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(54) Benævnelse: **BELYSNINGSANORDNING TIL BELYSNING AF ET MÅLEOMRÅDE VED HJÆLP AF RETROREFLEKSION AF LYS FRA ET LYSDIODEMODUL PÅ EN REFLEKTOR**

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Luminaire for illuminating a target area by means of retroreflection of light from a light-emitting diode module on a reflector

Description

Technical Area

The invention relates to a luminaire for illuminating a target area by means of retroreflection on a reflector comprising a light-emitting diode module having at least one light-emitting diode (LED), and a cooling device for the light-emitting diode module, the cooling device comprising a liquid that is transparent to the light from the light-emitting diode module as a coolant and a transparent coolant container to hold the coolant.

Prior Art

A lighting system which uses such a luminaire is known from US 2007/0253733 A1. This document describes the use of the lighting system for a fluorescent microscope. An LED light source is positioned in a focal point of an elliptical mirror and emits its radiation into a hemisphere facing toward the mirror. The mirror reflects back the incident radiation and focuses it on a downstream optical system. Because of the retroreflection on the reflector, i.e., reflection of beams having an angle of incidence of less than 45°, it cannot be avoided that the LED light source and the mechanical structures required for its mounting themselves stand in the way of the reflected light.

Because the light yield of an LED decreases with increasing temperature, dissipation of the heat arising during its operation must be ensured to minimize the heating of the LED during operation. If an LED module is arranged in the focal point of a retroreflective reflector, it cannot be cooled by an otherwise typical cooling body, because the cooling body would shade a still greater part of the light reflected on the reflector. Instead, the heat must be guided outward

through the mounts. Even if they can be designed as very compact, to keep losses of the reflected light as small as possible, they occupy more space than an LED alone and therefore result in shading of the reflected light. Even if the mounts are embodied as transparent, the reflected radiation incident thereon will be influenced and the optical efficiency of the arrangement will be reduced.

Description of the Invention

The object of the present invention is to provide a luminaire of the type in question, in which high efficiency of the light transmission and the cooling of the LED module is enabled, the occurrence of artifacts, such as shade, being minimized.

This object is achieved by a luminaire having the features of Claim 1.

Particularly advantageous embodiments are found in the dependent claims.

The present invention is based on the finding that liquid cooling of an LED module can be embodied so that the light emitted by the LED and reflected by the reflector is influenced in a defined manner when it is incident on the coolant container. For this purpose, the coolant container comprises a first and a second transparent wall, between which the coolant is located and which extend substantially perpendicular to the optical axis of the reflector and have an area such that, in a mounted state, in which the LED module is coupled to the reflector, nearly all, i.e., at least 90%, of the radiation from the light-emitting diode module which is reflected on the reflector and reaches the target area passes through the coolant container.

The coolant container thus has two walls parallel to one another and covers the entire cross section of the radiation originating from the light-emitting diode module and reflected by the reflector. The walls of the coolant container can be made of glass or plastic. The coolant can be water, for example, the index of

refraction of which, 1.33, differs only slightly from the lower-refracting glasses or transparent plastics (approximately 1.5), or transparent oil. In the selection of the coolant and the material for the coolant container, it is advantageous in any case if the index of refraction of the first and the second walls and that of the coolant are sufficiently similar that the reflection losses at the interfaces between the walls and the coolant are very small. The first and the second walls of the coolant container can be rectangular, in particular square, or their outline can be adapted to the outline of the reflector. It is advantageous in this case if the outer edge of the coolant container is located outside the region in which the radiation originating from the luminaire is reflected, to preclude impairment of the reflected radiation. It then also does not play a role whether the edge itself is transparent or not. In the ideal case, all the radiation of the light-emitting diode module which is reflected on the reflector and reaches the target area passes through the coolant container.

The LED module is preferably formed in such a way that it emits at most in a hemisphere. In this manner, the LED module can be arranged so that all of the emitted light is incident on the reflector and is reflected thereby in the direction of the target area, so that the light reaching the target area has a defined characteristic.

According to one preferred embodiment of the invention, the cooling device additionally serves as a mount for the light-emitting diode module. Two functions are thus unified in one component, shading due to an additional mount being avoided.

According to a particularly preferred embodiment of the invention, the light-emitting diode module comprises a heat conducting element which is coupled to the at least one light-emitting diode and which is incorporated into the coolant container in such a way that it is in contact with the coolant. In this manner, the LED module is fastened on the cooling device and effective dissipation of the heat arising in operation is ensured simultaneously. Particularly efficient heat

transfer from the heat conducting element to the coolant may be achieved in that the heat conducting element is formed as a solid cylinder with fins projecting therefrom or has holes through which the coolant flows. Furthermore, the heat conducting element can have a rough or structured surface.

According to a further particularly preferred embodiment of the invention, the light-emitting diode module comprises a printed circuit board, on the top side of which one or more light-emitting diodes are mounted, and the underside of which is connected in particular by means of a thermally conductive material to the heat conducting element, the dimension of the heat conducting element in a direction perpendicular to the optical axis of the light-emitting diode module being less than or equal to the corresponding dimension of the printed circuit board. In this manner, only the shading at the LED module reduces the amount of the light reaching the target area.

According to a further preferred embodiment of the invention, the first wall, i.e., the wall facing the reflector in the mounted state, of the coolant container has conductive coatings to make electrical contact with the light-emitting diode module, which can be embodied as transparent.

According to a further preferred embodiment of the invention, the first and the second wall of the coolant container are formed as plane-parallel plates. In this manner, the radiation passing through the coolant container is influenced as little as possible.

According to a further preferred embodiment of the invention, the outer side of the first and/or the second wall of the coolant container is formed so as to be curved in order to implement an optical function. The coolant container can thus simultaneously assume the function of an optical element, for example, a lens, whereby additional components and therefore costs may be saved.

A two-dimensional lens array is particularly preferably formed on the outer side

of the first and/or the second wall of the coolant container. In particular, the coolant container can have the design of a honeycomb condenser, whereby homogenization of the radiation passing through it is caused.

Brief Description of the Drawings

The invention will be explained in greater detail hereafter on the basis of exemplary embodiments. In the figures:

Figure 1 shows a schematic side view of a first exemplary embodiment of the luminaire according to the invention; and

Figure 2 shows a schematic sectional view of a second exemplary embodiment of the luminaire according to the invention.

Preferred Embodiment of the Invention

In the figures, components corresponding to one another are provided with the same reference signs. The illustrated components and the size ratios of the components among one another are not to scale.

Figure 1 shows a first exemplary embodiment of a luminaire according to the invention. The luminaire comprises an LED module 12, which is combined with a reflector 30 so that the light emitted by the LED or LEDs 14 is reflected by the reflector 30 in the reverse direction, and a cooling device 10 for cooling the LED module, which serves simultaneously as a mount for the LED module 12. The LED module 12 comprises one or more LEDs 14, which are shown by a semicircle, and a heat conducting element 16. An LED module 12 can also have multiple LEDs 14 instead of one.

The LED or LEDs 14 are located on a printed circuit board, on the underside of which the heat conducting element 16 is arranged. The heat conducting element 16 is preferably a copper block. Its outline is adapted to the shape of the printed

circuit board, its dimension in a direction perpendicular to the optical axis of the LED module being less than or equal to the corresponding dimension of the printed circuit board. In this manner, the light lost due to shading is reduced to a minimum. In particular, the heat conducting element 16 is formed as a solid cylinder and has pins or ribs projecting therefrom, to be able to dissipate the heat absorbed in operation particularly well to the cooling device 10.

The cooling device comprises a coolant container 20 through which coolant flows having a first wall 22 and a second wall 24, between which a coolant 26 is located. The heat conducting element 16 is introduced through a corresponding opening in the first wall 22 into the coolant container 20 so that it is in contact with the coolant 26, and the LED module 12 is thus anchored on the coolant container 20. For the electrical contacting of the LED module 12, a transparent conductive coating (not shown in the figure), which is connected to the printed circuit board of the LED module 12, is formed on the outside on the first wall 22. Alternatively, however, the electrical contacting can also be produced using thin wires. As is apparent from Figure 1, the coolant container 20 has supply lines 27, 28 on the upper and lower edge, through which the coolant 26 can flow into the coolant container 20 and out thereof. For example, the coolant 26 flows into the coolant container 20 through the upper supply line 27 and back out of the coolant container 20 through the lower supply line 28, so that coolant flows around the heat conducting element 16. However, it would also be conceivable that the coolant container is sealed after being filled with coolant, and no active circulation of coolant takes place during operation. A transparent liquid is used as the coolant 26. It may be water in this case, the index of refraction of which, 1.33, does not strongly differ from the index of refraction of transparent materials coming into consideration for the walls of the coolant container 20, for example, glass having an index of refraction of 1.41. The walls 22 and 24 of the coolant container 20 are aligned parallel to one another and perpendicular to the optical axis 36 of the LED module 12. Their area is greater than that of the bundle reflected from the reflector 30.

In Figure 1, the two edges of the radiation emitted by the LED module 12 are shown to illustrate the beam path. The walls 22 and 24 are rectangular or adapted in their outline to the reflector 30. At their edges, they are connected to one another by suitable means, in particular by side walls. These edge areas are preferably located outside the region of the reflected radiation to avoid interference with the reflected radiation. The inner sides of the walls of the coolant container 20 are formed as flat to avoid eddy formation of the coolant 26 on the walls as it flows past. According to the first exemplary embodiment of the invention shown in Figure 1, the outer sides in particular of the first wall 22 and the second wall 24 of the coolant container 20 are also formed as flat, so that the two walls 22 and 24 are plane-parallel plates. In this manner, the entire coolant container 20 acts on the incident radiation like a plane-parallel plate.

Figure 2 shows a second exemplary embodiment of the luminaire according to the invention. The exemplary embodiment according to Figure 2 is distinguished in that the coolant container 20, in addition to the function of the cooling and the mounting of the LED module 12, also assumes an optical function. Otherwise, the cooling device 10 according to the second exemplary embodiment corresponds to the description provided in conjunction with the first exemplary embodiment according to Figure 1. The coolant container 20 shown in Figure 2 is in the form of a honeycomb condenser. For this purpose, lens arrays are formed on the outer sides of the first wall 22 and the second wall 24 of the coolant container 20. Homogenization of the radiation passing through the coolant container 20 is thus caused. Viewed in the propagation direction of the radiation, a Fresnel lens 32 is also provided for bundling the radiation onto the target area 34 after the coolant container 20. Due to the integration of the optical function of a honeycomb condenser in the coolant container 20, both space and also material and thus costs may be saved. In a similar manner, other desired optical functions may be implemented by suitable formation of the walls 22 and 24 of the coolant container 20.

In both exemplary embodiments, the coolant container 20 is arranged in the luminaire so that the LED module 12, the LED or LEDs of which emit at most into a hemisphere, is located close to the focal point of the reflector. The reflector 30 therefore collects all of the LED radiation and can transmit it through the coolant container. In particular conical section figures, such as paraboloids or ellipsoids, are used as reflectors. The usage of a reflector in retroreflection therefore causes good utilization of the radiation with simple construction.

The luminaire according to the invention may be designed so that it can be installed in existing lamps having a reflector, so that a retrofit of previous halogen lamp solutions is possible. Preferred applications for the solution according to the invention are medical luminaires, applications of small etendue, such as projectors, or applications of high axial luminosity, such as headlights. It is particularly efficient and cost-effective if a larger diameter of the optics is required.

P A T E N T K R A V

1. Belysningsanordning til belysning af et målområde (34) ved hjælp af retrorefleksion på en reflektor (30) omfattende

- et lysdiodemodul (12) med mindst én lysdiode (14) og
- en køleindretning (10) til lysdiodemodulet (12), hvor køleindretningen omfatter en for lyset fra lysdiodemodulet transparent væske (26) som kølemiddel og en transparent kølemiddelbeholder (20) til modtagelse af kølemidlet (26),

k e n d e t e g n e t ved, at

kølemiddelbeholderen (20) omfatter en første (22) og en anden transparent væg (24), mellem hvilke kølemidlet (26) befinder sig, og hvilke strækker sig i det væsentlige vinkelret på den optiske akse (36) af reflektoren (30) og har en sådan flade, at i en monteret tilstand, hvor lysdiodemodulet (12) og køleindretningen (10) er forbundet med reflektoren (30), passerer mindst 90 % af den af reflektoren (30) reflekterede stråling fra lysdiodemodulet (12), som når målområdet (34), gennem kølemiddelbeholderen (20).

2. Belysningsanordning ifølge krav 1,

k e n d e t e g n e t ved, at

den første (22) og den anden væg (24) af kølemiddelbeholderen (20) har en sådan flade, at al den af reflektoren (30) reflekterede stråling fra lysdiodemodulet (12), som når målområdet (34), passerer gennem kølemiddelbeholderen (20).

3. Belysningsanordning ifølge krav 1 eller 2,

k e n d e t e g n e t ved, at

den mindst ene lysdiode (14) er udformet således, at den højst udstråler i et halvrum.

4. Belysningsanordning ifølge et af kravene 1 til 3,

k e n d e t e g n e t ved, at

køleindretningen også tjener som en holder til lysdiodemodulet (12).

5. Belysningsanordning ifølge krav 4,

k e n d e t e g n e t ved, at

lysdiodemodulet (12) omfatter et varmeledende element (16) koblet med den mindst ene lysdiode (14), hvilket er indlejret i kølemiddelbeholderen (20) således, at det er i kontakt med kølemidlet (26).

6. Belysningsanordning ifølge krav 5,

k e n d e t e g n e t ved, at

det varmeledende element (16) er udformet som en massiv cylinder med derfra udragende finner.

7. Belysningsanordning ifølge krav 5 eller 6,

k e n d e t e g n e t ved, at

lysdiodemodulet (12) omfatter en printplade, på hvis overside en eller flere lysdioder (14) er monteret, og hvis underside er forbundet, særligt ved hjælp af et termisk ledende materiale, med det varmeledende element (16), hvor dimensionen af det varmeledende

element (16) i en retning vinkelret på den optiske akse af lysdiodemodulet (12) er mindre end eller lig med den tilsvarende dimension af printpladen.

8. Belysningsanordning ifølge et af de foregående krav,

k e n d e t e g n e t ved, at

den første væg (22) af kølemiddelbeholderen (20) har ledende belægninger for elektrisk kontakt med lysdiodemodulet (12).

9. Belysningsanordning ifølge et af de foregående krav,

k e n d e t e g n e t ved, at

den første (22) og den anden væg (24) af kølemiddelbeholderen (20) er udformet som planparallelle plader.

10. Belysningsanordning ifølge et af kravene 1 til 8,

k e n d e t e g n e t ved, at

den ydre side af den første (22) og/eller den anden væg (24) af kølemiddelbeholderen (20) er udformet krumt for at realisere en optisk funktion.

11. Belysningsanordning ifølge krav 10,

k e n d e t e g n e t ved, at

et todimensionelt linsearray er udformet på den ydre side af den første (22) og/eller den anden væg (24) af kølemiddelbeholderen (20).

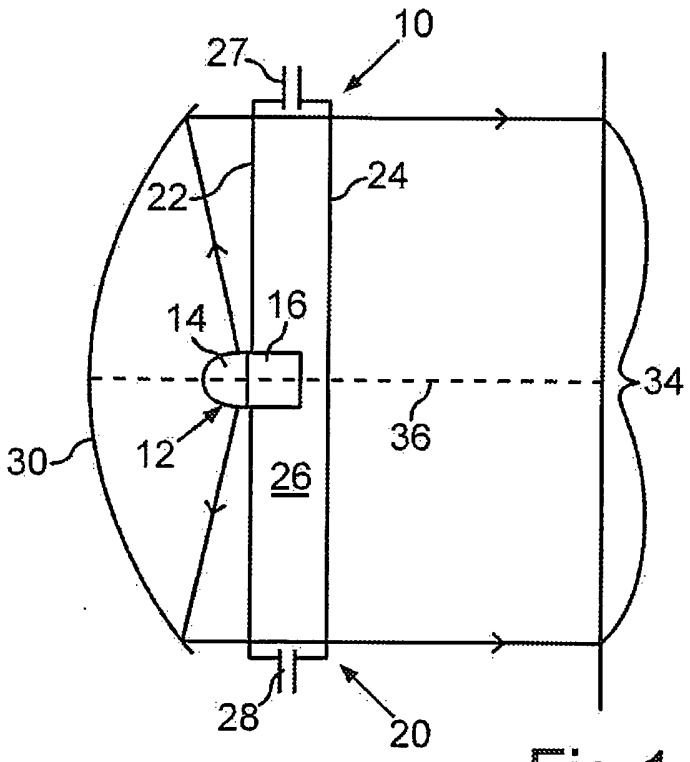

Fig.1

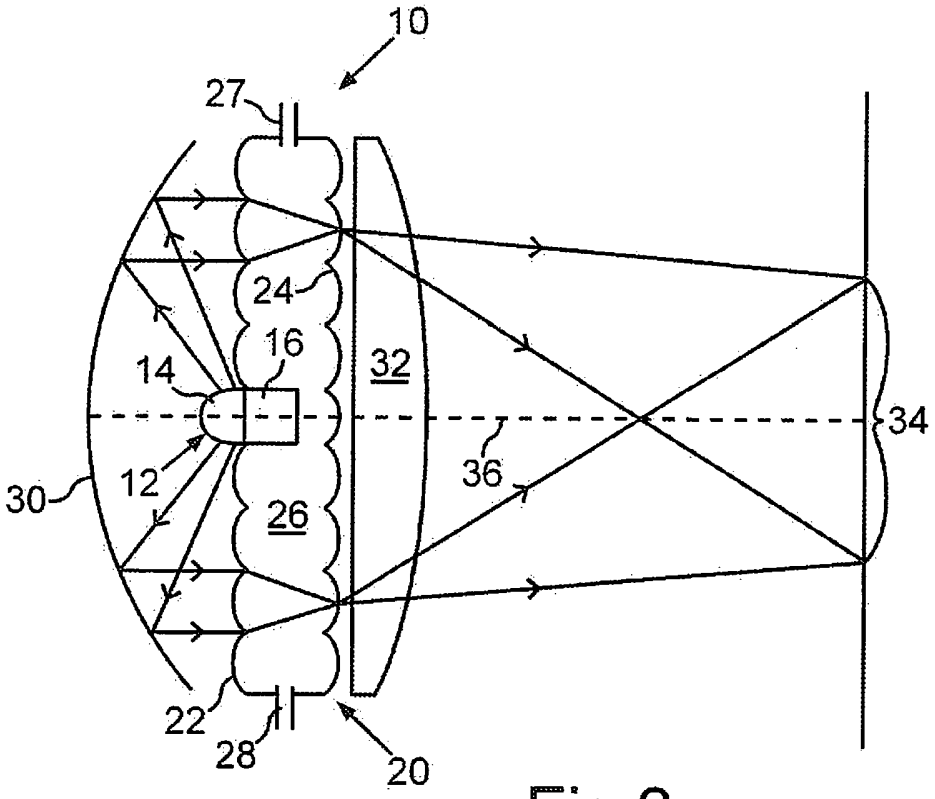

Fig.2