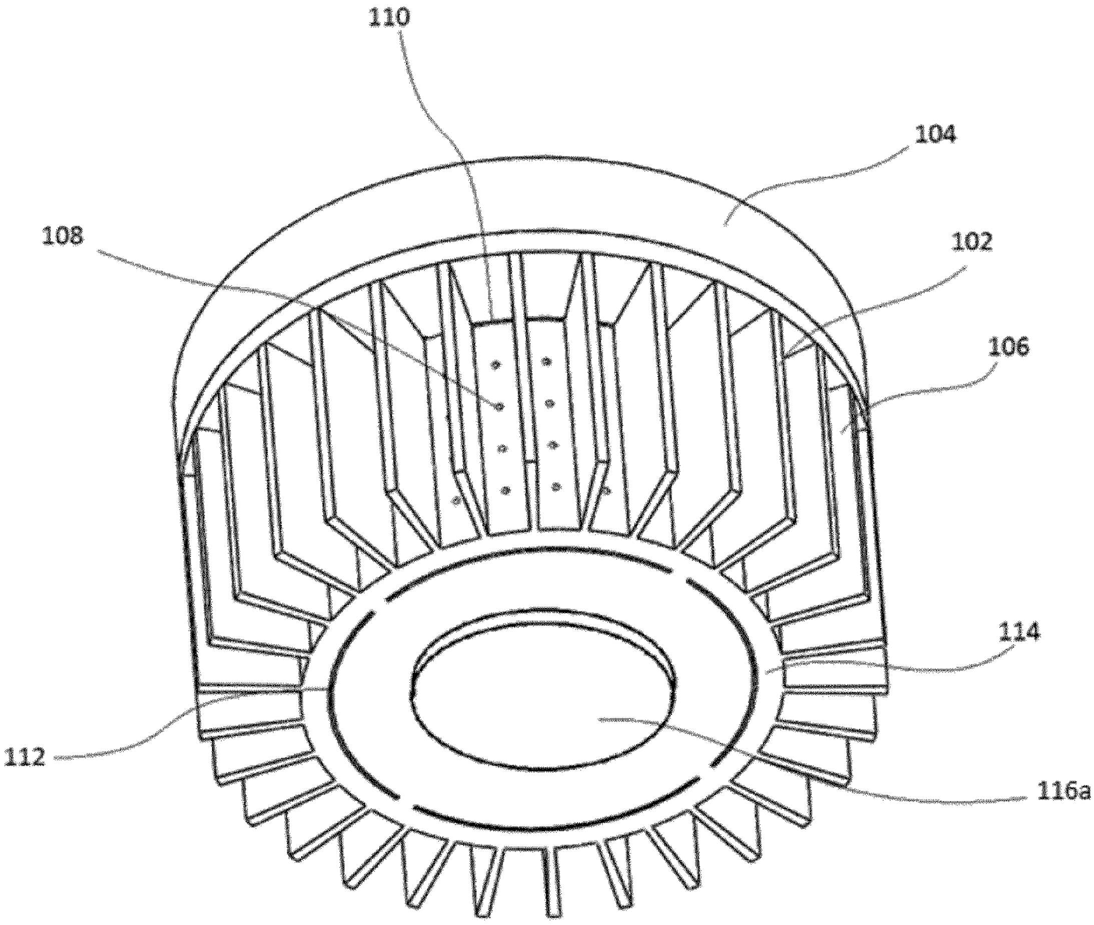

Fig. 7

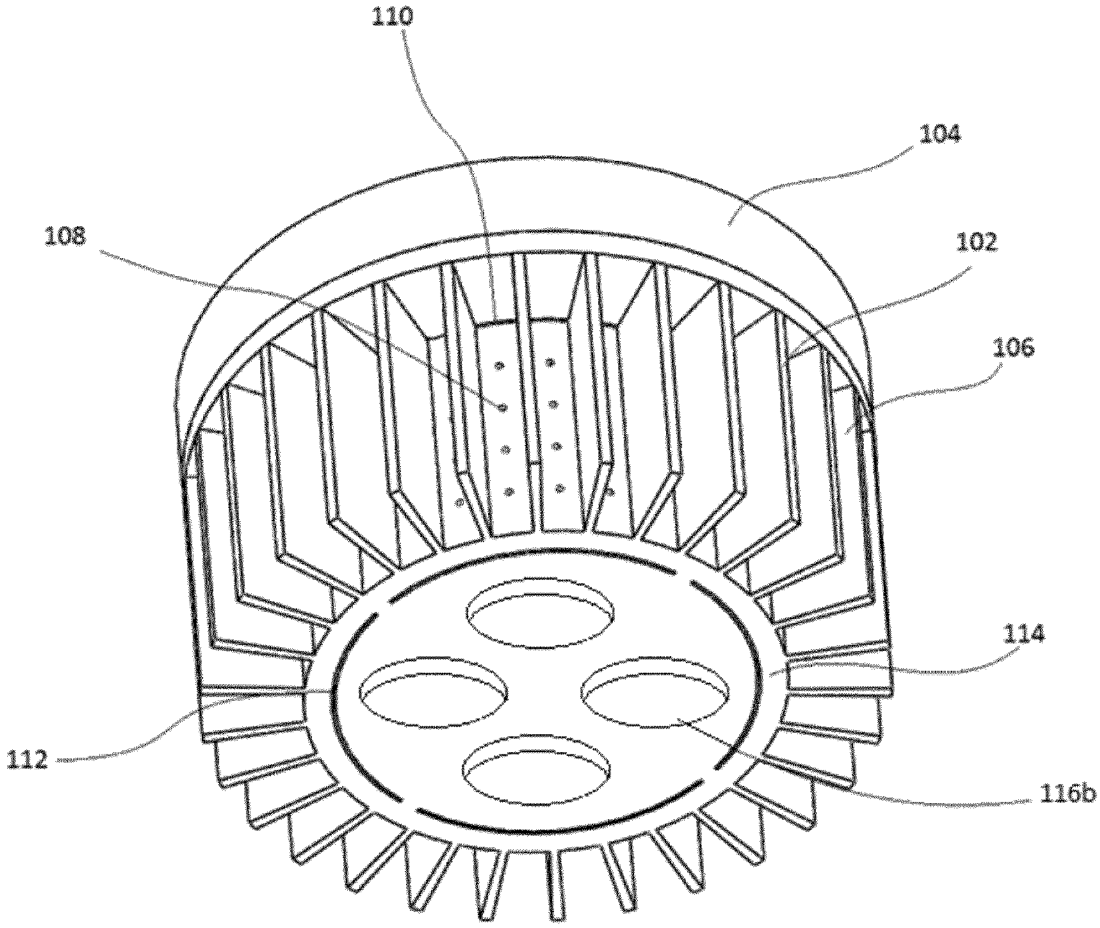

Fig. 8

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EUROPEAN SEARCH REPORT

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EP 15 18 8358

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 March 2017	Demirel, Mehmet

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