(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 487 265 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.05.2019 Bulletin 2019/21

(51) Int Cl.:
H05B 33/08 *(2006.01)*

(21) Application number: **17201953.1**

(22) Date of filing: **15.11.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Vestel Elektronik Sanayi ve Ticaret A.S.**
45030 Manisa (TR)

(72) Inventor: **KÍRÍSKEN, Barbaros**
45030 Manisa (TR)

(74) Representative: **Flint, Adam**
Page White & Farrer
Bedford House
John Street
London WC1N 2BF (GB)

(54) **LIGHTING APPARATUS FOR A DISPLAY DEVICE**

(57) A lighting apparatus has a plurality of light sources (31) for emitting light. The lighting apparatus has a reflective element (33) and a photodetector (34). The light sources (31) are located at different respective locations on a surface (32). The reflective element (33) is arranged to receive light from at least two of the plurality of light sources (31) and to direct the received light to the photodetector (34). The photodetector (34) is located at a location on the surface that is between the locations of the at least two light sources (31). The lighting apparatus may be used in a display device (50), with each of the light sources being operable to generate an image for display at a screen of the display device (50).

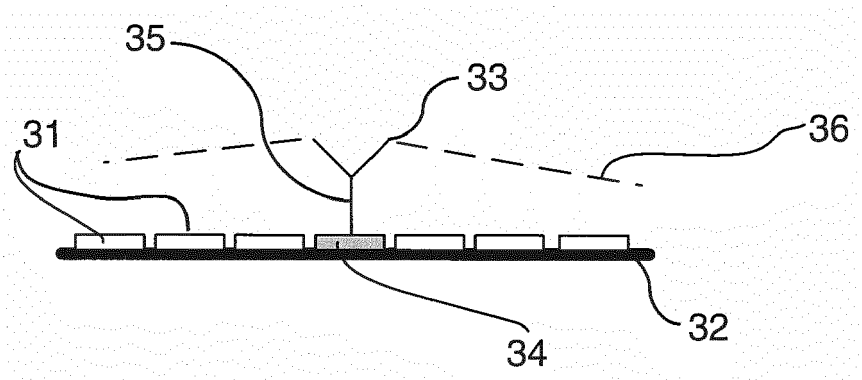

Fig. 3

EP 3 487 265 A1

Description

Technical Field

[0001] The present disclosure relates to a lighting apparatus and to a display device.

Background

[0002] Light sources are used in a variety of consumer apparatus and devices. These include, for example, display devices. In devices such as these, it is desirable that the light sources are calibrated. This ensures, for example, that the light output by the individual pixels can be controlled in a predictable and uniform manner. Generally, calibration of the light sources is done during the manufacture of the device that employs the light sources. However, variations in the behaviour of the individual light sources can develop over time, as the device is used. These variations can have an unwanted effect on for example the intensity and / or colour of the light that is output by the device.

Summary

[0003] According to an aspect disclosed herein, there is provided a lighting apparatus comprising:

a plurality of light sources for emitting light;
a reflective element; and
a photodetector;
the light sources being located at different respective locations on a surface;
the reflective element being arranged to receive light emitted by at least two of the plurality of light sources and to direct the received light to the photodetector; and
the photodetector being located at a location on the surface that is between the locations of the at least two light sources.

[0004] In examples, the lighting apparatus allows the light output by two or more light sources to be monitored accurately (by virtue of being located close to the two or more light sources), whilst providing minimal interference with the overall light that is output by the apparatus (by virtue of the photodetector occupying a small portion of the surface).

[0005] In an example, the photodetector is configured to detect at least one of the colour and luminance of the light emitted by the at least two light sources.

[0006] In an example, the reflective element comprises a conical mirror having an outwardly facing reflective surface for receiving light from the at least two light sources.

[0007] In an example, the photodetector is configured to measure an average luminance of light received from at least light sources that are nearest neighbours of the photodetector.

[0008] In an example, the photodetector is configured to measure an average luminance of light received from at least light sources that are nearest neighbours and next-nearest neighbours of the photodetector.

[0009] In an example, the lighting apparatus comprises plural reflective elements, each reflective element being configured to receive light from a different group of light sources.

[0010] In an example, the photodetector comprises a diffusive layer, the diffusive layer overlaying a surface of the photodetector that is arranged to receive light.

[0011] In an example, the reflective element comprises a diffusive layer, the diffusive layer overlaying an outward reflective surface of the reflective element.

[0012] In an example, the light sources are arranged in a regular array, with the light sources and the or each photodetector being located being located at nodes of the array.

[0013] In an example, the lighting apparatus comprises a controller, the controller being coupled to the photodetector, the controller being configured to control the output of the light sources based on an input received from the photodetector.

[0014] In an example, each light source is an inorganic or organic light-emitting diode

[0015] There may also be provided a display device comprising a lighting apparatus as described above, the plurality of light sources being controllable so as to cause an image to be displayed on a display screen of the display device.

Brief Description of the Drawings

[0016] To assist understanding of the present disclosure and to show how embodiments may be put into effect, reference is made by way of example to the accompanying drawings in which:

Figure 1 shows schematically a side view of an example of a display device having a plurality of light sources;

Figure 2 shows schematically a plan view of a plurality of photodetectors located between light sources of a display device;

Figure 3 shows schematically a side view of a reflective element located between light sources of a display device;

Figure 4 shows schematically a reflective element and a photodetector, each with an associated diffusive layer.

Figure 5A shows schematically an example of a panel of a display device comprising a plurality of modules;

Figure 5B shows schematically an example of a module and the different groups of light sources from which each reflective element is able to receive light; and

Figure 5C shows schematically a plurality of light sources from which a reflective element can receive light.

Detailed Description

[0017] Many devices and apparatus need or provide light sources. Examples include lamps or luminaires, many consumer electronics apparatus or devices, display devices for many different types of consumer apparatus, including for example television screens or monitors, computer displays or monitors, and displays for other computing devices, including smartphones, tablet computers, laptop computers, etc. Display devices are also used in many public environments in so-called "signage", for example, for displaying adverts or for information or entertainment that is of interest to a larger audience.

[0018] Conventionally, display devices in particular employ a number of light sources for providing light to generate an image or, more simply, to generate lighting effects. Each light source may correspond to an individual pixel or "sub-pixel" (i.e. different coloured parts of the pixel) of the image and generates the pixel of the image directly. For example, the light source may be an (inorganic) light-emitting diode (LED) or an organic light-emitting diode (OLED) and may be used as part of an LED or OLED display device (described below).

[0019] Figure 1 shows schematically an example of a display device 10 having a plurality of light sources. In Figure 1, the display device 10 comprises at least a reflector panel 12 and a display panel 14. The display panel 14 comprises a plurality of light sources 16 for generating the pixels of an image directly. The light sources 16 may for example generate coloured light of different colours or may generate white light which is then passed through coloured filters of different colours. The colour of light emitted by the light sources (directly or via their respective filters) may be for example red, green or blue ("RGB"). In some examples, some of the light sources may also be configured to emit yellow light (so-called RGBY) or white light (so-called RGBW). In general, the light sources 16B may each be formed of three light sources which emit red, green or blue light respectively. It will be appreciated that the light sources (and any associated colour filters) may in general be arranged according to any type of geometric layout, for example, a regular rectangular array. Display devices that generate the pixels directly include for example display screens that use OLEDs (organic light emitting diodes) or plasma technology and display screens or devices that use (inorganic) LEDs, including for example so-called LED walls (often used for "signage") and micro LED displays.

[0020] For the devices and apparatus described above, the behaviour of the light sources may change over time. Initially, each of the light sources may behave substantially the same way as each other or at least in a predictable manner. However, during use, some of the light sources may start to behave differently from the other light sources, or differently from an expected behaviour. For example, the intensity of light and / or colour output by one or more of the light sources may vary from a desired value. This may occur, for example, as a result of changes in temperature to the one or more light sources whilst in use. This may also occur as a result of the light sources changing their behaviour over time, or the light sources approaching the end of their life expectancy.

[0021] In examples described herein, a lighting apparatus is provided in which a plurality of light sources are located at different respective locations on a surface, and are used for emitting light. A reflective element is arranged to receive light from at least two of the plurality of light sources and to direct the received light to a photodetector. The photodetector is located at a location on the surface that is between the locations of the at least two light sources. In an example, the reflective element has a shape that enables light to be gathered over a relatively large area and to be directed to the photodetector. Moreover, in an example of the present lighting apparatus, the photodetector occupies a small area of the surface, the area typically corresponding in size to the area of the surface occupied by an individual light source.

[0022] The present lighting apparatus allows the light output by two or more light sources to be monitored accurately (by virtue of being located close to the two or more light sources), whilst providing minimal interference with the overall light that is output by the apparatus (by virtue of the photodetector occupying a small portion of the surface). In this way, examples of present lighting apparatus according to the present disclosure do not suffer from the drawbacks that are often found in known systems for monitoring the light output of a device / apparatus.

[0023] Specific examples of lighting apparatus as described above are described in further detail below. It will be appreciated that references to a display device may correspond to any of the display devices described previously. It will be also appreciated that the same principles may apply to for example a luminaire device that comprises a plurality of light sources as described above.

[0024] Figure 2 shows schematically a plan view of a section 20 of a lighting apparatus comprising a plurality of light sources 21. The light sources 21 may comprise, for example, the light sources of an LED or an OLED screen. In the example shown in Figure 2, each light source 21 is operable to generate a sub-pixel of an image. For example, each light source 21 is operable to generate at least red, green or blue light (labelled 'R', 'G', and 'B' in Figure 2 respectively).

[0025] In Figure 2, a photodetector 22 (denoted 'X') is

shown as being located between two of the light sources 21. In some examples, the photodetector 22 is comparable in size to the size of the light sources 21 (as shown schematically in Figure 2). The photodetector 22 is arranged to receive light from at least two light sources 21 that are neighbours to the photodetector 22. This is achieved via a reflective element (not shown in Figure 2 but discussed further below). In the example shown in Figure 2, the photodetector 22 is arranged to receive light from the 'B' and 'G' light sources 21 located to the left and right of the photodetector 22. In some examples, the photodetector 22 is arranged to receive light from more than two light sources 21 (described later in relation to Figures 5A - 5C).

[0026] Figure 3 shows schematically a side view of a plurality of light sources 31 of a lighting apparatus in accordance with the present disclosure. The plurality of light sources 31 may correspond to the light sources of an LED or OLED screen, as described previously. The plurality of light sources 31 are attached to a surface 32. The surface 32 may correspond, for example, to a portion of a panel of a display device, such as an LED or OLED display screen. It will be appreciated that the lighting apparatus will generally employ a larger number of light sources 31 than those shown in Figures 2 and 3.

[0027] As can be seen in Figure 3, a reflective element 33 is shown as being located at a position above or in front of a location between at least two of the light sources 31. The reflective element 33 is arranged to receive light from the at least two light sources 31, and to direct the received light to a photodetector 34 which is located on the surface 32 between the at least two light sources 31 and under the reflective element 33.

[0028] In some examples, the reflective element 33 comprises a conical mirror 33, with the tip of the conical mirror being located closest to and pointing towards the surface 32 of the lighting apparatus. The conical mirror 33 may be suspended above the surface 32 of the lighting apparatus via a supportive element 35. The supportive element 35 will generally have a small cross-sectional area so as to not obstruct the amount of light reaching the photodetector 34 located beneath the reflective element 33 (described below). In some examples, the conical mirror 33 and supportive element 35 may form one continuous shape. The conical mirror 33 has an outwardly facing reflective surface for receiving light from at least two light sources 31. The outwardly facing reflective surface may be straight (as shown) or curved (not shown). Indeed, the outwardly facing reflective surface may be other than conical and the shape may be adapted according to the number and location of the light sources from which light is to be received at the outwardly facing reflective surface.

[0029] The reflective element 33 will be made of a material that has a high reflectivity in the visible light spectrum. For example, the reflective element 33 may be made of a metal such as aluminium, silver, gold, etc. In some examples, the reflective element 33 may be made of an alloy that includes at least two of these metals. Generally, the reflective element 33 will be made of a material that allows a large portion of the light received at the reflective element 33 to be directed to the photodetector 34.

[0030] In some examples, the reflective element 33 may be arranged to receive light from more than two light sources 31. For example, the reflective element 33 may be associated with a region of light sources 31 from which light can be received at the reflective element 33. This region of light sources 31 may include light sources 31 that are nearest neighbours to and / or next nearest neighbours to the reflective element 33 (or, equivalently, to the photodetector 34 associated with the reflective element 33). This region of light sources 31 is indicated schematically in Figure 3 as receiving area 36. The receiving area 36 indicates the region or area over which light can be received at the reflective element 33 from different light sources 31.

[0031] In the specific example shown in Figure 3, the reflective element 33 is arranged to receive light from at least three light sources 31 located either side of the reflective element 33 (i.e. in the horizontal direction). It will be appreciated that in some examples, the reflective element 33 may be arranged to receive light from a corresponding, or different, number of light sources 31 in a perpendicular direction (e.g. the vertical direction). It will be further appreciated that, in practice, different contributions of light will be received at the reflective element 33 from each of the light sources 31 that fall within the reflective element's receiving area 36.

[0032] In some examples, the lighting apparatus comprises plural reflective elements 33 and correspondingly plural photodetectors 34. The plural reflective elements 33 and photodetectors 34 may be distributed uniformly amongst the light sources 31 of the lighting apparatus. For example, each reflective element 33 and photodetector 34 may be spaced apart by three light sources 31 (as would be the case in Figure 2). The positions of the reflective elements 33 and photodetectors 34 in a first row of light sources 31 may be offset from the positions of the reflective elements 33 and photodetectors 34 in a second row of light sources 31 (which may or may not be immediately above or below the first row), for example, by one or two light sources 31. Generally, the reflective elements 33 and photodetectors 34 are distributed amongst the light sources 31 such that each reflective element 33 and photodetector 34 can receive light from a different respective group of light sources 31. In some examples, there may be some overlap between the different groups of light sources 31 from which each reflective element 33 and photodetector 34 are able to receive light.

[0033] The photodetector 34 is configured to detect an average luminance of the light that is received at the photodetector 34. This light corresponds to the combined light output (or a portion of the combined light output) of the two or more light sources 31 that are within the re-

ceiving area 36 of the reflective element 33. In additional or alternative examples, the photodetector 34 is configured to detect the colour (or an average colour) of the light that is received at the photodetector 34. The photodetector 34 may employ any known mechanism for detecting the luminance and / or colour of the light received at the photodetector 34.

[0034] The detected luminance and/or colour of the light received at the photodetector 34 may be provided as an input to a controller (not shown). The controller is configured to control the output of one or more of the light sources of the lighting apparatus, based on at least one of the luminance and colour of the light received at the photodetector 34. For example, the controller may be configured to determine whether a given region of light sources 31 is outputting light at an average intensity and / or with an average colour that deviates from a desired or expected average intensity and / or average colour.

[0035] In response to determining that a region of light sources 31 is not outputting light correctly, the controller may, for example, adjust the intensity and / or average colour of light that is output by at least one group of light sources 31. The group may be, for example, a group of light sources that are identified by the controller as being neighbours to the region of light sources 31 that are outputting light incorrectly (i.e. with an incorrect colour and / or intensity). In some examples, the controller may adjust the intensity and / or average colour of the light output by the light sources 31 that are identified as having an incorrect light output. In either case, adjusting the intensity and / or average colour of light output by the light sources 31 may involve, for example, adjusting the intensity of light that is generated by the light sources 31. For example, where the lighting apparatus comprises for example an LED or OLED display, the controller may be configured to control the intensity of light that is generated by the light sources. It will be appreciated that the controller may adjust the average colour of light that is output by the light sources 31 by varying individual contribution (i.e. intensity) of e.g. red, green or blue light that is output by each of the light sources 31.

[0036] The controller may comprise at least one processor for receiving the input from the photodetector(s) 34 and for determining an action that is to be performed, in response to the received input. The at least one processor may be configured to retrieve computer program instructions stored in a memory, which when executed by the at least one processor, cause the controller to perform one or more of the operations described above. The functionality of the controller may be performed by a single piece of hardware, software, or firmware. In some examples, the controller may be configured to determine the average luminance and / or colour of the light received at the photodetector, based on the input(s) received from the photodetector.

[0037] Figure 4 shows an example of a reflective element 33 and photodetector 34 comprising at least one diffusive layer 42A, 42B. In some examples, a diffusive layer 42A may be located in front of, i.e. overlay, the outward reflective surface of the reflective element 33. This diffusive layer 42A ensures for example, that the light incident at, and reflected from, the reflective element 33 is spread out more evenly over the surface of the photodetector 34. This prevents, for example, a spike in the intensity of light being localised to one specific portion of the photodetector 34. In additional or alternative examples, the photodetector 34 may be associated with a diffusive layer 42B which overlies the photodetector 34. This diffusive layer 42B may again help to spread light received from the reflective element 33 more evenly. This diffusive layer 42B may also ensure that e.g. any light reflected off the photodetector 34 is spread out over the screen of the display device, so as to not appear as an excessively bright spot on the screen.

[0038] As described previously, the light sources 31 of the lighting apparatus may be arranged in a geometric pattern. In some examples, the light sources 31 are arranged in a regular rectangular array and the locations of the light sources 31 in the array may correspond to the nodes of the array. In the present disclosure, the photodetector 34 is located at a position in the geometric pattern that would otherwise be reserved for one of the light sources 31. For example, if the light sources 31 are arranged in a regular array, the photodetector 34 is located at a position in the array corresponding to one of the nodes of the array. The photodetector 34 may therefore be thought of as replacing one of the light sources 31 in the array. For example, the photodetector 34 replaces one of the light sources of an LED or OLED display (which may be "sub-pixels", in the sense that each light source generates a specific colour for the pixel, such as red or green or blue). As can be seen in Figure 3, the photodetector 34 occupies an area of the surface 32 that is comparable in size to the area occupied by an individual light source 31. In some examples, the size of the photodetector 34 is the same as the size of a light source 31. Generally, the size of the photodetector is such that a substantial portion of the light reflected from the reflective element 33 can be received (and detected) at the photodetector 34.

[0039] Figure 5A - 5C schematically shows an example of a display device 50 and the organisation of light sources within the display device 50. The display device 50 employs the lighting apparatus described previously. As can be seen in Figure 5A, the display device 50 comprises a plurality of panels 51, with each panel 51 comprising a plurality of modules 52. It will be appreciated that in some examples, the display device 50 may employ just one continuous panel 51. Each module 52 comprises a plurality of light sources. In one example, each module 52 comprises an 18 x 18 grid of light sources. In Figure 5A, only some of the panels 51 and their associated modules 52 are shown. The panels 51 may be arranged in a regular array, with equal spacing between each of the panels 51. Similarly, the modules 52 within a panel 51 may be arranged in a regular array, with equal spacing

between each of the modules 52. The individual panels 51 may be connectable to and detachable from one another. The modules 52 within a given panel 51 may also be attachable to and removable from the panel 51. This means, for example, that a panel 51, or a module 52 within a panel 51, can be replaced, without all of the panels 51, or all of the individual modules 52 within the panel 51, having to be replaced. Hence, faulty groups of light sources can be removed and replaced by e.g. a technician more easily.

[0040] Figure 5B shows schematically one of the modules 52 within a given panel. As can be seen in Figure 5B, the module 52 comprises a plurality of light sources 53. The light sources 53 in Figure 5B are grouped into different respective regions 54. The regions 54 shown in Figure 5B correspond to regions of light sources 53 for which light can be received at a respective reflective element (not shown). Generally, the reflective element will be located at the centre of its associated region 54. In some examples, the regions 54 associated with the reflective elements are not the same for each reflective element. For example, the size and shape of the regions 54 may vary for the different reflective elements. This may be a result, for example, of the detailed shape and / or orientation of the reflective element. The shape or orientation of a given reflective element may determine a direction from which more or less light is able to be received at the reflective element and the specific light sources 53 from which light is received. In other examples, each reflective element may be arranged to receive light from a uniform region 54 of light sources 53, such as the light sources 53 that are within a predetermined radius of the reflective element. This radius may include, for example, the light sources 53 that are nearest neighbours to, and / or next nearest neighbours to the photodetector associated with the reflective element.

[0041] Figure 5C shows a subset of the plurality of light sources 53 shown in Figure 5B. In Figure 5C, a reflective element 55 with an associated region of light sources 54 is shown. The associated region 54 of light sources 53 corresponds to the light sources 53 from which light may be received at the reflective element 55. In some examples, the lateral extent of the reflective element 55 (when viewed from above) may extend over a light source 53. For example, in Figure 5C, the lateral extent of the reflective element extends outwardly along the horizontal direction beyond the location of the corresponding photodetector 56. In Figure 5C, the photodetector 56 is shown as having the size of a light source 53 and being located beneath the reflective element 55. In some examples, the reflective element 55 may extend in the vertical direction beyond the location of the corresponding photodetector 56.

[0042] It will be understood that the processor or processing system or circuitry referred to herein may in practice be provided by a single chip or integrated circuit or plural chips or integrated circuits, optionally provided as a chipset, an application-specific integrated circuit (ASIC), field-programmable gate array (FPGA), digital signal processor (DSP), graphics processing units (GPUs), etc. The chip or chips may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry, which are configurable so as to operate in accordance with the exemplary embodiments. In this regard, the exemplary embodiments may be implemented at least in part by computer software stored in (non-transitory) memory and executable by the processor, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware).

[0043] The examples described herein are to be understood as illustrative examples of embodiments of the invention. Further embodiments and examples are envisaged. Any feature described in relation to any one example or embodiment may be used alone or in combination with other features. In addition, any feature described in relation to any one example or embodiment may also be used in combination with one or more features of any other of the examples or embodiments, or any combination of any other of the examples or embodiments. Furthermore, equivalents and modifications not described herein may also be employed within the scope of the invention, which is defined in the claims.

Claims

1. A lighting apparatus comprising:

   a plurality of light sources for emitting light;
   a reflective element; and
   a photodetector;
   the light sources being located at different respective locations on a surface;
   the reflective element being arranged to receive light emitted by at least two of the plurality of light sources and to direct the received light to the photodetector; and
   the photodetector being located at a location on the surface that is between the locations of the at least two light sources.

2. A lighting apparatus according to claim 1, wherein the photodetector is configured to detect at least one of the colour and luminance of the light emitted by the at least two light sources.

3. A lighting apparatus according to claim 1 or claim 2, wherein the reflective element comprises a conical mirror having an outwardly facing reflective surface for receiving light from the at least two light sources.

4. A lighting apparatus according to any of claims 1 to 3, wherein the photodetector is configured to meas-

ure an average luminance of light received from at least light sources that are nearest neighbours of the photodetector.

5. A lighting apparatus according to claim 4, wherein the photodetector is configured to measure an average luminance of light received from at least light sources that are nearest neighbours and next-nearest neighbours of the photodetector.

6. A lighting apparatus according to any of claims 1 to 5, comprising plural reflective elements, each reflective element being configured to receive light from a different group of light sources.

7. A lighting apparatus according to any of claims 1 to 6, wherein the photodetector comprises a diffusive layer, the diffusive layer overlaying a surface of the photodetector that is arranged to receive light.

8. A lighting apparatus according to any of claims 1 to 7, wherein the reflective element comprises a diffusive layer, the diffusive layer overlaying an outward reflective surface of the reflective element.

9. A lighting apparatus according to any of claims 1 to 8, wherein the light sources are arranged in a regular array, with the light sources and the or each photodetector being located being located at nodes of the array.

10. A lighting apparatus according to any of claims 1 to 9, comprising a controller, the controller being coupled to the photodetector, the controller being configured to control the output of light sources based on an input received from the photodetector.

11. A lighting apparatus according to any of claims 1 to 10, wherein each light source is an inorganic or organic light-emitting diode.

12. A display device comprising a lighting apparatus according to any of claims 1 to 11, the plurality of light sources being controllable so as to cause an image to be displayed on a display screen of the display device.

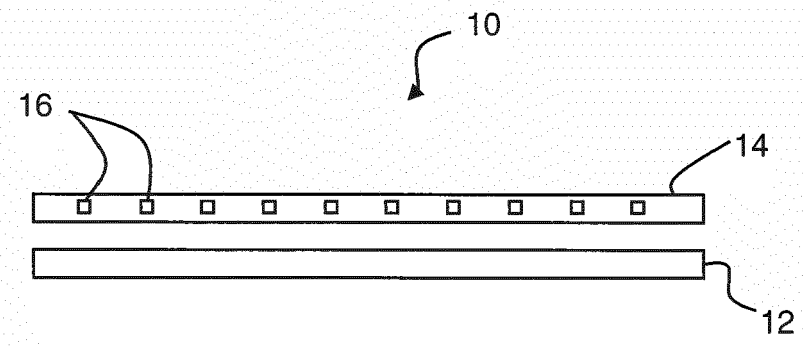

Fig. 1

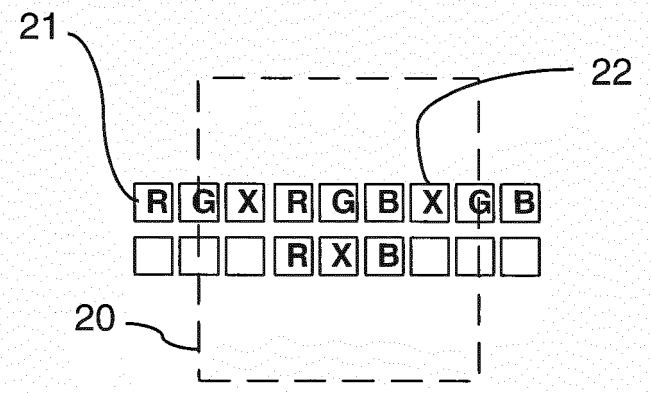

Fig. 2

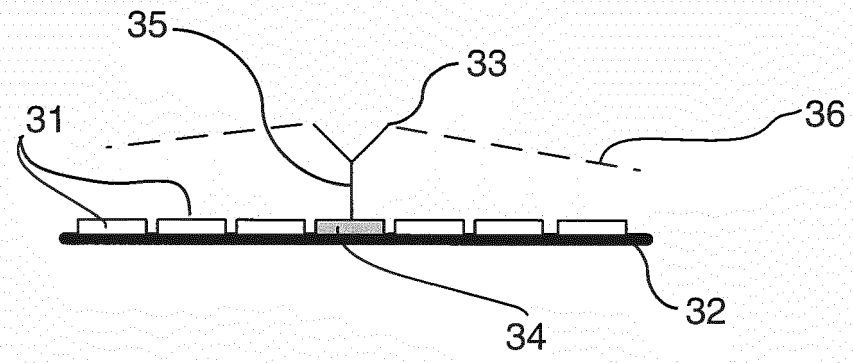

Fig. 3

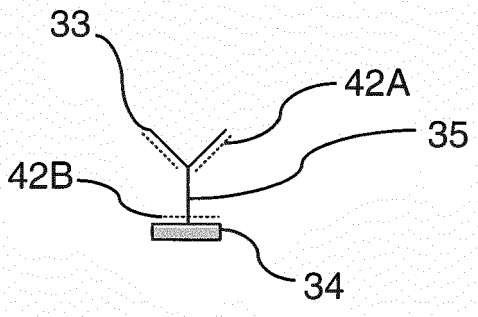

Fig. 4

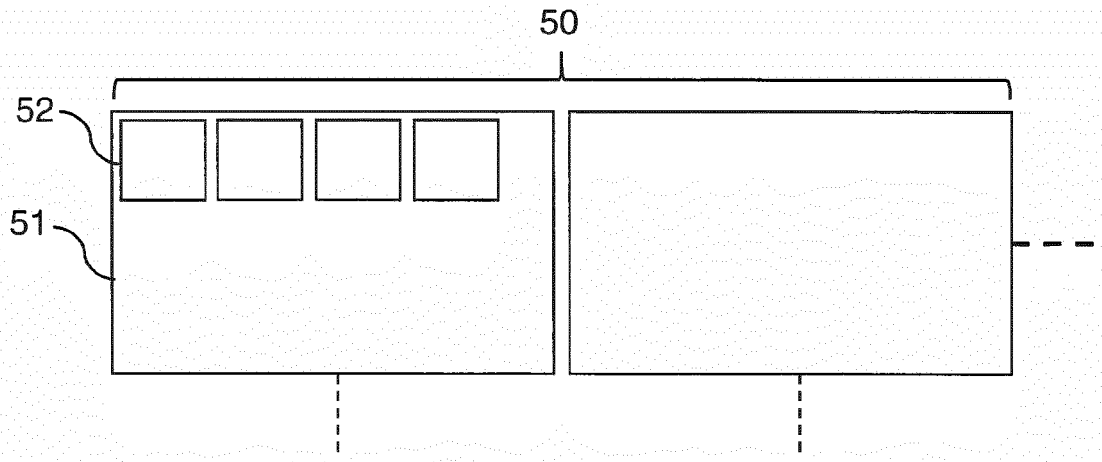

Fig. 5A

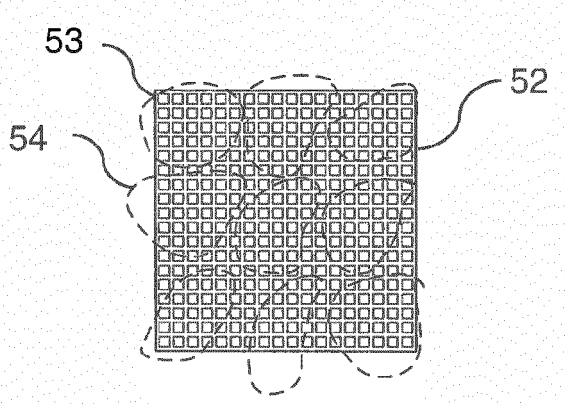

Fig. 5B

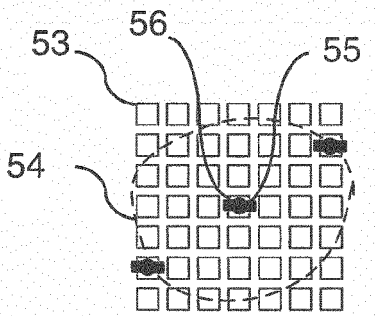

Fig. 5C

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 20 1953

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/146058 A1 (TSANG JIAN-SHIHN [TW]) 14 June 2012 (2012-06-14) * the whole document *	1-12	INV. H05B33/08
X	WO 2006/054234 A2 (KONINKL PHILIPS ELECTRONICS NV [NL]; MEIJER EDUARD J [NL]; DEKKER RONA) 26 May 2006 (2006-05-26) * claims 1-7; figures 1-2 *	1-12	
X	US 2007/045524 A1 (RAINS JACK C JR [US] ET AL) 1 March 2007 (2007-03-01) * paragraphs [0059] - [0086]; claims 1,33,44; figures 1,8,10-11,15-16 *	1-12	
X	US 2013/293877 A1 (RAMER DAVID P [US] ET AL) 7 November 2013 (2013-11-07) * paragraph [0102]; figures 4,6 *	1-12	
X	US 2013/169163 A1 (SWAMY RAJENDRA [US] ET AL) 4 July 2013 (2013-07-04) * paragraph [0062]; figure 7 *	1-12	TECHNICAL FIELDS SEARCHED (IPC)
X	WO 2009/144657 A1 (PHILIPS INTELLECTUAL PROPERTY [DE]; KONINKL PHILIPS ELECTRONICS NV [NL]) 3 December 2009 (2009-12-03) * claims 5,14 *	1-12	H05B
A	WO 2013/178597 A1 (OSRAM GMBH [DE]) 5 December 2013 (2013-12-05) * claim 1; figures *	1-12	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 April 2018	Maicas, Jesús

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 20 1953

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-04-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012146058 A1	14-06-2012	TW 201225740 A	16-06-2012
		US 2012146058 A1	14-06-2012
WO 2006054234 A2	26-05-2006	CN 101438093 A	20-05-2009
		EP 2002695 A2	17-12-2008
		JP 4988586 B2	01-08-2012
		JP 2008521190 A	19-06-2008
		KR 20070086360 A	27-08-2007
		TW I390760 B	21-03-2013
		US 2009212709 A1	27-08-2009
		WO 2006054234 A2	26-05-2006
US 2007045524 A1	01-03-2007	US 2007045524 A1	01-03-2007
		US 2009194670 A1	06-08-2009
		US 2010213854 A1	26-08-2010
		US 2011180687 A1	28-07-2011
US 2013293877 A1	07-11-2013	US 2013293877 A1	07-11-2013
		US 2014252961 A1	11-09-2014
		US 2015156851 A1	04-06-2015
US 2013169163 A1	04-07-2013	EP 2798914 A1	05-11-2014
		US 2013169163 A1	04-07-2013
		WO 2013098062 A1	04-07-2013
WO 2009144657 A1	03-12-2009	CN 102047031 A	04-05-2011
		EP 2288842 A1	02-03-2011
		JP 2011522371 A	28-07-2011
		TW 201002991 A	16-01-2010
		US 2011089841 A1	21-04-2011
		WO 2009144657 A1	03-12-2009
WO 2013178597 A1	05-12-2013	CN 104379985 A	25-02-2015
		DE 102012209131 A1	05-12-2013
		US 2015109775 A1	23-04-2015
		WO 2013178597 A1	05-12-2013

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82