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(54) Title: LIGHTING SYSTEM, AND METHOD AND COMPUTER PROGRAM FOR CONTROLLING THE LIGHTING SYSTEM

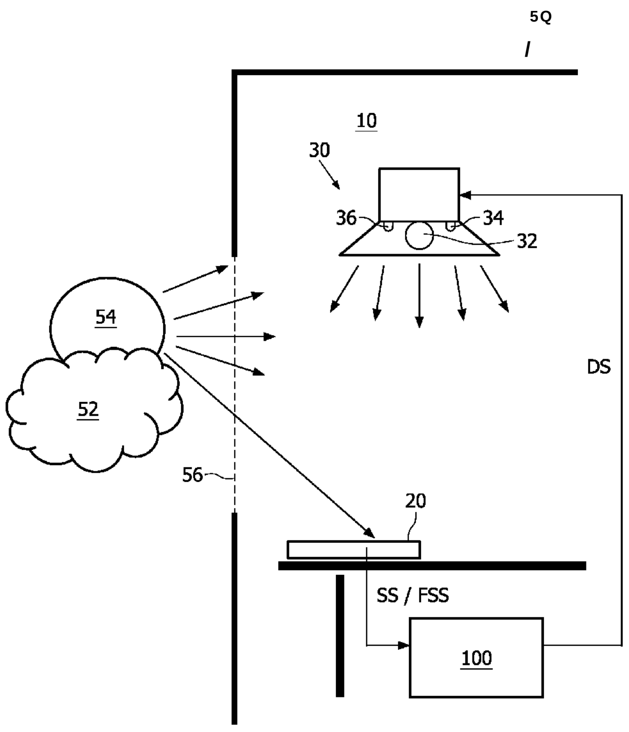

FIG. 1

(57) Abstract: The invention relates to a lighting system (10), a method of controlling the lighting system and a computer program product. The lighting system comprises a light source (30), a controller (100) for controlling the light source (30), and a light sensor (20). The light source is configured for altering a spectrum of the light emitted by the light source. The light sensor is arranged for sensing spectral information comprising at least two different portions of a spectrum of light impinging on the light sensor. The controller is configured for receiving a sense signal (SS) and for generating a drive signal (DS) supplied to the light source to determine the spectrum of the light emitted by the light source in dependence on the spectral information from the light sensor. The effect of the measures according to the invention is that the sensing of the spectral information of the light impinging on the light sensor enables the controller to adapt the color temperature of the light emitted by the light source such that the perceived color temperature more closely corresponds to the intended color temperature.

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Lighting system, and method and computer program for controlling the lighting system

FIELD OF THE INVENTION:

The invention relates to a lighting system comprising a light source, a controller and a light sensor.

The invention also relates to a method of controlling the lighting system and to a computer program arranged for performing the method of controlling the lighting system.

BACKGROUND OF THE INVENTION:

Such lighting systems are known per se. They are used, inter alia, as indoor lighting systems for general lighting purposes, for example, for office lighting or for shop lighting, for example, shop window lighting.

Such a lighting system is, for example, known from US patent US 5,861,717. In this US patent a lighting system is disclosed having at least one light source for supplying artificial light and a control unit for controlling the light source. The light source is of the type having an adjustable color temperature. The control unit is arranged to adjust the color temperature of the light source in dependence on the mean daylight level. The known lighting system provides artificial light which increases the color temperature from approximately 3300 K to 4300 K when the daylight level, as measured on an office desk, increases from approximately 400 lux to approximately 800 lux.

A disadvantage of the known lighting system is that the color temperature experienced by a user may not correspond to the intended color temperature.

SUMMARY OF THE INVENTION:

It is an object of the invention to provide a lighting system in which the experienced color temperature of the light emitted by the light source better corresponds to the intended color temperature.

According to a first aspect of the invention the object is achieved with a lighting system comprising a light source for emitting light, the light source being configured for altering a spectrum of the light emitted by the light source,

- a light sensor for sensing spectral information comprising at least two different portions of a spectrum of light impinging on the light sensor and for providing a sense signal, and
- a controller for receiving the sense signal and for generating a drive signal supplied to the light source to determine the spectrum of the light emitted by the light source in dependence on the spectral information from the light-sensor.

The at least two different portions cover different wavelength ranges of the spectrum of the light impinging on the light sensor, enabling part of the color spectrum of the light impinging on the light-sensor to be measured.

The effect of the measures according to the invention is that the sensing of at least two different portions of the spectrum of the light impinging on the light-sensor enables the controller to adapt the color temperature of the light emitted by the light source such that the perceived color temperature more closely corresponds to the intended color temperature. The color temperature in a room is determined by the light emitted by the light source together with other elements in the room which influence the perceived color temperature. The other elements, for example, are other light sources, or the ambient light which reflects from walls of the room, or, for example, sunlight which passes through a window and enters the room. Other light sources, which are not controlled by the controller, may influence the color temperature as perceived by the user. The ambient light level in the room, for example, resulting from reflection from a painted wall, will influence the perceived color temperature in the room. Furthermore, the ambient light in the room may, for example, include sunlight which is, for example, reflected from the painted wall which, for example, only reflects part of the spectrum of the light impinging on the wall. In the known lighting system only the intensity of the light is used to determine the color temperature of the light emitted by the light source. In such a system, the color temperature perceived by the user may not correspond to the color temperature emitted by the light source, due to the contributions of further light sources, the ambient light level and/or the impinging sunlight. In the lighting system according to the invention, the light sensor senses a spectrum of the light impinging on the sensor. In such a lighting system according to the invention, the light-sensor may, for example, be placed in the vicinity of the user. The sense signal is sent to the controller to verify the color temperature, which is measured by the light-sensor and thus perceived by the user. The controller consequently adapts the drive signal in dependence on the spectral information from the light sensor in order to adapt the spectrum of the light emitted by the light source in such a manner that the color temperature sensed by the light sensor corresponds more to the intended color temperature, and thus that the color temperature perceived by the user corresponds to a significantly higher degree to the intended color temperature.

Another benefit of the lighting system according to the invention is that the light emitted by the lighting system may be corrected for color variations of one or more light emitters in the light source due to, for example, aging of the specific light emitter in the light source and/or due to an increase of the temperature of the light emitter. The color of the light emitted by the light emitter generally changes over time. If, for example, the light emitter is a low-pressure gas discharge lamp, the color of the light emitted by a low-pressure gas discharge lamp changes over time due to different degradation characteristics of the different luminescent materials used in the low-pressure gas discharge lamps. If the light emitter is a solid-state light emitter, for example, a light emitting diode, the color of the light emitted by the solid-state light emitter is dependent on the temperature of the solid-state light emitter. When applying the low-pressure gas discharge lamp or the solid-state light emitter in the lighting system according to the invention, the light sensor senses at least two different portions of the spectrum part of the light impinging on the light sensor which, for example, includes the light emitted by the lighting system. In response to the sensed spectral information, the controller may dynamically control the spectral characteristic of the light emitted by the light source to correct any aging effect or degradation. This dynamic control of the spectral characteristic may be used to correct for any color variation of the light emitters due to, for example, aging and/or temperature.

In an embodiment of the lighting system, the light impinging on the light sensor comprises the light emitted by the light source and additional light. A benefit of this embodiment is that the light sensor senses at least two different portions of the spectrum of substantially all the light in a room, including, for example, sunlight entering through a window and ambient light from other light sources in the room or light reflected from other objects which may influence the color of the reflected light. Measuring substantially all the light in the room enables the controller to adapt the color of the light emitted by the lighting system such that the color of the light at the light sensor substantially corresponds to the required color.

In an embodiment of the lighting system, a major part of the light impinging on the light sensor is outdoor light. Outdoor light comprises all the light which is currently present, for example, outside a room. This outdoor light includes direct, impinging sunlight and reflected sunlight, for example, reflected from buildings. The light sensor may, for example, be placed outside the room to sense at least two different portions of the spectrum of the current daylight outside the room. A major part of the light means at least 50%, or preferably more than 80% of the light spectrum, either measured as an amount of energy or as a number of photons. The lighting system receives the sense signal comprising the spectral information of the daylight and may, for example, control the color of the light in the room to substantially correspond to the spectrum of the current daylight. Such a system may, for example, be suitable for illuminating a closed room, being a room having no windows and thus having substantially no daylight contribution to the illumination of the closed room. By controlling the light emitted by the light source so as to emulate the spectral variation of the current daylight, a person working in the room will still perceive the natural spectral variation as if there were a contribution of the daylight to the illumination of the closed room. Due to this mimicking of the spectral variation, the circadian rhythm of a person working in the closed room substantially remains in sync with the prevailing outdoor lighting conditions.

Such a closed room may, for example, also suitably be used to change the circadian rhythm of a person from one time zone to another, for example, when preparing to travel to another time zone or after arriving from another time zone. In the closed room, the controller may control the spectral variation of the light to gradually adapt the circadian rhythm of the person in the room to the required time zone. The spectral information of the current outdoor lighting may be used to enable a smooth transition from the current time zone or to the current time zone.

In an embodiment of the lighting system, the controller uses the spectral information from the light sensor to control the spectrum of the light emitted by the light source to maintain the spectrum of the light impinging on the light sensor substantially constant. The spectrum of the light impinging on the light sensor may change due to several reasons, such as: the contribution of sunlight changes, for example, when the sun is blocked by clouds or by sun blinds. Alternatively, the spectrum of the light impinging on the sensor may change because a user switches on another lamp in the room and part of the light thereof also impinges on the sensor. If the other lamp emits a different spectrum of light, the spectrum as measured by the light sensor changes. Also people moving through a room may alter the spectrum of the light due to reflections from these people and/or due to blocking of specific contributions to the light impinging on the light sensor. The controller receiving the altered sense signal may adapt the spectrum of the light emitted by the light source to substantially correct for the altered sense signal.

Alternatively, the controller uses the spectral information from the light sensor to control the spectrum of the light emitted by the light source to maximize the color rendering index of the light impinging on the light sensor. The color rendering index indicates the ability of light to reproduce the color of an object illuminated by the light. The color rendering index is determined by the spectrum of the light impinging on the object. Two light sources which emit, for example, substantially the same color may have a different color rendering index, depending on the individual spectral content of the light emitted by the two light sources. The color rendering is compared with the color rendering when the object is illuminated by a black-body-radiator. When the color of the light impinging on the sensor changes, the color rendering ability of the light changes. The controller may amend the spectrum of the light emitted by the light source such that the light impinging on the light-sensor has the highest color rendering index possible.

In a further embodiment, the controller uses the spectral information from the light sensor to ensure that the light impinging on the light sensor comprises a predetermined intensity and/or variation of light of a specific blue color, the specific blue color reducing the melatonin concentration in a human. It is well known in the art that light of the specific blue color influences the melatonin production in humans and that the level of melatonin influences alertness of the humans. So the light illuminating a room may comprise a predetermined intensity of light of the specific blue color and/or may comprise a predetermined variation of the light of the specific blue color during a day. When the light source has, for example, a surplus of different light emitters, the light source may have several means to generate light of a specific color. The controller may, for example, choose to generate a specific color while maintaining the level of light of the specific blue color at the required level to influence the level of alertness of the humans in the room.

In a further embodiment, the controller uses the spectral information from the light sensor to maximize the efficiency for generating a predetermined color of the light impinging on the light sensor. The light source may, for example, comprise different light emitters, for example, a combination of a low-pressure gas discharge lamp and a plurality of light emitting diodes. The controller may choose a specific combination of light emitters such that the required color may be produced at a minimal energy consumption. Light emitting diodes typically emit light of a predominant color having a relatively narrow spectral bandwidth around a center wavelength. The use of light emitting diodes enables the controller to efficiently add a specific color at the relatively narrow bandwidth and at a specific intensity to the emission spectrum of the light source to generate the predetermined color. Especially when the lighting system is used in office buildings, the energy consumption is a very important issue and should be controlled for environmental and cost reasons.

Light of a predominant color comprises light of a predefined spectral bandwidth around a center wavelength. For example, a light emitting diode emitting light of the predominant color Blue emits light at the center wavelength of, for example, 470 nanometer, having a spectral bandwidth of, for example, 10 nanometer. When using light emitters which emit light of the predominant colors Red, Green and Blue in the lighting system according to the invention, the lighting system according to the invention is able to emit substantially any color (including white) within a triangle as defined by the three predominant colors in the CIE color diagram. The predominant colors Red, Green and Blue are also indicated as primary colors. Also other combinations of light emitters emitting other predominant or primary colors may be used in the lighting system, for example, Red, Green, Blue, Cyan, Yellow and White.

In an embodiment of the lighting system, the light sensor is arranged for sensing the direction of the impinging light and for providing a further sense signal to the controller, the further sense signal comprising the directional information sensed by the light sensor. The directional information may be used by the controller to further control the light source, for example, to compensate the directional content of the light such that a surface is substantially uniformly illuminated. A further benefit of this embodiment is that the sunlight is optimally used. Typically, the sunlight is blocked and the artificial light is used to uniformly illuminate a surface of a table. When using the system in which directivity of the light is used and compensated for, the sunlight is optimally used and the intensity of the artificial light source may be reduced to save energy.

The controller may use the directional information to activate, for example, sun blinds for blocking the impinging directional light. The directional information, for example, provides information as to which sun blinds to activate in order to block the impinging directional light.

Alternatively, the directional information may, for example, be measured outside the room and may be used to imitate the directionality of the illumination in the room and thus to substantially correspond to the measured directional information outside the room. This may beneficially be used in a closed room in which no sunlight can enter, and in which you want to have the same directionality effect as currently on the outside.

In addition, the lighting system may use additional information, such as the day, daytime and geographical location to calculate the expected direction of the sunlight. This embodiment may be beneficial when the sun is temporarily blocked by clouds and when the adaptation of the lighting system to compensate for the directional light takes time. The part of the lighting system which has to compensate for the directional light may be preset depending on the day, daytime and geographical location and may be switched on as soon as the sun is no longer blocked by the clouds. The geographical location may be inputted by hand or may be retrieved from a GPS system, after which the geographical location is, for example, stored in the controller or in a storage medium connected to the controller.

In an embodiment of the lighting system, the lighting system comprises an additional light sensor providing a further sense signal to the controller, the additional light sensor being arranged for sensing a direction of the impinging light and the further sense signal comprising the directional information sensed by the additional light sensor. Using a different sensor for the spectral information and the directional information has the benefit that both sensors may be optimized for gathering the spectral information and the directional information, respectively, such that the individual sensors are more accurate.

In an embodiment of the lighting system, the additional light sensor comprises a plurality of light sensors arranged at a distance from each other, the sensing of the direction being derived from differences between the intensities of the plurality of light sensors. The use of a plurality of light sensors may also serve to more gradually control the light inside a room. For example, when a person walking through a room blocks the light sensor, the whole illumination of the room may change. If, on the other hand, a plurality of light sensors is used to determine the illumination of the room, the blocking of a single sensor of the plurality of sensors by the person walking through the room may, for example, be disregarded if the sense signal from the remainder of the sensors of the plurality of sensors does not change.

In an embodiment of the lighting system, the light source is arranged for altering the direction of the light emitted from the light source in response to a further drive signal from the controller. The direction of the emitted light is altered, for example, by using servo motors for changing the orientation of the light emitters in the light source and hence the direction of the light emitted by the light emitters. Alternatively, a plurality of light emitters may be used, and some of these light emitters, when in operation, emit light in a different direction. This may be compensated for by selectively switching on some of the light emitters of the plurality of light emitters. Also moving collimators, mirrors and/or lenses may be used to alter the direction of the light emitted by the light emitters. As indicated above, the alteration of the direction may be used to compensate for the sensed directionality of, for example, impinging sunlight or impinging light from a different light source. Alternatively, the alteration of the direction of the emitted light may be used for emulating the sensed directionality of, for example, the sunlight impinging on the sensor such that the indoor lighting substantially continuously is similar to the outdoor lighting. Such an embodiment may, for example, be beneficial in closed rooms where no sunlight can enter. The sensor may be placed outside and sense the spectral information from the sunlight and sense the direction of the sunlight. The lighting system, for example, emulates the current outdoor sunlight by emitting light having substantially the same spectrum and/or direction, such that the circadian rhythm of a person in the room remains in sync with the prevailing outdoor lighting conditions.

In an embodiment of the lighting system, the controller generates the drive signal and/or the further drive signal in dependence on a clock. The clock determines the time of day and thus may be used to determine, for example, the required stage in the circadian rhythm of a human. The light emitted by the lighting system may be adapted to comply with the light associated with the required stage in the circadian rhythm.

Alternatively, the controller generates the drive-signal and/or the further drive signal in dependence on a calendar. The controller may take specific seasonal variations into account when controlling the light emitted by the light source. Again, the use of the calendar may aid in providing light corresponding to the circadian rhythm or may aid in changing the circadian rhythm of a human.

The controller may also generate the drive signal and/or the further drive signal in dependence on manual input from manual input means. A human may, for example, override the programming of the controller to generate the lighting levels and colors of his choice.

The controller may further generate the drive signal and/or the further drive signal in dependence on input from a biosensor, the biosensor being arranged for sensing a biological state of a user. By measuring the biological state of the user, the current state of the circadian rhythm may be determined and/or a general state of well-being of the user may be determined. The controller may anticipate the sensed signals and adapt the color and/or intensity of the light emitted by the light source to correspond to the sensed biological state. In this context, a biosensor is any sensor which provides an indication of the well-being or biological state of a human. This, for example, includes heart-beat sensors and temperature sensors worn on the body of the human. However, this also includes a feedback signal indicating, for example, the typing speed of somebody working behind a desk. The typing speed variation may be an indication of the level of alertness of the person behind the computer. This information may, for example, be used by the controller to adapt the drive signal and/or the further drive signal accordingly.

The controller generates the drive signal and/or the further drive signal in dependence on the maintained history stored on a memory module. The user may, for example, override the current program of the controller via manual inputs. The controller logs the history of, for example, the manual inputs in the memory module and uses this history to adapt the standard programming to more closely correspond to the requirements of the user as indicated via the manual overrides. Alternatively, the history of the sensed biological state of the user may be stored on the memory module and used to anticipate the light color and/or level which may currently be preferred by the user.

In an embodiment of the lighting system, the light source comprises at least two light emitters, the spectrum of the light emitted by the at least two light emitters being different from each other. By adapting the intensity of the at least two light emitters individually, the spectrum of the light emitted by the light source can be altered.

In an embodiment of the lighting system, one of the at least two light emitters is a light emitting diode. For example, a combination of a low-pressure gas discharge lamp and a light emitting diode provides the possibility to alter the color of the light emitted by the light source, while requiring a relatively low energy contribution. This is due to the typical emission spectrum of light emitting diodes which comprise a predominant color having a relatively narrow bandwidth. Only the required amount of a specific color is added to mix with the other light source such that the light emitted by the light source comprises the required color.

In an embodiment of the lighting system, the light source includes light emitting diodes emitting a primary color, wherein the number of primary colors emitted by different light emitting diodes is in excess of three. Generally, using three primary colors enables every color, including white, to be made that lies within the triangle defined by the three primary colors. Adding a further primary color has as a first benefit that the gamut of colors that can be produced by the system is increased. A further benefit is that using more than three colors generally allows some colors to be generated by asubstantially infinite combinations of intensities of the different primary color light emittingdiodes . Due to this benefit, the lighting system is able to choose the combination and intensity of the specific light sources which produce the required color in addition to a further constraint, for example, to maximize the contribution of the specific blue color or to vary the contribution of the specific blue color according to a predefined variation during the day. Alternatively, the light source may adapt the color of the light emitted by the lighting system while complying with the further constraint of, for example, maximizing the color rendering index of the light emitted by the lighting system, or maximizing the efficiency of generating the required color of the light emitted by the lighting system.

The invention also relates to a method according to claim 13 and to a computer program product according to claim 14.

BRIEF DESCRIPTION OF THE DRAWINGS :

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 shows a schematic overview of a lighting system according to the invention,

Fig. 2 shows a CIE-diagram in which the color gamut in a multi-primary system is shown, and

Fig. 3 shows a schematic overview of a controller of the lighting system according to the invention.

The figures are purely diagrammatic and not drawn to scale. Particularly for clarity, some dimensions are exaggerated strongly. Similar components in the figures are denoted by the same reference numerals as much as possible.

DETAILED DESCRIPTION OF EMBODIMENTS:

Fig. 1 shows a schematic overview of a lighting system 10 according to the invention. The lighting system 10 is arranged inside a room 50, for example a living room 50 in a house, or, for example, an office 50. The lighting system 10 comprises a light source 30, a light sensor 20 and a controller 100. The light source 30 is configured for altering the spectrum of the light emitted by the light source 30 in dependence on a received drive signal DS. The light sensor 20 is configured for sensing spectral information comprising at least two different portions of the spectrum of light impinging on the light sensor and for providing a sense signal SS to the controller 100. The sense signal SS comprises the spectral information of the impinging light as measured by the light sensor 20. The controller 100 is configured for receiving the sense signal SS and for generating the drive signal DS. The drive signal DS generated by the controller 100 is configured to determine the spectrum of the light source 30 in dependence on the spectral information from the light sensor 20.

The light source 30 comprises a plurality of light emitters 32, 34, 36. The light source 30 as shown in Fig. 1 comprises a low-pressure gas discharge lamp 32 which emits, in operation, a specific spectrum of light depending on the mixture of luminescent materials used in the low-pressure gas discharge lamp. The light source 30 as shown in Fig.l further comprises a plurality of light emitting diodes 34, 36 as light emitters. The light emitting diodes 34, 36 may be rows of light emitting diodes 34, 36 which are arranged substantially parallel to the low-pressure gas discharge lamp 32.

Preferably, the light source 30 comprises a light-mixing element (not shown) to mix the contributions of the different light emitters 32, 34, 36 such that the light emitted by the light source 30 is substantially homogeneous and uniform.

Alternatively, the light source 30 may comprise means (not shown) to alter the direction of the individual light emitters 32, 34, 36. The light source 30 is arranged for receiving a further drive signal FDS (see Fig. 3) from the controller 100 for controlling the direction of the individual light emitters 32, 34, 36. The means to alter the direction may be used to compensate for a sensed directionality or to induce the directionality of the light emitted by the light source 30. The means for altering the direction of the light may be, for example, motors (not shown) for altering the orientation of the light emitters 32, 34, 36 inside the light source 30, or, for example, moving lens-elements, mirrors or collimators for altering the direction of the light emitted by the individual light emitters 32, 34, 36.

The light sensor 20 is arranged for sensing the spectral information comprising at least two different portions of the spectrum of the light impinging on the light sensor 20. As can be seen from the schematic arrangement in Fig.l, the light impinging on the light-sensor 20 is not only light from the light source 30, but also contains contributions of the light emitted by the sun 54 which passes through the window 56 and impinges on the light sensor 20. The light sensed by the light sensor 20 may also comprise light which is reflected from any of the walls of the room 50, or reflected from any object inside the room 50. This reflected light typically changes color when the object or wall from which the light has been reflected is not white. This contribution causes the spectrum of the light sensed by the light sensor 20 to be different from the spectrum of the light emitted by the light source 30. The light sensor 20 is further arranged for providing a sense signal SS to the controller 100. The sense signal SS comprises the spectral information sensed by the light sensor 20.

In an alternative embodiment, the light sensor 20 may also sense the directionality of the light impinging on the light sensor 20. In such an embodiment, the light sensor 20 is arranged to generate a further sense signal FSS which comprises the directional information as sensed by the light sensor 20. The sense-signal SS and/or the further sense signal FSS are sent to the controller 100 and are used by the controller 100 to generate the drive signal DS which is sent to the light source 30 for determining the spectrum of the light emitted by the light source 30 and/or for determining the direction of the light emitted by the light source 30.

The controller 100 generates the drive signal DS for driving the light source 30. The drive signal DS may be generated by the controller 100 such that the spectrum of the light emitted by the light source 30 and impinging on the light sensor 20 remains uniform When the sun 54 is partially covered by a cloud 52, the contribution of the sunlight which enters through the window 56 changes, which is sensed by the light sensor 20. The controller 100 receives the spectral information via the sense signal SS of the light sensor 20 and alters the spectrum and/or intensity of the light emitted by the light source 30 such that the color or spectrum of the light impinging on the light sensor 20 remains substantially constant.

Alternatively, the controller 100 may generate the drive signal DS for driving the light source 30 such that the light impinging on the light sensor 20 has a maximized color rendering index. When, for example, part of the impinging light from the sun 54 is shielded by the cloud 52, the controller may adapt the drive signal DS such that the color of the light in the room 50 substantially remains the same. However, the spectral contribution of the light inside the room 50 may have changed and thus the color rendering possibilities of the light may have changed. The controller 100 may adapt the drive signal DS such that the color rendering of the light inside the room 50 always enables a maximum color rendering index to be achieved with the current light source 30. This may be especially beneficial in shops where, for example, it is very important to show the true color of an object.

In a further embodiment of the controller 100, the drive signal DS may be generated to obtain a predetermined intensity and/or variation of light of the specific blue color Bs (see Fig. 2). Typically, this is only possible when the light source 30 comprises light emitters 32, 34, 36 which are able to produce the specific blue color Bs. In such a lighting system 10, the controller 100 may influence the well-being, alertness and circadian rhythm of a person who is in the room 50.

In a further alternative embodiment of the controller 100, the drive signal DS may be generated to generate the required color of the light in the room 50 in a most energy-efficient way. Because light emitting diodes 34, 36 typically have a relatively narrow spectrum (not shown), the use of light emitting diodes 34, 36 enables a very specific contribution of light of a color to the light emitted by the light source 30, so that the color can be changed in a very efficient way.

The sense signal SS, further sense signal FSS, the drive signal DS and the further drive signal FDS may be signals which are transmitted via a wire or wirelessly (not indicated) and continuously or periodically. When the signals are transmitted continuously, the lighting system 10 responds relatively rapidly to changes in the lighting conditions in the room 50, while, when the signals are transmitted periodically, the lighting system 10 responds relatively slowly to changing lighting conditions.

Fig. 2 shows a CIE-diagram 60 in which the color gamut 70 in a multi-primary system R, A, G, C, B, Bs is shown. The color gamut 70 is a gamut 70 of a light source 30 (see Fig. 1) which comprises at least six light emitting diodes 34, 36, each light emitting diode 34, 36 emitting a different color. The color gamut 70 is constituted of light emitting diodes 34, 36 emitting the primary colors Red R, Yellow A, Green G, Cyan C, Blue B and the specific blue color Bs. Also indicated in the CIE-diagram 60 is the Black-Body-curve 62 which defines the color variation of a black-body radiation when its temperature changes. As can clearly be seen in Fig. 2, the light source 30 having the current color gamut 70 may use an infinite number of combinations to generate a specific color, indicated in Fig. 2 with reference X on the Black-Body-curve 62. Due to the access of light emitters 34, 36, the lighting system 10 may emit light of a predefined color while complying with some additional constraints. Such an additional constraint may be, for example, to maximize the color rendering effect of the light emitted by the light source 30, or, for example, to have a predetermined intensity of the specific Blue color Bs to influence the circadian rhythm of a human in the room 50 (see Fig. 1), or to alter the level of alertness of the human in the room 50. If the different light emitters 34, 36 may have different efficiencies, the controller 100 (see Fig. 1) may also, for example, choose a specific combination of primary colors R, A, G, C, B, Bs which provide the required color of the light emitted from the light source 30 at the highest efficiency.

Fig. 3 shows a schematic overview of a controller 100 of the lighting system 10 according to the invention. The controller 100 as shown in Fig. 3 comprises a clock 102 for determining the time of day, which may be used as a timer, for example, for switching off the system to save energy, or which may be used to adapt or control the circadian rhythm of a human. The controller further comprises a calendar 104 which enables the controller 100 to implement specific seasonal variations into the light emitted by the light source 30. For example, when the light source 30 is able to generate UV-A and/or UV-B radiation, the controller 100 may add some UV-A and/or UV-B light to the light emitted by the light source 30, for example, to ensure a healthy vitamine-D concentration in a human inside the room 50 (see Fig. 1). The controller 100 may further comprise input means for receiving manual input from manual input means 106. These manual input means 106 enable a user to override the programming of the controller 100 to generate the light levels and/or colors of his choice. A further input means, for example, is arranged for receiving an input signal from a biosensor 108. The biosensor 108 senses a biological state of a user, for example, it measures the well-being of the human, or measures the concentration of melatonin in the human or measures bio-parameters from which the location in the circadian rhythm of the human can be determined. A biosensor may be any sensor which provides an indication of the bio-parameters of a human, such as his heartbeat, his temperature, etc. The controller shown in Fig. 3 further comprises a memory module 110 to store, for example, a history of the manual inputs of the user and/or of the biosensor signal.

The controller 100 further comprises sensor input means via which the sense signal SS is received from the light sensor 20 and via which the further sense signal FSS is received from the additional light sensor 25. The light sensor 20, for example, senses spectral information comprising at least two different portions of a spectrum of light impinging on the light sensor 20. The sense signal comprises the spectral information sensed by the light sensor 20. The additional light sensor 25, for example, senses the directionality of the light impinging on the additional light sensor 25. The further sense signal FSS comprises the directional information sensed by the additional light sensor 25.

The controller 100 further comprises output means for providing the generated drive signal DS and the further drive signal FDS to the light source 30 (see Fig. 1). The drive signal DS determines the spectrum of the light emitted by the light source 30. The further drive signal FDS determines the direction of the light emitted by the light source 30. The drive signal DS and the further drive signal FDS may also be combined into a single signal sent by the controller 100 to the light source 30.

Memory module 110 may, for example, store specific characteristics of the light emitters 32, 34, 36 (see Fig. 1) to enable determination of the color rendering of the emitted light and to enable determination of the efficiency of producing a specific color. Furthermore, the memory module 110 may be used for storing the history of, for example, manual inputs of the user or biosensor signals from the bio-sensor 108 such that the processor 101 of the controller 100 may use this history for, for example, self-learning purposes.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims.

In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. Lighting system (10) comprising:

- a light source (30) for emitting light, the light source (30) being configured for altering the spectrum of the light emitted by the light source (30),

- a light sensor (20) for sensing spectral information comprising at least two different portions of the spectrum of light impinging on the light sensor (20) and for providing a sense signal (SS), and

- a controller (100) for receiving the sense signal (SS) and for generating a drive signal (DS) supplied to the light source (30) to determine the spectrum of the light emitted by the light source (30) in dependence on the spectral information from the light sensor (20).

2. Lighting system (10) as claimed in claim 1, wherein the light impinging on the light sensor (20) comprises the light emitted by the light source (30) and additional light.

3. Lighting system (10) as claimed in claim 1, wherein a major part of the light impinging on the light sensor (20) is outdoor light.

4. Lighting system (10) as claimed in claim 1, 2 or 3, wherein the controller (100) uses the spectral information from the light sensor (20) to control the spectrum of the light emitted by the light source (30):

- to maintain the spectrum of the light impinging on the light sensor (20) substantially constant, and/or

- to maximize the color rendering index of the light impinging on the light sensor (20), and/or

- to ensure that the light impinging on the light sensor (20) comprises light of a specific blue color (Bs) having a predetermined intensity and/or variation , the specific blue color (Bs) reducing the melatonin concentration in a human, and/or

- to maximize the efficiency for generating a predetermined color of the light impinging on the light sensor (20, 25).

5. Lighting system (10) as claimed in claim 1, 2, 3 or 4, wherein the light sensor (20) is arranged for sensing the direction of the impinging light and for providing a further sense signal (FSS) to the controller (100), the further sense signal (FSS) comprising the directional information sensed by the light sensor (20).

6. Lighting system (10) as claimed in claim 1, 2, 3 or 4, wherein the lighting system (10) comprises an additional light sensor (25) providing a further sense signal (FSS) to the controller (100), the additional light sensor (25) being arranged for sensing the direction of the impinging light, and the further sense signal (FSS) comprising the directional information sensed by the additional light sensor (25).

7. Lighting system (10) as claimed in claim 6, wherein the additional light sensor (25) comprises a plurality of light sensors arranged at a distance from each other, the sensing of the direction being derived from differences between the intensities of the plurality of light sensors.

8. Lighting system (10) as claimed in claim 5, 6 or 7, wherein the light source (30) is arranged for altering the direction of the light emitted from the light source (30) in response to a further drive signal (FSS) from the controller (100).

9. Lighting system (10) as claimed in any one of the preceding claims, wherein the controller (100) generates the drive signal (DS) and/or the further drive signal (FDS) in dependence on:

- a clock (102), and/or
- a calendar (104), and/or
- manual input from manual input means (106), and/or
- biosensor input from a biosensor (108), the biosensor (108) being arranged for sensing the biological state of a user, and/or
- a maintained history stored on a memory module (110).

10. Lighting system (10) as claimed in any one of the preceding claims, wherein the light source (30) comprises at least two light emitters (32, 34, 36), the spectrum of the light emitted by the at least two light emitters (32, 34, 36) being different from each other.

11. Lighting system (10) as claimed in claim 10, wherein one of the at least two light emitters (32, 34, 36) is a light emitting diode (34, 36).

12. Lighting system (10) as claimed in claim 10 or 11, wherein the light source (30) includes light emitting diodes (34, 36) emitting a primary color (R, G, B, C, A), and wherein the number of primary colors (R, G, B, C, A) emitted by different light emitting diodes is in excess of three (R, G, B, C, A).

13. Method of controlling a lighting system (10), the lighting system (10) comprising a light source (30) for emitting light, the light source (30) being configured for altering the spectrum of the light emitted by the light source (30), a light sensor (20) for sensing spectral information comprising at least two different portions of the spectrum of light impinging on the light-sensor (20) and for providing a sense signal (SS), and a controller (100) for receiving the sense signal (SS) and for generating a drive signal (DS) supplied to the light source (30), wherein the method comprises the step of:

- generating the drive signal (DS) for determining the spectrum of the light emitted by the light source (30) in dependence on the spectral information from the light sensor (20)

14. A computer program product stored on a computer-readable medium, the computer program product being arranged to perform the method as claimed in claim 13.

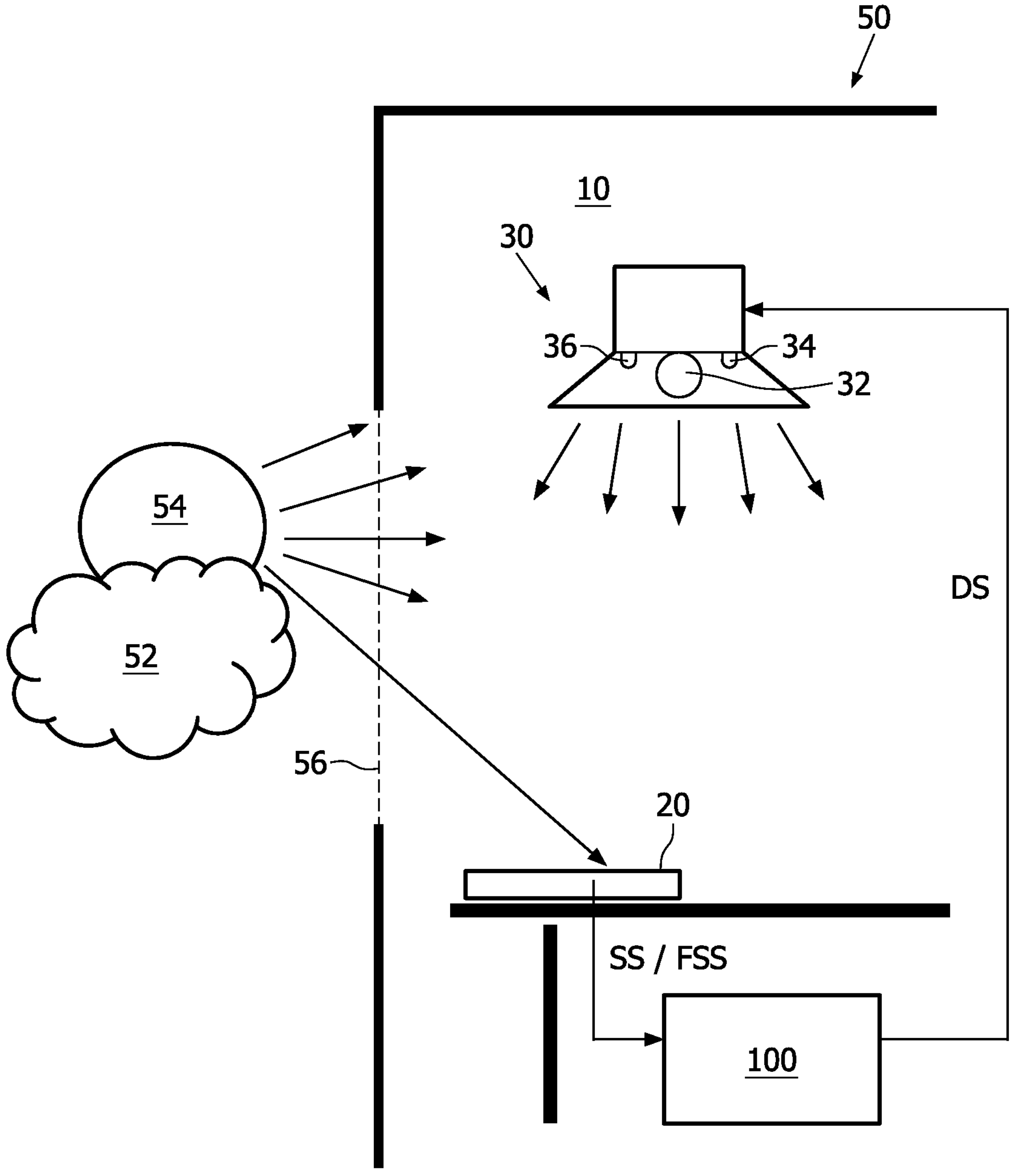
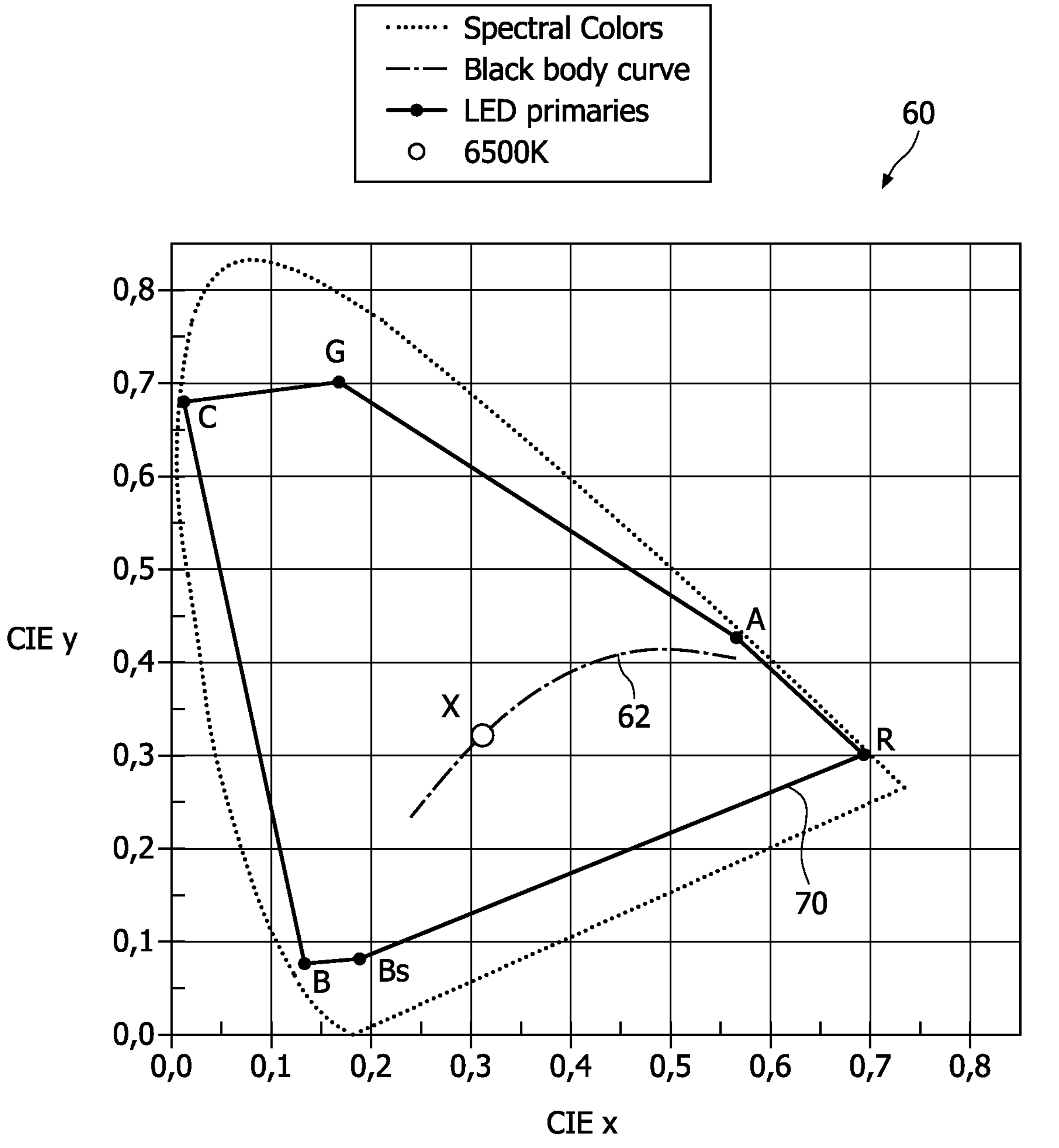


FIG. 1


Spectral Colors
Black body curve
LED primaries
6500K
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CIE y
CIE x
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0,1
0,2
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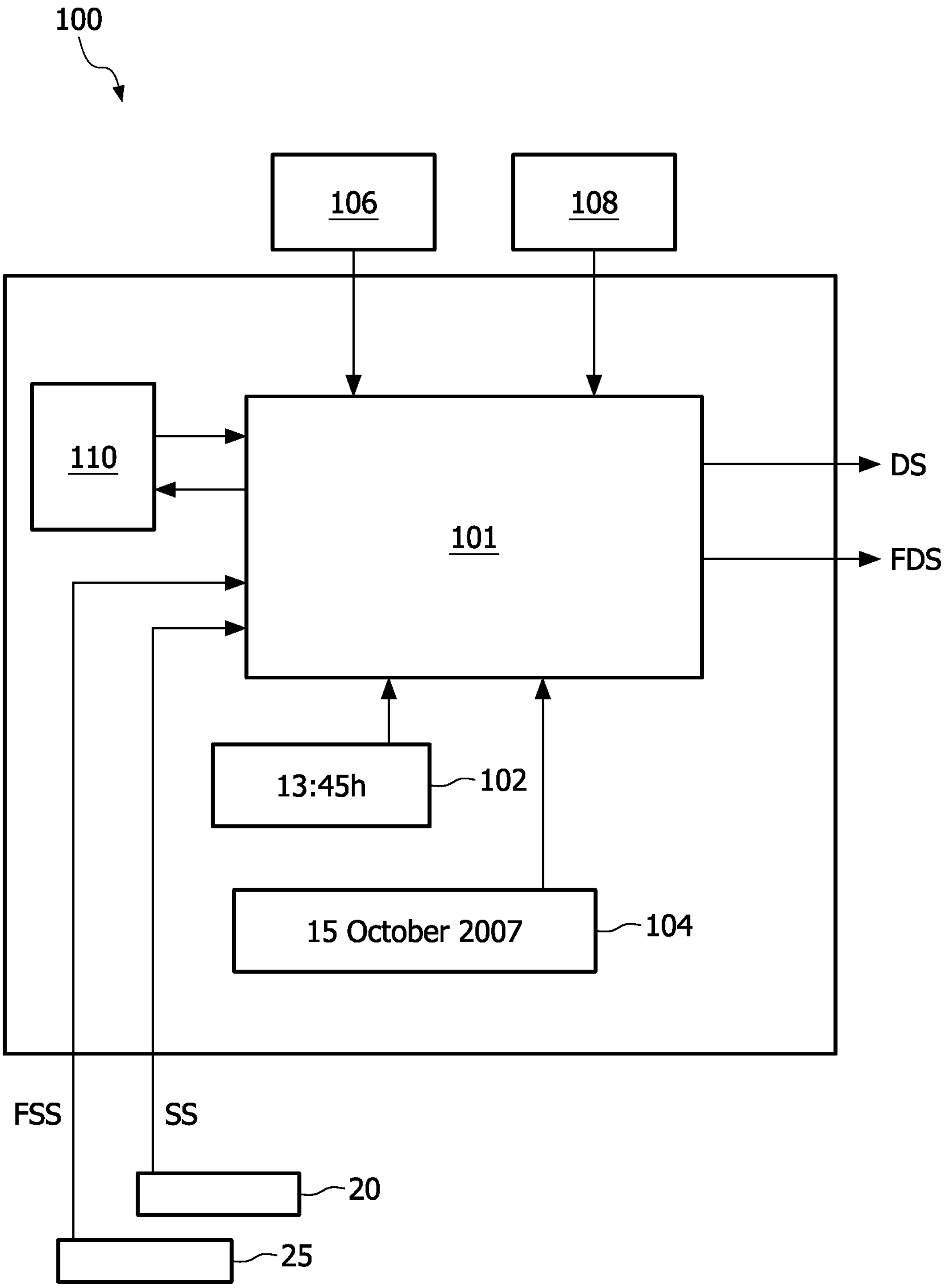
0,6
0,7
0,8
G
C
A
R
X
62
70
B
Bs

FIG. 2


100
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101
DS
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102
15 October 2007
104
FSS
SS
20
25

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/053959

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05B37/02

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

B. RELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B

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

Electronic data base consulted dunng the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	EP 1 067 825 A (TARGETTI SANKEY SPA [IT]) 10 January 2001 (2001-01-10) page 3, paragraph 14 page 3, paragraph 17 page 3, paragraph 18 figure 5a -----	1-14
X	EP 1 821 582 A (FAGERHULTS BELYSNING AB [SE]) 22 August 2007 (2007-08-22) column 4, paragraph 15-17 column 5, paragraph 18 column 6, paragraph 22 column 7, paragraph 28 ----- -/--	1-14

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents

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

"E" earlier document but published on or after the international filing date

'L' document which may throw doubts on priority daım(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

'P' document published prior to the international filing date but later than the priority date claimed

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

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

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

'&' document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 January 2009	26/01/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P B 5818 Patentlaan 2 NL - 2280 HV RI|SWI|k Tel (+31-70) 340-2040, Fax (+31-70) 340-3016	Benedetti , Gabriele

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/053959

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
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A	US 2007/189000 A1 (PAPAMICHAEL KONSTANTINOS [US] ET AL) 16 August 2007 (2007-08-16) -----	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2008/053959

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