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(54) Improving reliability of a lighting apparatus

(57) A lighting module for arrangement inside a housing that comprises a non-opaque portion for enabling light output from the lighting module, the lighting module comprising a base member, one or more light sources arranged on the base member, one or more light sensors arranged in locations on the base member such that they are insensitive to direct light emitted by the light sources and such that they are sensitive to indirect light from the light sources, and means for providing a first output signal based on light level observed by the light sensors. The lighting module may be arranged inside a housing of such that the direct light emitted by the light sources is directed towards the non-opaque portion of the housing and that the one or more light sensors are able to receive light arriving from direction of the non-opaque portion of the housing.

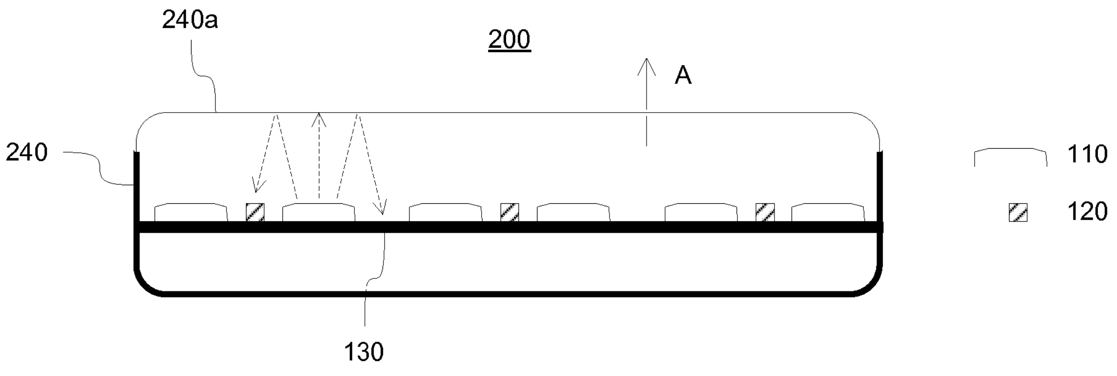

Figure 2

EP 2 882 261 A1

Description

FIELD OF THE INVENTION

[0001] The invention relates to operation of a lighting module and/or a lighting apparatus. In particular, embodiments of the present invention relate to an apparatus and a method for detecting an operating condition where the light output from a lighting module and/or a lighting apparatus is temporarily reduced e.g. due to snow, ice, dust, dirt and/or other obstacles degrading the light output from one or more light sources of the lighting module/apparatus.

BACKGROUND OF THE INVENTION

[0002] Many lighting apparatuses are operated in environments where the light output therefrom may be temporarily and/or occasionally obscured due to environmental factors.

[0003] As an example, a lighting apparatus operated outdoors or in another environment where the temperature may drop below freezing (e.g. unheated storage facilities) may suffer from ice forming on housing of the lighting apparatus, possibly degrading or completely blocking the light output from the lighting apparatus. Especially in case of a lighting apparatus relying on light emitting diodes or other light sources of high energy efficiency (thus producing a low amount of heat as a by-product) formation of snow and/or ice that partially or even completely blocks the light output may cause a substantial reduction in the light output. While in all usage scenarios this is likely to lead to inconvenience due to lower-than-designed level of illumination, in certain usage scenarios, e.g. in case of a lighting apparatus used in car headlights or taillights, such problem may lead to serious consequences due to reduced visibility.

[0004] As another example, a lighting apparatus operated outdoors may suffer from dust and/or dirt (in addition to snow and/or ice) gathering on the surface of the lighting apparatus, thereby potentially causing reduced light output from the light apparatus. Again, a headlight or a taillight of a car serves as an example of such a usage condition. Similarly, dust and/or dirt may be gathered also on the surface of a lighting apparatus operated indoors, especially e.g. in a factory, in a garage, in a storage facility or in another industrial establishment but also in office rooms/spaces, meeting rooms and in recreational or domestic environments.

[0005] It would be hence desirable to provide a lighting module, a lighting apparatus, a lighting arrangement and/or components thereof that are capable of recognizing such a condition and possibly also capable of invoking measures to react to such a condition upon detection.

SUMMARY OF THE INVENTION

[0006] Hence, it is an object of the present invention to provide an approach that facilitates automatic detection of temporarily reduced light output from a lighting module or a lighting apparatus and, possibly, automatic invocation of a measure or measures that facilitate alleviating such a condition.

[0007] The object(s) of the invention are reached by an apparatus and a method as defined by the respective independent claims.

[0008] According to a first aspect of the invention, a lighting module is provided. The lighting module may be provided for arrangement inside a housing that comprises a non-opaque portion for enabling light output from the lighting module, the lighting module comprising a base member, one or more light sources arranged on the base member, one or more light sensors arranged in locations on the base member such that they are insensitive to direct light emitted by the one or more light sources and such that they are sensitive to indirect light from the one or more light sources, and means for providing a first output signal based on light level observed by the one or more light sensors.

[0009] According to a second aspect of the invention, a lighting apparatus is provided, the lighting apparatus comprising a housing for hosting a lighting module, the housing comprising a non-opaque portion for enabling light output from the lighting module arranged inside the housing, a lighting module according to the first aspect of the invention arranged inside the housing such that the direct light emitted by the one or more light sources is directed towards the non-opaque portion of the housing and further such that the one or more light sensors are able to receive light arriving from direction of the non-opaque portion of the housing.

[0010] According to a third aspect of the invention, a lighting arrangement is provided, the lighting arrangement comprising a lighting module according to the first aspect of the invention or a lighting apparatus according to the second aspect of the invention. The lighting arrangement further comprises a control portion configured to receive the first output signal and to invoke a predetermined action for facilitating or ensuring sufficient light output from the lighting module 100 in response to a comparison of the light level indicated in the first output signal to a reference light level indicating deviation exceeding a predetermined threshold. Invoking the predetermined action may comprise issuing an indication regarding reduced light transmission via the non-opaque portion or issuing a heating control signal arranged to cause defrosting the non-opaque portion of the housing.

[0011] According to a fourth aspect of the invention, a method for controlling a lighting arrangement according to the third aspect of the invention is provided. The method comprises receiving the output signal from the lighting module and invoking a predetermined action for facilitating or ensuring sufficient light output from the lighting module 100 in response to a comparison of the light level indicated in the first output signal to a reference light level indicating deviation exceeding a predetermined threshold. As in case of the third aspect of the invention, invocation of the predetermined action may comprise issuing an indication regarding reduced light transmission via the non-opaque portion or issuing a heating control signal arranged to cause defrosting the non-opaque portion of the housing

[0012] According to a fifth aspect of the invention, a computer program for controlling a lighting arrangement according to the third aspect of the invention is provided. The computer program comprises one or more sequences of one or more instructions which, when executed by one or more processors, cause an apparatus to at least perform the method according to fourth aspect of the invention.

[0013] The exemplifying embodiments of the invention presented in this patent application are not to be interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" and its derivatives are used in this patent application as an open limitation that does not exclude the existence of also unrecited features. The features described hereinafter are mutually freely combinable unless explicitly stated otherwise.

[0014] The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following detailed description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Figures 1 a and 1 b schematically illustrate an exemplifying lighting module in accordance with an embodiment.

Figure 2 schematically illustrates an exemplifying lighting apparatus in accordance with an embodiment.

Figure 3 schematically illustrates an exemplifying lighting arrangement in accordance with an embodiment.

Figure 4 schematically illustrates an exemplifying lighting arrangement in accordance with an embodiment.

Figure 5 illustrates a method in accordance with an embodiment.

Figure 6 schematically illustrates an exemplifying apparatus upon which an embodiment may be implemented

DETAILED DESCRIPTION

[0016] Figures 1 a and 1 b schematically illustrate an exemplifying lighting module 100 in accordance with an embodiment of the present invention. The lighting module 100 comprises one or more light sources 110 for providing the light output of the lighting module 100. The lighting module further comprises one or more light sensors 120 for providing indication(s) of the observed light level. These indication(s) of the observed light level may be also considered as first measurement signal(s) descriptive of the observed light level. Figure 1a provides a schematic 'side view' (e.g. a cross-section thereof) of the lighting module 100 such that the arrow A denotes general direction of the light output from the lighting module 100, whereas Figure 1b provides a schematic 'top view' of the lighting module 100 from direction opposite to the direction indicated by the arrow A in Figure 1 b.

[0017] The light sources 110 and the light sensors 120 are arranged in locations on a base member 130 such that the light sensors 120 are insensitive to the direct light emitted by the light sources 110, in other words in locations (and positions) in which they are unable to receive direct light output from the light sources 110. On the hand, the light sensors 120 are arranged on the base member 130 such that they are sensitive to light arriving from direction opposite to the arrow A depicted in Figure 1 a. This may be accomplished e.g. by arranging the light sensors 120 on the base member 130 in locations/positions in which the direct light from the light sources 110 is unable to enter light sensitive areas thereof at an angle to which the light sensors 120 are sensitive, while at the same time the light sensors 120 are arranged in positions in which the light arriving from direction opposite of the arrow A is able to enter light sensitive areas of the light sensors 120 at an angle to which the light sensors 120 are sensitive. This 'detection angle' of the light sensor 120 is typically a few tens of degrees around the center axis of the sensing direction, e.g. [LA1]50º around the center axis. Hence, a light sensor of the light sensors 120 may be arranged in a position in which its center axis of the sensing direction is parallel or essentially parallel with the arrow A. As another example, at least some of the light sensors 120 may be arranged in positions in which their center axes deviate from a direction parallel to the arrow A by a few degrees (e.g. up to 10º). In general, a person skilled in the art is able to envisage numerous ways to locate/position the light sensors 120 such that they are insensitive to the direct light emitted by the light sources 110 while being sensitive to light arriving from direction opposite to the arrow A.

[0018] Figure 2 schematically illustrates an exemplifying lighting apparatus 200, comprising a housing 240 for enclosing a lighting module and the lighting module 100 arranged inside the housing 240. The lighting apparatus 200 may serve any purpose of illumination, and it may be provided e.g. as a luminaire or a lighting fixture for indoor or outdoor use, as a headlight or a taillight (or another lighting device to be installed in) a vehicle, etc.

[0019] The housing 240 comprises a non-opaque portion 240a for enabling light output from the light sources 110 therethrough. In Figure 2 the non-opaque portion 240a is illustrated using a regular line, whereas the remaining portion of the housing 240 is illustrated using a bold line. This remaining portion of the housing 240 is typically made of opaque material. The non-opaque portion 240a may be provided as a transparent portion, as a translucent portion, or as a portion of other type that enables light transmission therethrough. The lighting module 100 is arranged inside the housing 240 such that the direct light emitted by the light sources 110 is directed towards the non-opaque portion 240a so that the light sources 110 are able to provide their light output through the non-opaque portion 240a. The lighting module 100 is further arranged inside the housing 240 such that the light sensors 120 are able to receive light arriving from direction of the non-opaque portion 240a. This may be accomplished e.g. by arranging the lighting module 100 inside the housing 240 e.g. such that the light sensitive area(s) of the light sensors 120 are able to receive light from direction of the non-opaque portion 240a at an angle to which the light sensors 120 are sensitive.

[0020] Consequently, the light sensors 120 are able to receive the ambient light that may able to enter the housing 240 through the non-opaque portion 240a. Moreover, in case there are one or more objects or material partially or completely covering the non-opaque portion 240a and thereby at least partially blocking the light output from the lighting apparatus 200, the light sensors 120 are able to receive the reflection of the light output of the light sources 110 from the blocking object(s)/material. With such an arrangement of the light sensors 120 with respect to the non-opaque portion 240a, the level of light observed by the sensors may be applied as an indication regarding the possible blockage or the degree of blocking of the non-opaque portion 240a. Interpretation of the observed light level in this regard may depend on characteristics of the employed non-opaque portion 240a and/or the ambient lighting conditions.

[0021] As an example in this regard, in case ambient light is not able to enter the housing through the non-opaque portion 240a due to characteristics of the non-opaque portion (e.g. in case of a non-opaque portion 240a having an reflective outer surface), the indication(s) of the observed light level indicate low observed light level in normal operating conditions of the lighting apparatus 200. In contrast, the indication(s) of the observed light level indicate high(er) observed light level in case there are objects/material covering at least part of the non-opaque portion 240a and hence partially or completely blocking the light output from lighting apparatus 200. Similar considerations are valid also for a scenario where the contribution of the ambient light entering the housing 240 through the non-opaque portion 240a can be assumed insignificant e.g. due to characteristics of the non-opaque portion 240a or due to knowledge (or assumption) regarding the lighting conditions outside the housing.

[0022] As another example, in case a non-insignificant amount of ambient light is able to enter the housing 240 through the non-opaque portion 240a and further assuming ambient light level outside the housing 240 to be low in relation to the light output of the light sources 110, the indication(s) of the observed light level indicate low observed light level in normal operating conditions, whereas the indication(s) of the observed light level indicate high(er) observed light level in case there are objects/material on the non-opaque portion 240a partially or completely blocking the light output from lighting apparatus 200. In contrast, in case the ambient light level entering from outside the housing 240 is relatively high (and in case the blocking object(s)/material does not provide a strong reflection), low observed light level may serve as an indication of normal operating conditions whereas a high(er) observed light level may indicated at least partially blocked light output. Examples of typical objects or material that may block the light output include dust, dirt, ice or snow temporarily covering at least part of the non-opaque portion 240a. The dashed arrows in Figure 2 illustrate an example of the light output from one of the light sources 110 and its reflection from (an object/material blocking the light output via) the non-opaque portion 240a.

[0023] In context of the lighting module 100 the light sources 110 are, preferably, provided as light emitting diodes (LEDs) or other light sources that provide relatively narrow and directional beam of light. For example for a LED light source the viewing angle may be 120º or even less. Consequently, in view of the 'detection angle' and locations/positions of the light sensors 120 described hereinbefore, for example arranging the light sources 130 on the base member 130 in positions in which their optical axes are parallel to the arrow A or deviate from a direction parallel to the arrow A by a few degrees (e.g. up to 10 º) typically ensures that the direct light output from the light sources does not enter the light sensitive areas of the light sensors 120 regardless of the relative locations of the light sources 110 and the light sensors 120. A straightforward solution, though, is to arrange the light emitting surfaces of the light sources 110 and the light sensitive areas of the light sensor 120 on the same or essentially the same plane that is parallel to the base member 130 (and/or perpendicular to the arrow A of Figures 1 a and 2). However, it is not necessary to arrange (the light emitting surfaces of) the light sources 110 in the same (or essentially the same) plane with (the light sensitive areas of) the light sensors 120. Moreover, it is not necessary to arrange the light sources 110 in the same plane with each other or to arrange the light sensors 120 in the same plane witch each other. In general, a person skilled in the art is capable of envisaging numerous ways to locate/position the light sources 110 with respect to the light sensors 120 such that the light sensors 120 are insensitive to the direct light emitted by the light sources 110 while being sensitive to light arriving from direction opposite to the arrow A.

[0024] The lighting module 100 may be provided as a component integrated to housing 240 (and/or other components of the lighting apparatus 200), e.g. in a lighting apparatus comprising the lighting module 100. On the other hand, the lighting module 100 may be provided separately from the lighting apparatus 200 for subsequent arrangement inside the housing 240 such that the light output is provided through the non-opaque portion 240 and that the light sensors 120 are able to receive light arriving from direction of the non-opaque portion 240a - and are hence also able to receive the possible reflection of the light output of the light sources 110 from an object partially or completely covering the non-opaque portion 240a.

[0025] The number of light sources 110 may be selected in accordance with the characteristics of the employed light sources 110 in view of the desired level of light output from the lighting module 100. The number of the light sensors 120 may be selected in view of desired level of reliability and accuracy of the measurement of the reflected light. Hence, it may be sufficient to employ a single light sensor 120. Typically, however, the number of light sensors 120 is increased with the increasing number of light sources 110. In particular, the light sensors 120 are preferably evenly or essentially evenly distributed over the area of the base member 130 in order to facilitate detection of possible reflections from objects disturbing the light output throughout the area of the non-opaque portion 240a.

[0026] The constellation of the light sources 110 illustrated in Figures 1a, 1b and 2, i.e. in two rows with a row of first light sensors 120 therebetween serves as a non-limiting example only, and any constellation or arrangement of the light sources 110 and the first light sensors 120 may be applied without departing from the scope of the present invention. Arrangement of the light sources 110 and the first light sensors 120 in a single-piece planar base member 130 serves as a non-limiting example only, and base members 130 of different shape and construction may be applied instead. The base member 130 may be e.g. a circuit board serving as an installation platform e.g. for LEDs employed as the light sources 110 and the light sensors 120. The circuit board may include further components, such as electrical components for controlling operation of the light sources 110 and/or the light sensors 120, electrical wirings between the light sources 110, electrical wirings coupling the light sources 110 and the light sensors 120 to a power supply, electrical wirings for coupling the light sensors 120 to an output line, etc.

[0027] The lighting module 100 further comprises means for providing an output signal based on light level observed by the light sensors 120 to facilitate or enable estimation of the light transmission through the non-opaque portion 240a. The output signal may be provided to a control entity, which may be provided as part of the lighting module 100, as part of the lighting apparatus 200 or as an external control entity or control portion. The output signal may be considered to represent the observed light level L, which may serve as an indication of the level of light received through the non-opaque portion 240a, the level of light reflected from an object covering at least part of the non-opaque portion 240a or a combination of the two. The output signal may be derived on basis of the indications received from the light sensors 120. In this regard, the output signal may provide the light level indication (or measurement signal) received from a single light sensor 120 as such. Alternatively, the output signal may be derived as a combination, e.g. as the sum or as the average, of the light level indications (or measurement signals) received from a plurality of light sensors 120.

[0028] Figure 3 schematically illustrates an exemplifying lighting arrangement 300 comprising the lighting apparatus 200 hosting the lighting module 100 that is electrically coupled to a control portion 350. The control portion 350 may be provided as hardware means, as software means, or as a combination of hardware means and software means. As a particular example, the control portion 350 may be provided as a driver apparatus 360 or as a portion of the driver apparatus 360 for driving the operation of the lighting module 100 or the lighting apparatus 200 (e.g. as a LED driver or a portion thereof). The control portion 350 and/or the driver 360 may be further coupled to an external control entity 370. The external (or remote) control entity may be arranged to provide commands or instructions for controlling the operation of the control portion 350 and/or the driver 360 and further arranged to receive signals and/or indications from the control portion 350 and/or from the driver 360.

[0029] Although described herein together with the lighting apparatus 200, the control portion 350 (and/or the driver 360) may be provided separately from the lighting apparatus 200 for subsequent installation to form the lighting arrangement 300. As another example, the control portion 350 (and/or the driver 360) may be provided together with the lighting module 100 but without the housing 240 or other (further) components of the lighting apparatus 200 for subsequent installation to form the lighting arrangement 300.

[0030] The control portion 350 is arranged to receive the output signal from the lighting module 100, the control portion 350 hence arranged to receive an indication of the observed light level L. The control portion 350 is further configured to invoke, at least in part on basis of the light level L, a predetermined action for facilitating or ensuring sufficient light output from the lighting module 100.

[0031] As an example, the control portion 350 may be configured to compare the observed light level L to a predetermined reference light level L_{ref} and to invoke the predetermined action indicating deviation from the reference light level L_{ref} to exceed a predetermined threshold. In this regard, the control portion 350 may be configured to invoke the predetermined action in response to the comparison indicating the difference between the observed light level L and the reference light level L_{ref} to exceed a predetermined threshold Th_L. Depending on the configuration of the control portion 350, the predetermined action may be invoked e.g. in response one of the following:

- the observed light level L is larger than the reference light level L_{ref} by at least a margin indicated by the predetermined threshold Th_L (e.g. L - Lref ≥ Th_L),
- the observed light level L is smaller than the reference light level L_{ref} by at least a margin indicated by the predetermined threshold Th_L (e.g. $L_{ref} - L \geq Th_L$),
- the absolute value of the difference between the observed light level L and the reference light level L_{ref} is larger than or equal to a margin indicated by the predetermined threshold Th_L (e.g. abs(L - L_{ref}) ≥ Th_L).

[0032] Instead of considering the difference between the observed light level L and the reference light level L_{ref}, the comparison of the observed light level L to the reference light level L_{ref} in order to detect possible deviation therefrom may involve e.g. calculating the ratio $R_L = L / L_{ref}$. Consequently, the control portion 350 may be configured to invoke the predetermined action in response to the ratio R_L indication deviation exceeding a certain predetermined percentage, e.g. in response to the ratio R_L failing to reach a first (lower) predetermined threshold ratio (e.g. if $R_L < Th_{R1}$) or the ratio R_L exceeding a second (higher) predetermined threshold ratio (e.g. if $R_L > Th_{R2}$).

[0033] It should be noted, however, that the invocation of the predetermined action on basis of the difference or ratio between the observed light level L and the reference light level L_{ref} are described as non-limiting examples only, and the invocation of the predetermined action on basis of the observed light level L and the reference light level L_{ref} may be carried out in a manner different from these examples without departing from the scope of the present invention.

[0034] The threshold Th_L or the thresholds Th_{R1} and Th_{R2} may be applied as configurable parameters, which may be pre-set or predetermined in view of the (intended) operating environment of the lighting module 100 or the lighting apparatus 200 and/or in view of desired sensitivity to light level deviations from the reference light level L_{ref}. Configuration of the thresholds Th_L or the threshold Th_{R1} and Th_{R2} may take place e.g. upon installation or maintenance of the lighting arrangement 300.

[0035] Similarly, the reference light level L_{ref} may be applied as a configurable parameter that is set or configured upon installation or maintenance of the lighting arrangement 300. As an example in this regard, the control portion 350 may be arranged to store (e.g. in a memory provided in the control portion 350) currently indicated observed light level L as the reference light level L_{ref} for subsequent use in response to a request. The request to record a new value for the reference light level L_{ref} may be issued e.g. as part of the installation/maintenance process or in another situation where undisturbed light transmission through the non-opaque portion 240a is guaranteed.

[0036] Instead of immediately reacting to the difference between the observed light level L and the reference light level L_{ref} exceeding the threshold Th_L, the control portion 350 may be configured to invoke the predetermined action in response to the difference exceeding the threshold Th_L for at least a predefined period of time T_A. Depending on the usage scenario, time T_A may be set to a value in the range from a few seconds to a few minutes. Using a sufficiently high value of T_A facilitates avoiding false alarms e.g. due to accidental short term blocking of the non-opaque portion 240a or due to at least some of the light sensors 120 temporarily observing light originating from an external (possibly non-stationary) light source.

[0037] The predetermined action may comprise the control portion 350 providing an indication to the external (remote) control entity 370 regarding reduced light output or light transmission through the non-opaque portion 240a. Consequently, the external control entity 370 may be arranged to trigger an indication or request for maintenance operation to be carried out due to compromised illumination by the lighting apparatus 200 hosting the lighting module 100, which may e.g. result in a maintenance person cleaning up or replacing the light apparatus 200 to ensure proper illumination. The external control entity 370 may receive such indications/requests from (control portions of) a plurality of light apparatuses and it may be arranged to trigger the indication/request for maintenance in response to at least a predetermined number or at least a predetermined percentage of the light apparatuses having indicated reduced light output.

[0038] Alternatively or additionally, the lighting apparatus 200 may be provided with a heating arrangement for defrosting the non-opaque portion 240a in control of a heating signal, and the predetermined action may comprise the control portion 350 (or e.g. the external control entity 370) issuing the heating control signal causing the heating arrangement to apply heating to defrost the non-opaque portion 240a. The heating may be applied e.g. for a predetermined period of time or until the condition that resulted issuing the heating control signal no longer holds. In the latter example, the control portion 350 (or the external control entity 370) may apply a predefined maximum time for continuous defrosting of the non-opaque portion 240a. Applying the heat may be especially beneficial when applying LEDs or other light sources of high energy efficiency (hence producing a low amount of heat as a by-product) as the light sources 110 in a lighting module 100 for use in a lighting apparatus for use outdoors or indoor environments where the temperature may drop below zero.

[0039] As an example, the heating arrangement may comprise one or more heating resistors arranged in the lighting module 100 on the base member 130. While such an approach facilitates providing a housing 240 of simple and durable structure, on the other hand the defrosting performance may be compromised due to distance between the heating resistor(s) and the non-opaque portion 240a of the housing 240. As another example, the heating arrangement may comprise one or more heating wires arranged in the non-opaque portion 240a, e.g. on an inner surface of the non-opaque portion 240 or between layers of a non-opaque portion 240a having a two-layer or a multi-layer structure. Such an approach enables applying the heat directly where needed in order to defrost the non-opaque portion 240a, while on the other hand it may make the structure of the housing slightly more complex.

[0040] Figure 4 schematically illustrates a lighting arrangement 400 comprising the lighting apparatus 200 hosting the lighting module 100 that is electrically coupled to a control portion 450. Like the control portion 350 described hereinbefore, the control portion 450 may be provided as hardware means, as software means, or as a combination of hardware means and software means, e. g. as a driver apparatus 460 or as a portion of the driver apparatus 460 for driving the operation of the lighting module 100 or the lighting apparatus 200 (e.g. as a LED driver or a portion thereof). The control portion 450 and/or the driver 460 may be further coupled to the external control entity 370 arranged to control operation of the operation of the control portion 450 and/or the driver 460.

[0041] The lighting arrangement 400 further comprises one or more external light sensors 420 for measuring the ambient light level outside the housing 240. In particular, the external light sensors 420 are arranged in locations in the vicinity of the lighting apparatus 200 such that they are insensitive to both direct and indirect light emitted by the light sources 110 of the lighting module 100. The external light sensors 420 may be provided as an external sensor arrangement comprising means for providing a (second) output signal based on (ambient) light level observed by the external light sensors 420. As in case of the lighting arrangement 300, also in the lighting arrangement 400 the (second) output signal may provide the light level indication (or a measurement signal) received from a single external light sensor 420 as such or the (second) output signal may be derived e.g. as the sum or as the average of the light level indications (or measurement signals) received from a plurality of external light sensors 420.

[0042] Like the control portion 350, also the control portion 450 is arranged to receive the output signal from the lighting module 100 and hence to receive the indication of the observed light level L as observed by the light sensors 120. The control portion 450 is further configured to receive the (second) output signal from the sensor arrangement, thereby being arranged to receive the indication of the ambient light level L_{ext} outside the housing 240 of the lighting apparatus 200.

[0043] The operation of the control portion 450 is similar to that of the control portion 350 with the exception of setting the reference light level L_{ref}. In this regard, the control portion 450 is configured to use the ambient light level L_{ext} as basis for deriving the reference light level. The ambient light level L_{ext} may be applied as such to set the reference light level L_{ref}, e.g. to set $L_{ref} = L_{ext}$, or the ambient light level L_{ext} may be applied indirectly e.g. by setting $L_{ref} = f * L_{ext}$, where $f < 1$ in order to compensate the reduction in light level due to transmission through the non-opaque portion 240a. Consequently, the control portion 450 is enabled to continuously track the ambient light level L_{ext} in vicinity of the housing 240 and to invoke the predetermined action in response the observed light level L drifting too far from the ambient light level L_{ext} outside the housing 240.

[0044] At least some of the operations, procedures and/or functions assigned to the control portion 350, 450 may be provided as steps of a method. As an example of this regard, Figure 5 illustrates a method 500 for controlling operation of the lighting arrangement 300, 400. The method 500 comprises receiving the output signal from the lighting module 100, i.e. receiving the indication of the light level L observed by the light sensors 110, as indicated in block 510. The method 500 further comprises comparing the observed light level L indicated in the output signal to the reference light level L_{ref}, as indicated in block 520. The reference light level L_{ref} may be set based on the observed light level L or based on an indication of the ambient light level L_{ext} outside the housing 240, as described hereinbefore.

[0045] The method 500 continues with evaluating whether the deviation between the observed light level L and the reference light level L_{ref} exceeds a predetermined threshold, as indicated in block 530 (indicted in block 530 as a simple non-equality operation for brevity). In case the deviation between the observed light level L and the reference light level L_{ref} is found to exceed a predetermined threshold (examples of which are described hereinbefore), the method 500 proceeds to invoking the predetermined action, as indicated in block 540. As described hereinbefore, the predetermined action may comprise issuing an indication to the external control entity 370 or issuing the heating control signal in order to defrost the non-opaque portion 240a. In case the deviation between the observed light level L and the reference light level L_{ref} is found not to exceed the predetermined threshold, the method 500 proceeds back to block 510. The method 500 may be varied in a number of ways, e.g. in view of the examples concerning operation of the lighting arrangement 300, 400 and/or the control portion 350, 450 provided hereinbefore.

[0046] Figure 6 schematically illustrates an exemplifying apparatus 700 that may be employed for embodying the control portion 350, 450. The apparatus 700 comprises a processor 710 and a memory 720, the processor 710 being configured to read from and write to the memory 720. The apparatus 700 may further comprise a communication interface 730 for enabling communication with another apparatuses or portions and/or a user interface 740 for receiving data and/or other input from a user and/or presenting information to the user. The apparatus 700 may comprise further components not illustrated in the example of Figure 6.

[0047] Although the processor 710 is illustrated as a single component, the processor 710 may be implemented as one or more separate components. Although the memory 720 is illustrated as a single component, the memory 720 may be implemented as one or more separate components, some or all of which may be integrated/removable and/or may provide permanent/semi-permanent/ dynamic/cached storage.

[0048] The memory 720 may store a computer program 750 comprising computer-executable instructions that control the operation of the apparatus 700 when loaded into the processor 710 and executed by the processor 710. As an example, the computer program 750 may include one or more sequences of one or more instructions. The computer program 750 may be provided as a computer program code. The processor 710 is able to load and execute the computer program 750 by reading the one or more sequences of one or more instructions included therein from the memory 720. The one or more sequences of one or more instructions may be configured to, when executed by one or more processors, cause an apparatus, for example the apparatus 700, to implement the operations, procedures and/or functions described hereinbefore in context of the control portion 350, 450.

[0049] Hence, the apparatus 700 may comprise at least one processor 710 and at least one memory 720 including computer program code for one or more programs, the at least one memory 720 and the computer program code configured to, with the at least one processor 710, cause the apparatus 700 to perform the operations, procedures and/or functions described hereinbefore in context of the control portion 350, 450.

[0050] The computer program 750 may be provided independently of the apparatus, and the computer program 750 may be provided at the apparatus 700 via any suitable delivery mechanism. As an example, the delivery mechanism may comprise at least one computer readable non-transitory medium having program code stored thereon, the program code which when executed by an apparatus cause the apparatus at least implement processing to carry out the operations, procedures and/or functions described hereinbefore in context of the control portion 350, 450. The delivery mechanism may be for example a computer readable storage medium, a computer program product, a memory device a record medium such as a CD-ROM, a DVD a Blue-ray Disc, a corresponding optical media, an article of manufacture that tangibly embodies the computer program 750, etc. As a further example, the delivery mechanism may be a signal configured to reliably transfer the computer program 750.

[0051] Reference to a processor should not be understood to encompass only programmable processors, but also dedicated circuits such as field-programmable gate arrays (FPGA), application specific circuits (ASIC), signal processors, etc. Features described in the preceding description may be used in combinations other than the combinations explicitly described. Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not. Although features have been described with reference to certain embodiments, those features may also be present in other embodiments whether described or not.

Claims

1. A lighting module for arrangement inside a housing that comprises a non-opaque portion for enabling light output from the lighting module, the lighting module comprising
a base member,
one or more light sources arranged on the base member,
one or more light sensors arranged in locations on the base member such that they are insensitive to direct light emitted by the one or more light sources and such that they are sensitive to indirect light from the one or more light sources, and
means for providing a first output signal based on light level observed by the one or more light sensors.

2. A lighting apparatus comprising
a housing for hosting a lighting module, the housing comprising a non-opaque portion for enabling light output from the lighting module arranged inside the housing,
a lighting module according to claim 1 arranged inside the housing
such that the direct light emitted by the one or more light sources is directed towards the non-opaque portion of the housing, and
such that the one or more light sensors are able to receive light arriving from direction of the non-opaque portion of the housing.

3. A lighting module according to claim 1 or a lighting apparatus according to claim 2, further comprising one or more heating resistors arranged on the base member in control of a heating control signal.

4. A lighting apparatus according to claim 2 further comprising one or more heating wires arranged in the non-opaque portion of the housing for defrosting the non-opaque portion in control of a heating control signal.

5. A lighting arrangement comprising
a lighting module according to claim 1 or a lighting apparatus according to claim 2, and
a control portion configured to
receive the first output signal, and
issue an indication regarding reduced light transmis-

sion via the non-opaque portion in response to a comparison of the light level indicated in the first output signal to a reference light level indicating deviation exceeding a predetermined threshold.

6. A lighting arrangement comprising
a lighting module according to claim 3 or a lighting apparatus according to claim 3 or 4, and
a control portion configured to
receive the first output signal, and
issue the heating control signal in response to comparison of the light level indicated in the first output signal to a reference light level indicating deviation exceeding a predetermined threshold.

7. A lighting arrangement according to claim 5 or 6, wherein the control portion is arranged to set the reference light level on basis of the light level indicated in the first output signal in response to a request.

8. A lighting arrangement according to claim 5 or 6, further comprising one or more external light sensors arranged outside the housing in locations such that they are insensitive to direct and indirect light from the one or more light sources, and
means for providing a second output signal based on light level observed by the one or more external light sensors,
wherein the control portion is arranged to set the reference light level on basis of the light level indicated in the second output signal.

9. A method for controlling operation of a lighting arrangement comprising a lighting module according to claim 1 or a lighting apparatus according to claim 2, the method comprising
receiving the first output signal, and
issuing an indication regarding reduced light transmission through the non-opaque portion in response to a comparison of the light level indicated in the first output signal to a reference light level indicating deviation exceeding a predetermined threshold.

10. A method for controlling operation of a lighting arrangement comprising a lighting module according to claim 3 or a lighting apparatus according to claim 3 or 4, the method comprising
receiving the first output signal, and
issuing the heating control signal in response to comparison of the light level indicated in the first output signal to a reference light level indicating deviation exceeding a predetermined threshold.

11. A method according to claim 9 or 10, further comprising setting the reference light level on basis of the light level indicated in the first output signal in response to a request.

12. A method according to claim 9 or 10, further comprising
receiving a second output signal derived based on light level observed by one or more external light sensors arranged outside the housing in locations such that they are insensitive to direct and indirect light from the one or more light sources, and
setting the reference light level on basis of the light level indicated in the second output signal.

13. A computer program for controlling a lighting arrangement comprising a lighting module according to any of claims 1, 2 or 3 or a lighting apparatus according to any of claims 2 to 4, the computer program comprising one or more sequences of one or more instructions which, when executed by one or more processors, cause an apparatus to at least perform the method according to any of claims 9 to 12.

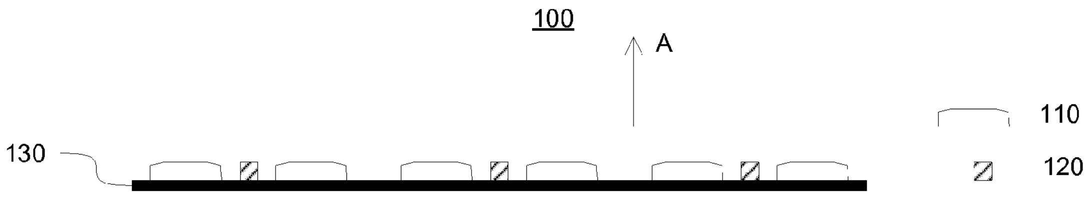

Figure 1a

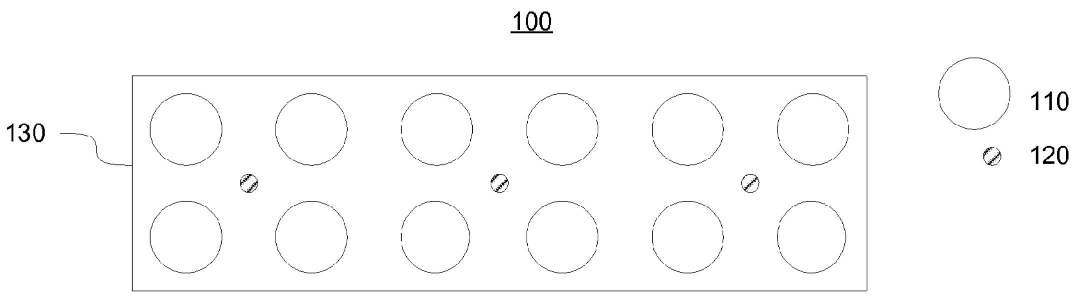

Figure 1b

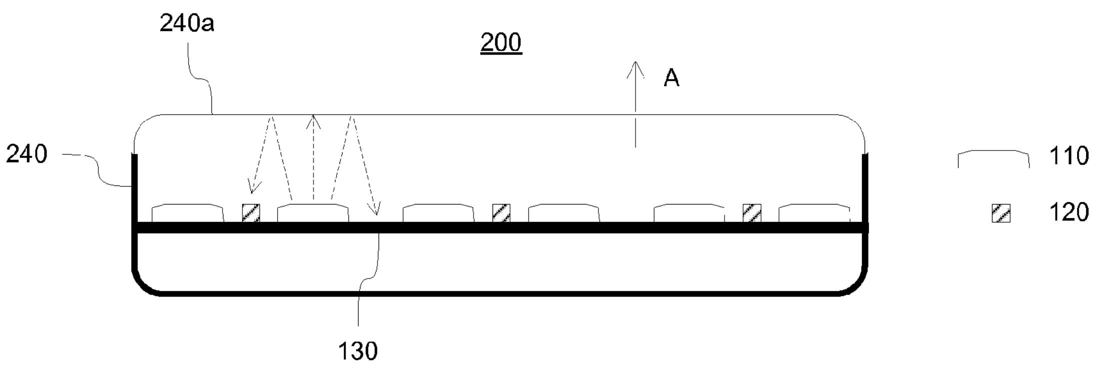

Figure 2

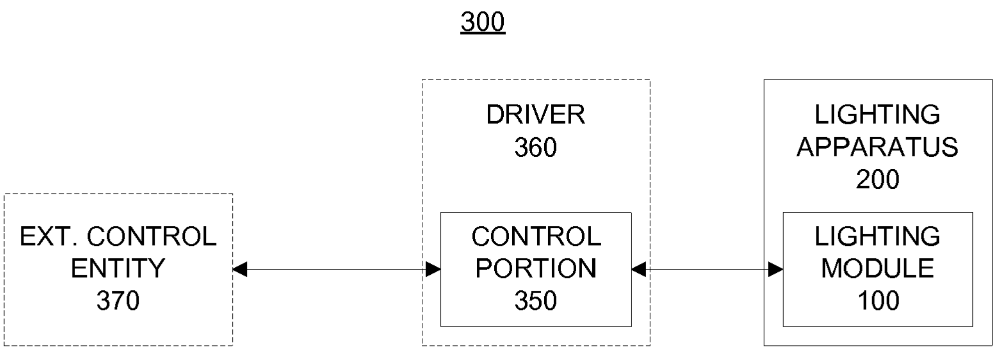

Figure 3

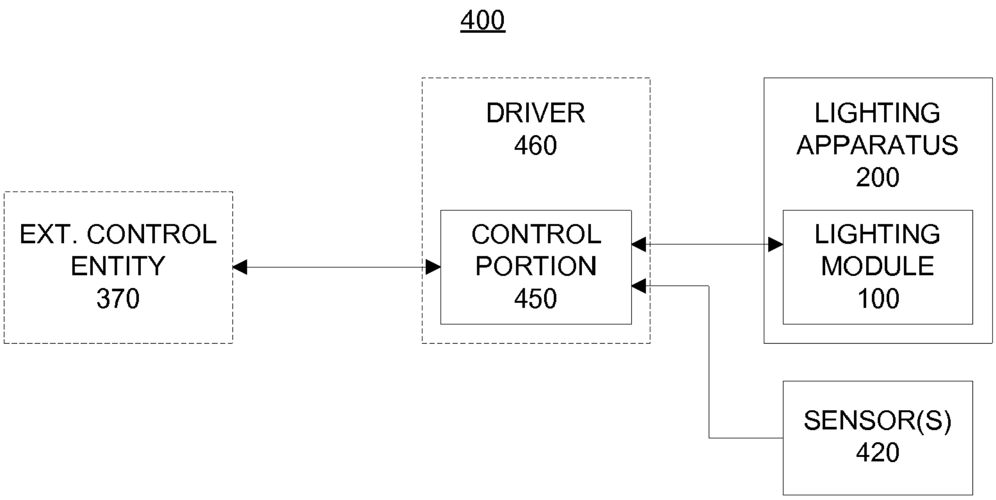

Figure 4

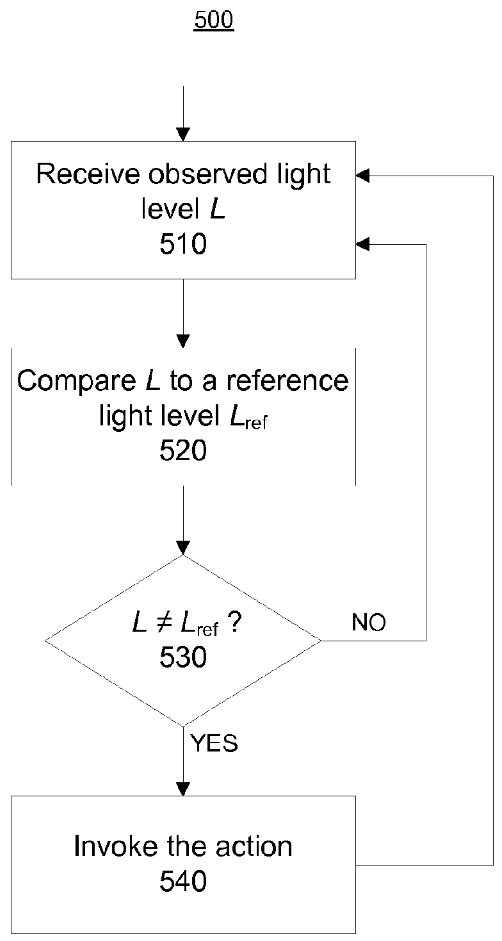

Figure 5

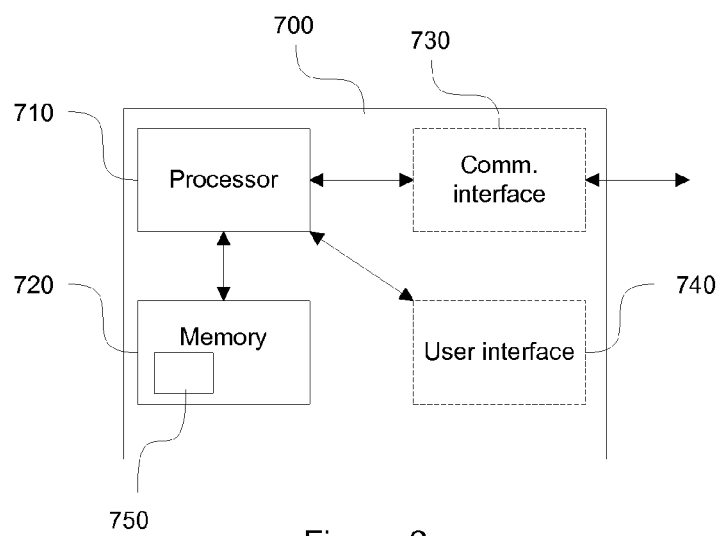

Figure 6

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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 5803

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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H05B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	24 April 2014	Brown, Julian

CATEGORY OF CITED DOCUMENTS

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