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(54) **LUMINAIRE WITH INTEGRATED MONITORING OF A DISPLAY SURFACE OF THE LUMINAIRE**

(57) A luminaire (1), preferably an escape sign luminaire (1), with an integrated monitoring unit (11) that monitors an image displayed via the display surface (130) of the luminaire (1). The controller (210) of the luminaire (1) is configured to generate the image to be displayed by the luminaire (1), wherein the monitoring foil (110) is arranged on the display surface (130) in a monitoring area. The monitoring foil (110) is configured to guide (G) at least a portion of an emitted light (E) - emitted by the display surface (130) - towards edge areas of the monitoring foil (110), wherein the edge areas of the

monitoring foil (110) have sensor elements (121) surrounding the monitoring foil (110) in a frame-like manner. Each of the sensor elements (121) is configured to detect the respective guided light and to output a corresponding detection signal to the controller (210), wherein the controller (210) is configured to evaluate the signals received from all sensor elements (121) and, based on this evaluation, to generate a reconstruction image, which is a reconstruction of the image actually displayed in the monitoring area of the display surface (130).

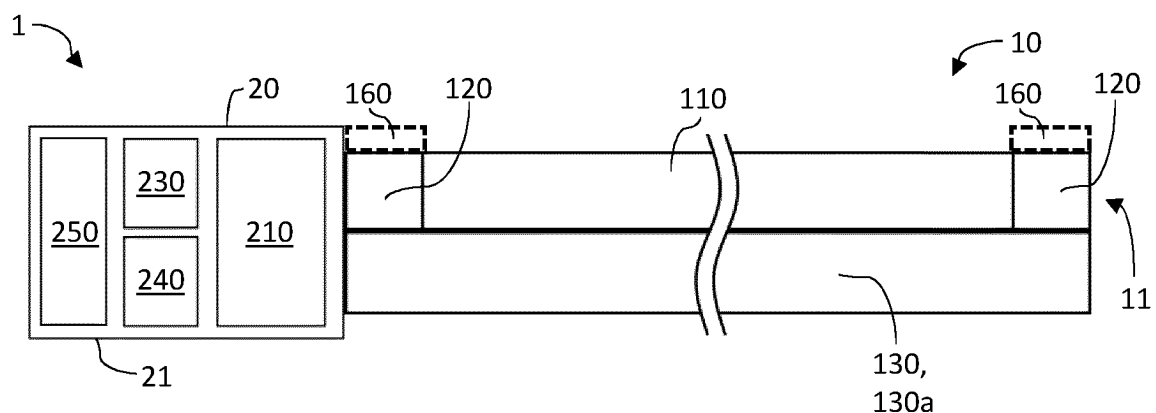


Fig. 2

Description

[0001] The invention relates to luminaires that comprise a display surface for displaying an image, wherein the luminaire is configured to monitor and thus verify the displayed image.

[0002] Such currently known luminaires are mostly in the field of dynamic escape sign luminaires where the luminaire itself checks on the situational displayed escape sign pictogram, to verify its correctness. The dynamic escape sign luminaires allow people to be guided out of the respective building dynamically depending on the situation in the building. Hereby displays are used in the escape sign luminaires to dynamically adapt the displayed pictogram. Monitoring the displayed pictogram is thus vital, to ensure correctness and reliability of the luminaire.

[0003] However, in this regard it is currently not known to monitor the displayed pictograms per se. Such an escape sign luminaire not monitoring the displayed pictograms but rather border areas of the displayed image where encoded information is displayed is proposed in EP 3 428 906 B1. This document describes such an escape sign luminaire in which a method for checking the displayed escape sign pictogram image is implemented, whereby the escape sign luminaire itself determines which escape sign pictogram image is currently displayed based on collected data from a video sensor monitored edge region of the displayed image. The display of this known escape sign luminaire is shown in Fig. 7. The display 1200 known from the prior art shows an escape sign image 1300 with a respective pictogram 1301. The display 1200 can be divided into an escape sign pictogram area 1210a and a control area 1210b, whereby only the control area 1210b is monitored by respective sensor positioned under a frame element of the luminaire. While the respective pictogram 1301 of the image 1300 is shown in the visible area 1210a and is thus visible to a user, several control fields 1211a, 1211b, 1211c, 1211d are displayed in the control area so as not to be visible to the user, each of which has an individual design and thus encodes a specific type of the displayed escape sign pictogram in combination. This coding of the control fields 1211a, 1211b, 1211c, 1211d is read out by the plurality of sensors installed in the frame of the escape sign light, whereby a corresponding controller of the escape sign light determines which image is currently being displayed based on the data output by the sensors. However, it is not possible to check the pictogram actually displayed with this escape sign luminaire, only the coded side edges. Errors in the display are not detected in this way, so that errors in which the display itself has errors (broken display pixel sections, faulty backlight) or errors in which the border area does not match the pictogram displayed are not recognised by this known implementation.

[0004] Thus, with the known implementation of monitoring a displayed image of the luminaire, errors are likely

to be missed. Therefore, reliability of the currently known luminaires respectively their method in determining the allegedly shown image is to be considered low.

[0005] Thus, the invention is concerned with the task of providing a luminaire with an improved reliability with regard to the monitoring of a respective image displayed by the luminaire. This task is solved by the luminaire according to independent claim 1. The invention is defined in the independent claim. Additional features of the invention are provided in the dependent claims.

[0006] According to the invention the luminaire with integrated monitoring of an image displayed by the luminaire, comprises:

- a plurality of illuminants with a common light emitting surface forming a display surface for displaying an image;
- a monitoring unit arranged on the display surface, wherein the monitoring unit is a monitoring foil and the edge areas of the monitoring foil have sensor elements surrounding the monitoring foil in a frame-like manner;
- a controller for controlling the illuminants and for evaluating data generated by the sensor elements.

[0007] Furthermore, the controller is configured to generate the image to be displayed by the luminaire by corresponding control of the several illuminants, wherein the monitoring foil is arranged on the display surface in a monitoring area. Hereby the light emitted within the monitoring area via the display surface enters the monitoring foil, wherein the monitoring foil is configured to guide at least a portion of this entered emitted light towards edge areas of the monitoring foil. Each of the sensor elements is configured to detect the respective guided light and to output a corresponding detection signal to the controller, wherein the controller is configured to evaluate the signals received from all sensor elements and, based on this evaluation, to generate a reconstruction image which is a reconstruction of the image actually displayed in the monitoring area of the display surface.

[0008] The such configured luminaire is capable of monitoring at least a portion of its display surface, to verify validity of the shown image. An observation of the actual displayed image is thus achieved, which improves safety and reliability of the luminaire. Hereby errors in displaying the image, such as a bleached-out image (respectively a loss of contrast), a defective display surface or respective defective illuminants or other errors related to the displayed image can be thus easily detected.

[0009] In general, the use of this monitoring mechanism presented herein is particularly useful for luminaires with a display as a light emitting unit (respectively as the plurality of illuminants), since in this case variable displayed images can be monitored particularly easily and reliably for their correctness, as well as the display per se for functionality with regard to lighting or pixel function-

ality, or other damage to the display surface, or the like, so that in particular the maintenance of such luminaires can be carried out remotely, and is thus particularly uncomplicated and cost-effective. However, the monitoring according to the invention can also be used in luminaires with a static image displayed on a display surface (for example an image or pictogram foil), whereby the benefit here is limited to being able to determine particularly easily and reliably whether the backlighting of the image is working properly, whether the image has faded - or whether the image still has sufficient contrast - or whether there is other damage (e.g. broken glass or similar) on the display surface, or the like.

[0010] The functioning of the monitoring of the display surface of the luminaire and in particular the reconstruction of the image may hereby be based on the imaging sensor foil of Alexander Koppelhuber and Oliver Bimber, that is presented in their publication "Towards a transparent, flexible, scalable and disposable image sensor using thin-film luminescent concentrators" published via the Optical Society of America (OSA) in Vol. 21, No. 4 of the Journal Optics Express, 2013 (<https://doi.org/10.1364/OE.21.004796>). This document is incorporated herein by reference. The document is referenced in the following as "Koppelhuber et al.".

[0011] In a specific embodiment of the luminaire, the luminaire is an escape sign luminaire with integrated monitoring of an image displayed by the escape sign luminaire comprising an escape sign pictogram, wherein the image with a respective escape sign pictogram is displayed on the display surface. Hereby the controller is configured to evaluate the signals received from all sensor elements, and, based on this evaluation, to generate a reconstruction image which is a reconstruction of the image of the escape sign pictogram actually displayed in the monitoring area of the display surface. With this implementation an utmost easy and reliable monitoring of the actual displayed escape sign pictogram is realized.

[0012] Optionally, and in particular preferably with regard to the escape sign luminaire, the plurality of illuminants with the common light emitting surface forming the display surface are realized by a display for displaying an image via the display surface. Hereby, dynamic displaying of images, and in particular with regard to the escape sign luminaire dynamic displaying of a respective situational required escape sign pictogram is achieved, whereas furthermore the dynamic visual display is also verified via the monitoring unit in conjunction with the controller, such that errors with regard to the displayed image are easily, quickly and reliably detected. Preferably the display together with the monitoring unit, forms a display unit. With this implementation the assembly of the luminaire is further facilitated, whereas maintenance is also eased. It is further possible, that the monitoring foil is an integral part of the display surface, forming an integral outer layer foil of it. Further preferably the display is an OLED display, an LC display, a TFT-LC display or an E-Ink display. With these display technologies, high con-

trast and clear visibility of the shown image, and especially of the escape sign pictogram is achieved, further improving detection of the displayed image via the monitoring unit and in particular by the monitoring foil.

[0013] Optionally the monitoring area on which the monitoring foil is arranged extends over the entire display surface. While monitoring just a smaller area might be beneficial with regard to costs and evaluation time (due to less sensor data is present as in general less sensor elements are required for a smaller area when resolution is unchanged), the monitoring of the whole area is beneficial with regard to checking the whole area for errors, and furthermore different shown images on the display surface are easier distinguishable from one another. Moreover, when covering the whole display surface the sensor elements are also arranged on edge areas of the display surface, which increases aesthetics and also readability of the displayed image.

[0014] Optionally the controller has data relating to which area of the image to be displayed is located in the monitoring area of the display surface, wherein based thereon the controller is further configured to compare the reconstructed image of the image actually displayed via the display surface in the monitoring area with the corresponding area of the image to be displayed. With this implementation, even when not the whole surface area of the display surface is covered by the monitoring foil, the controller is able to compare the correct area of the set image (i.e., the to be displayed image) and the actually detected and reconstructed image. Hereby the controller may distinguish between several outcomes of the comparison, whereas depending on the outcome different messages, e.g., to an external device are sent. For example it is conceivable that the controller detects that the displayed image (or at least the monitored part thereof) corresponds with the image sent to the display, or the controller detects that the displayed image (or at least the monitored part thereof) differs slightly from the image sent to the display, or the controller detects that the displayed image (or at least the monitored part thereof) differs vastly from the image sent to the display, or the like. With this distinction the controller (and thus also the luminaire itself) can evaluate an error level and a corresponding urgency level for maintenance. Therefore, the validity and error check of the respective displayed image is more reliable and thus the operational reliability of the luminaire is further improved.

[0015] Optionally the luminaire further comprises a communication unit for communicating with external devices, preferably with a luminaire management system, wherein the communication unit is also used for internal communication of components of the luminaire with the controller. Via this communication unit, the components of the luminaire can easily share data and control signals with each other, whereas furthermore this data and control can be directed and received from other external devices. Preferably the luminaire is configured to send the reconstructed image of the image actually displayed

in the monitoring area to an external device via the communication unit. With this implementation, the luminaire can communicate to external devices the result of the evaluation and in particular the reconstructed image to an external device, such as a server of a luminaire system. This server may then decide upon the received data, how the respective luminaire is to be controlled, or whether an error message is to be displayed on an other device within a luminaire system, to notify of an detected error in the displayed image of the respective luminaire. Alternatively or in addition thereto the luminaire is preferably configured to receive an image to be displayed via the communication unit and to transmit it to the controller for controlling the plurality of illuminants, respectively the display of the luminaire. By this configuration, an easy and quick control of the luminaire is possible, as situational control of the luminaire and the to be displayed image is achieved.

[0016] Optionally the luminaire is configured to send the result of the comparison of the image actually displayed in the monitoring area with the corresponding area of the image to be displayed to an external device via the communication unit. With this implementation the next step of comparing the to be displayed image with the reconstructed image (or respective parts thereof) is already performed within the luminaire, such that the external device - such as the previously mentioned server of a luminaire system - can quickly and easily decide the control of the respective luminaire.

[0017] Optionally the luminaire further comprises a storage unit in which different images are stored, wherein the controller has access to the images stored in the storage unit and is configured to select an image to be displayed from the storage unit and to control the plurality of illuminants accordingly. Preferably, if the luminaire also has a communication unit, the controller can be controlled by an external device via the communication unit to select a specific image from the storage unit. This eases control of the luminaire, as, e.g., an external device can easily control the respective luminaire to display a certain image already stored on the device. This minimizes bandwidth needed for communication. Furthermore, with this implementation an easy comparison of the respective image sent to the plurality of illuminants, respectively the display of the luminaire, and the respective reconstructed image (or at least parts thereof) is possible.

[0018] Optionally the monitoring foil is configured for light guidance by means of total internal reflection, TIR. With this implementation light loss during light guidance is minimized, resulting in a better detection of the displayed image via the monitoring unit and the controller. This also means, that less light is required to be taken from the light emitted via the display surface of the luminaire, such that efficiency of the luminaire is increased.

[0019] Optionally the monitoring foil is a transparent polymeric foil comprising particles configured to redirect

and guide at least a portion of the emitted light from the display surface within the monitoring area towards edge areas of the monitoring foil. Hereby the monitoring foil is adapted for an efficient light guidance of at least part of the light emitted via the display surface of the luminaire towards the sensor elements, further increasing efficiency.

[0020] Optionally the monitoring foil is a luminescent concentrator, LC, and the particles are fluorescent particles, in particular fluorescent dye particles, which initially absorb light of a certain wavelength and subsequently emit light of a longer wavelength, and wherein a part of the light emitted by a respective particle is guided within the monitoring foil towards the edge areas of the monitoring foil. With this implementation light of certain wavelengths (respectively wavelength intervals) can be monitored by the monitoring unit, resulting in a reconstruction image only considering elements which are displayed in the respective wavelength (interval). Also a mixing of respective particles is possible, such that the reconstruction image represents a grey tone image of the actually displayed image.

[0021] Optionally the monitoring foil comprises several foil layers, wherein the foil layers have different particles, in particular different fluorescent dye particles, and wherein each foil layer is configured to redirect and guide light of a certain wavelength range, different from the respective other foil layers, of the light emitted by the display surface within the monitoring area for displaying the image and entering the monitoring foil. Hereby with this multi-layer setup, a reliable detection of coloured images or specific coloured elements in the image is possible. With regard to the implementation as an escape sign luminaire this application is beneficial when coloured differences between the different to be displayed escape sign pictograms are possible - such as a crossed displayed escape sign pictogram in red, or different warning signs in yellow or blue apart from the usual green and white pictogram. Preferably the total wavelength range covered by the several foil layers extends substantially from 400 nm to 800 nm, in particular from 490 nm to 800 nm, or 490 nm to 700 nm. With theses ranges the mostly used colours of escape sign pictograms are covered.

[0022] Optionally the sensor elements are arranged in the edge areas of the monitoring foil on a surface of the monitoring foil opposite the surface of the monitoring foil in contact with the display surface. With this implementation the thickness of the luminaire increases, as the sensor elements are also positioned on the display surface. Alternatively the sensor elements are arranged in the edge areas of the monitoring foil on the lateral end faces of the monitoring foil. This increases length (and height) of the luminaire.

[0023] Optionally the monitoring foil has in its edge areas with the sensor elements a reflective surface for light guidance towards the respective sensor elements. This improves light guidance towards the sensor elements and further increases efficiency and reliability of

the monitoring unit.

[0024] Optionally the sensor elements are bundled into several sensor units, wherein one sensor unit is provided per edge area of the monitoring foil. This eases assembly of the monitoring unit. Furthermore, the communication towards and from the grouped sensor elements can be facilitated with this hierarchy implementation. Preferably the monitoring foil is rectangular, and a sensor unit is provided on each of the four side surfaces. This covers the most common applications of luminaires and in particular of escape sign luminaires.

[0025] Optionally the luminaire further comprises a power unit, which is configured to supply power to the luminaire, and preferably comprises a power storage, for example an emergency battery for supplying power to the luminaire in an emergency. This increases reliability of the luminaire and enables the luminaire to be used in emergency situations.

[0026] Optionally the luminaire further comprises a housing in which at least the controller is arranged. With this implementation a common housing for the critical electronical components (controller, power unit, storage, communication unit) is achieved, whereas these components are thus protected from outside influences.

[0027] Optionally the luminaire further comprises a frame element which is arranged in the direction of light emission of the illuminants following the sensor elements and covering them. With this implementation the sensor elements, respectively the sensor units, are protected, whereas furthermore depending on the positioning of the sensor elements also the edge areas of the display surface may be protected. Besides the increased protection, aesthetics of the luminaire is also increased, as the electronic components positioned under the frame is not visible for a user.

[0028] The invention is explained in detail below with reference to examples of embodiments and with reference to the drawing. The figures show:

Figure 1 Schematic illustration of an exemplary embodiment of a luminaire according to the invention, whereas the luminaire is an escape sign luminaire with an integrated monitoring of the image displayed by the luminaire;

Figure 2 Schematic illustration of an exemplary layout of an embodiment of a luminaire according to the invention;

Figure 3A Schematic illustration of an exemplary layout of an embodiment of a display unit of a luminaire according to the invention with a monitoring foil having one foil layer;

Figure 3B Schematic illustration of an exemplary layout of an other embodiment of a display unit of a luminaire according to the inven-

tion with a monitoring foil having three foil layers;

Figure 4 Schematic representation of an exemplary embodiment of the principle of operation of the monitoring of the image displayed on the display surface by means of the monitoring unit comprising a monitoring foil and a sensor element;

Figure 5A Schematic representation of an exemplary embodiment of a monitoring unit of the luminaire according to the invention, the monitoring unit comprising a monitoring foil and a sensor element;

Figure 5B Schematic representation of an exemplary embodiment of a monitoring unit of the luminaire according to the invention in an enlarged view of the end regions of the monitoring foil and the thereto arranged sensor elements;

Figure 6 Schematic illustration of an enlarged view on an end region of the monitoring foil and the thereto arranged sensor elements together with exemplary diagrams of data measured by the sensor elements;

Figure 7 Schematic illustration of an escape sign luminaire known from the prior art.

[0029] Figure 1 schematically shows a luminaire 1, respectively an escape sign luminaire 1, with a display 130a having a display surface 130, whereas a respective escape sign pictogram 131 showing a direction for an escape route is displayed thereon. Of course the escape sign luminaire 1, is not limited to showing escape route pictograms but any escape sign pictogram 131 (see, e.g., ISO 7010) may be displayed on such a specific type of luminaire 1. In addition it is also conceivable that a certain displayed pictogram 131 is crossed out, particularly with a red "X" sign, to illustrate, e.g., to a user that a certain information is no longer valid. Thus a vast amount of different possibly displayed images exists. Similar use cases are possible with regard to regular luminaires 1, whereas hereby different design elements or colour gradient or patterns or the like can be displayed thereon. Features shown or described with regard to the exemplary embodiment of the luminaire 1 being an escape sign luminaire 1 also apply to luminaires 1 in general.

[0030] In order to simplify and improve the monitoring of the displayed image of such a luminaire 1, in particular of such an escape sign luminaire 1, a monitoring unit 11 is integrated into the luminaire 1. This unit is configured to monitor and evaluate an image actually displayed on the display surface 130, whereby this information can then be compared with the data relating to the image originally

to be displayed via the display 130a (or generally via the illuminants). From this, appropriate conclusions can be drawn about the correctness of the displayed image and/or the functionality of the display, and finally appropriate measures can be initiated (preferably automatically).

[0031] In the displayed embodiment of Figure 1 the whole area of the display surface 130 is covered with a monitoring foil 110, whereas in each edge area (respectively edge region) of the monitoring foil 110 (i.e., on all four sides of the side of the shown rectangular display surface 130, and thus on all four sides of the side of the shown rectangular monitoring foil 110) sensor elements 121 are positioned. These sensor elements 121 are taken together in so called sensor units 120, whereas the shown luminaire 1 has one sensor unit 120 on each of its four sides, such that the whole edge region of the monitoring foil 110 is equipped with sensor elements 121 surrounding the monitoring foil 110 in a frame-like manner. As in the shown exemplary embodiments the monitoring foil 110 expands over the whole display area of the display surface 130, the monitored area of the monitoring foil 110 substantially corresponds to the area of the display surface 130 - thus the monitoring area corresponds to the display surface 130 in the examples shown in the figures.

[0032] For an improved visual appearance of the luminaire 1 and for deleting possible distortions created by external light exposure the sensor elements 121, respectively the sensor units 120, may be covered by a frame element 160 that shields the sensor from external light (e.g., artificial light of other luminaires, daylight, or the like) and other influences like dust, moisture and water, to ensure proper operation of the monitoring unit 11 and also the display unit 10 of the luminaire 1 as a whole.

[0033] As further shown in the embodiment of Figure 1 the display unit 10 is connected to a carrier element 20, whereas the carrier element 20 holds electronical components of the luminaire 1, as previously described. As shown in Figures 1 and 2 the carrier element 20 may have a housing 21 providing protection against outside influences such as moisture, water and/or dust. Further, a mounting element 30 can be connected to the carrier element 20, respectively the housing 21, for easy, flexible and situational adapted positioning of the respective luminaire 1.

[0034] If contrary to the herein described exemplary embodiments the monitoring area of the luminaire 1 does not cover the whole display surface 130 but merely a part thereof, it is preferably envisaged that the controller 210 has data relating to which area of the image to be displayed is located in the monitoring area of the display surface 130. Thus, the controller 210 knows which part of the reconstructed image of the image displayed on the display surface 130 is to be regarded and thus compared with the image intended to be displayed.

[0035] The display 130a may be an OLED display, an LC display, a TFT-LC display or an E-Ink display.

[0036] Figure 2 schematically shows an exemplary embodiment of a luminaire 1 in a cross-sectional view. Hereby - in contrast to Figure 1 - the setup of the monitoring unit 11 being placed on the display surface 130 forming the display unit 10 is notably shown.

[0037] Furthermore Figure 2 schematically illustrates other components of the luminaire 1 being positioned inside a carrier element 20. Most importantly the luminaire further comprises a controller 210 that is responsible for displaying a certain image on the display surface 130, as well as for evaluating received signals of the respective sensor elements 121.

[0038] Additionally the luminaire 1 further comprises a communication unit 230 for communicating with external devices, in particular with a luminaire management system. Hereby the communication unit 230 is also used for internal communication of components (such as, e.g., the subsequently described power unit 250, and/or storage unit 240) of the luminaire 1 with the controller 210. The shown luminaire 1 is furthermore configured to send the reconstructed image of the image actually displayed on the display surface 130 (i.e., in the monitoring area) to an external device via the communication unit 230. With this implementation the control and check of the luminaire 1 from a remote place is possible and thus facilitated. Further, it can be envisaged that the luminaire is also configured to receive an image to be displayed by the luminaire 1 via the communication unit 230 and to transmit it to the controller 210 for controlling the display 130a (respectively the plurality of illuminants). Moreover, the shown luminaire 1 is configured to send the result of the comparison of the image intended to display on the display surface 130 and the respective reconstructed image of the image actually displayed on the display surface 130 to an external device via the communication unit 230, such that the method step of comparing is already performed on the luminaire 1 itself, reducing computational power of the external device and furthermore reducing the required bandwidth for communication as the mere results have to be transmitted.

[0039] Moreover, the luminaire 1 further comprises a power unit 250, which is configured to supply power to the luminaire 1, and preferably also comprises a power storage, for example an emergency battery for supplying power to the luminaire 1 in an emergency. The power unit 250 may also be connected to an external power grid.

[0040] The shown luminaire 1 further comprises a storage unit 240 in which different images are stored, wherein the controller 210 has access to the images stored in the storage unit 240 and is also configured to select an image to be displayed from the storage unit 240 and to control the plurality of illuminants (respectively the display 130a accordingly. If the luminaire 1 comprises the storage unit 240 and a communication unit 230, whereas the controller 210 may be controlled by an external device via the communication unit 230 to select a specific image from the storage unit 240. Furthermore it is conceivable that

[0041] As shown these components of the luminaire 1 are ideally positioned within the housing 21 on the carrier element 20.

[0042] The sensor units 120, respectively their sensor elements 121, are positioned in an edge area of the monitoring foil 110. In the exemplary embodiment of Figure 2 these sensor elements 121 (respectively sensor units 120) are arranged in the edge areas of the monitoring foil 110 on the respective lateral end faces of the monitoring foil 110. In an other alternative embodiment the sensor units 120 (respectively the sensor elements 121) are arranged in the edge areas of the monitoring foil 110 on a surface of the monitoring foil 110 opposite the surface of the monitoring foil 110 that faces the display surface 130, as exemplary and schematically illustrated in Figures 3A, 3B and 4.

[0043] In the displayed sketch of Figure 2, the monitoring foil 110 is arranged on the whole display surface 130, such that the light emitted via the display surface 130 enters the monitoring foil 110. The entered light E - or at least a portion of it - is then guided via the monitoring foil 110 towards the edge area of the monitoring foil 110 where the respective sensor units 120 are positioned. This guided light G is thus recognized by the respective sensor elements 121 and results in a respective signal S of the individual sensor element 121 - as exemplary illustrated in Figure 6. Then, each sensor element 121 forwards the respective signal S to the controller 210 of the luminaire 1, whereas the controller 210 evaluates the received signals of the sensor elements 121 and based thereon generates a reconstruction image, which is a reconstruction of the image actually displayed in the respectively monitored area of the display surface 130. A more detailed explanation of the functioning of the monitoring foil 110 in combination with the display surface 130, respectively the display 130a, will be given with regard to Figures 3A, 3B, 4, 5A, 5B and 6.

[0044] For sake of simplicity the functionality of the monitoring foil 110 is presented schematically in Figures 3A and 3B by example of one simplified light beam. Hereby light emitted by the display surface 130 enters the monitoring foil 110 as emitted light E, interacts with elements of the monitoring foil 110 and is thus redirected towards an edge area of the monitoring foil 110, where the sensor unit 120 (respectively its sensor elements 121) is positioned for detection of the respective guided light G.

[0045] Figure 3A shows a sketch of a display unit 10 in a cross-sectional view comprising the monitoring unit 11 and the display 130a (respectively the display surface 130). The shown monitoring unit 11 comprises a monitoring foil 110 (with one layer 110a) and sensor units 120. As the display unit 10 is shown in a cross-sectional view, only two sensor units 120 are illustrated, whereas - as described previously - the sensor units 120 are usually positioned in general in a frame-like manner in the end areas of the display surface 130.

[0046] Figure 3B shows the same basic setup of a display unit 10, whereas the monitoring foil 110 now

comprises three layers of monitoring foil 110a, 110b, 110c. Each layer of monitoring foil 110a, 110b, 110c hereby has its own sensor units 120 in the respective edge areas. Moreover it is desired in the setup of the monitoring foil 110 with three layers 110a, 110b, 110c that each foil layer 110a, 110b, 110c has different characteristics with regard to the light which is directed towards its sensor elements 121.

[0047] In particular it is conceivable that the first layer 110a is configured to redirect light of a certain wavelength that is different to the respective light wavelength considered by the respective other layers 110b, 110c and vice versa. Thus, the respective guided light G of the different layers 110a, 110b, 110c may have different light characteristics. In Figure 3B the different guided lights are schematically displayed as light beams G1, G2, and G3 being redirected and guided towards the respective edge areas of the respective layer 110a, 110b, 110c of the monitoring foil 110. Hereby it is in particular possible that the first layer 110a redirects light of the reddish colours (i.e., redirects light in a wavelength range of, e.g., circa 580 nm to 800 nm, or any subgroup thereof, in particular with other additional possible approximate boundaries such as 590 nm, 600 nm, 625 nm, 700nm, 740 nm), and that the second layer 110b redirects light of greenish colours (i.e., redirects light in a wavelength range of, e.g., circa 490 nm to 590 nm, or any subgroup thereof, in particular with other additional possible approximate boundaries such as 495 nm, 500 nm, 565 nm, 570nm), and that the third layer 110c redirects light of blueish colours (i.e., redirects light in a wavelength range of, e.g., circa 400 nm to 500 nm, or any subgroup thereof, in particular with other additional possible approximate boundaries such as 430 nm, 440 nm, 485 nm, 490 nm). A (small) overlap in respectively redirected wavelengths of the different layers 110a, 110b, 110c may hereby be explicitly intended, to achieve better results in evaluation.

[0048] Also it is conceivable that merely two layers (e.g. a first and second monitoring foil layer 110a, 110b) are present, whereas the composition of the monitoring foil 110 may hereby be selected based on the situational requirements of the respective luminaire 1. For example a luminaire 1 that will only displays two coloured images, might be sufficiently equipped with a respective two layer monitoring foil 110, 110a, 110b.

[0049] However, even the one layered monitoring foil 110, 110a is sufficient for monitoring the respective displayed image, whereby a colour distinction may not be possible in this case. Here, the signals provided by the sensor elements 121 are evaluated by the controller 210 to reconstruct a grey-scale image, which - in most use cases, and especially with regard to an escape sign luminaire - is sufficient for detecting a respectively shown pictogram 131. In general - independent on the number of layers 110a, 110b, 110c of the monitoring foil 110 it is desired that the wavelength range covered by the monitoring foil (respectively the several foil layers 110a, 110b, 110c) extends substantially from 400 nm to 800 nm,

preferably from 490 nm to 800 nm, or further preferably from 490 nm to 700 nm. As previously mentioned, depending on the respective scenario also other wavelength ranges are conceivable, that may be tailored to the respectively shown images.

[0050] Hereby it is to be considered that of course it shall not be intended that all of the light emitted by the display surface 130a is redirected by the monitoring foil 110 towards the respective sensor elements 121, as this would result in a scenario where light emitted from the luminaire 1 is not used for illumination of an area used by a user - which clearly is the main task of the luminaire 1. Thus, only a fraction of the light E emitted from the display surface 130 into the monitoring foil 110, will be redirected and guided towards the edge areas of the monitoring foil 110. This is also schematically illustrated in Figure 4, with the light beams E1 and E2 penetrating the monitoring foil 110 without colliding with a redirecting element 111 of the monitoring foil 110, and thus exit the monitoring foil 110 without any changes concerning their respective light path.

[0051] Figure 4 further schematically illustrates the redirection of the specific emitted light E3 to receive a guided light G inside the monitoring foil 110 and guiding this light G towards one sensor unit 120. The monitoring foil 110 hereby comprises particles 111 as redirecting elements 111, whereas the particles 111 are configured to redirect and guide (a portion of) the emitted light E, E1, E2, E3 (represented with dashed lines) from the display surface 130 within the monitoring area towards edge areas of the respective monitoring foil 110. Ideally the monitoring foil 110 is a transparent polymeric foil comprising these particles 111. In the specific exemplary embodiment shown in Figure 4, the monitoring foil 110 is a luminescent concentrator LC and the particles 111 are fluorescent particles 111, and in particular fluorescent dye particles 111 that initially absorb light of a certain wavelength and subsequently emit light of a longer wavelength. Hereby - as schematically indicated - a certain part of the light emitted by such a particle 111 is guided within the monitoring foil 110 towards the edge areas of the monitoring foil 110, whereas the other part is emitted approximately in the direction of the original emitted light E3. The reemission of light in the original light emission direction has the benefit of an increase of light being emitted to the surrounding of the respective luminaire 1.

[0052] With regard to the exemplary embodiment of the monitoring foil 110 being a luminescent concentrators LC having fluorescent dye particles 111 the following may be additionally considered. Luminescent concentrators LC are polymer plates or foils that are doped with fluorescent molecules. Light that is not reflected on the surface of a luminescent concentrator LC passes through, making it transparent. The dye inside the luminescent concentrator LC absorbs a specific portion of the light spectrum that passes through, and reemits it in a lower frequency. For instance, blue light is absorbed and re-emitted as green light. The band of the spectrum that can

be absorbed depends on the chemical structure of the dye. The fluorescent particles randomly emit light in all directions. Most of the first-generation photons are preferably trapped inside the luminescent concentrators LC due to total internal reflection TIR and are propagated to the edges of the luminescent concentrators LC where the respective sensor elements 121 are positioned.

[0053] With regard to the exemplary embodiment of the monitoring foil 110 having multiple layers 110a, 110b, 110c it can be desired in this respect that the foil layers 110a, 110b, 110c have different particles 111, in particular different fluorescent dye particles 111, wherein each foil layer 110a, 110b, 110c is configured to redirect and guide G light of a certain wavelength range, different from the respective other foil layers 110a, 110b, 110c.

[0054] As the wavelength is altered by the such configured monitoring foil 110 the colour configuration of the respective to be displayed images of the luminaire 1 may be adapted thereto, such that confusion of a user is avoided (e.g., with a luminaire showing an escape route pictogram in a reddish colour instead of the usual green colour). This can be achieved by tuning the colouring of the respective to be displayed image, which can be performed, e.g., by the controller 210, via a respective configuration.

[0055] As further shown in Figure 4 the monitoring foil 110, respectively each layer 110a, 110b, 110c thereof, is configured for light guidance by means of total internal reflection TIR, such that guided light G that reaches a surface of the respective monitoring foil 110 (or of its respective layer 110a, 110b, 110c) is totally reflected. Via this configuration a very effective and loss-less light guidance towards the sensor elements 121, respectively the sensor unit 120, is achieved.

[0056] Based on the amount of light that reaches a respective sensor element 121 the sensor element gives a respective feedback signal to the control 210. The controller 210 then evaluates all the signals received from the individual sensor elements 121 - respectively from the respective sensor units 120 who gather the information and forward it to the controller 210. Based thereon the controller 210 generates a respective reconstruction of the displayed image.

[0057] The light guidance towards the sensor elements 121, respectively the sensor unit 120, can be supported by a reflective surface of the monitoring foil 110 in the edge areas of the foil 110.

[0058] The cooperation between the monitoring foil 110 and its respective sensor elements 121 is illustrated in Figures 5A and 5B, whereas Figure 6 focuses on the illustration of signals to be evaluated by the controller 210, for reconstructing the respective image.

[0059] The described specific exemplary embodiment of Figures 5A, 5B and 6 concerning the design of the monitoring unit 11 and the evaluation process performed by the controller is further described in detail in the publication of Koppelhuber et al.

[0060] Figure 5A shows the monitoring unit 11 with the centrally positioned monitoring foil 110 and this element frame-like surrounding sensor units 120 with their respective sensor elements 121 in a top view. In the specific implementation shown at the edge area of the monitoring foil 110 triangular slit structures 113 are provided. Each triangular slit structure 113 has its widest part aligned towards the respective sensor elements 121, and its narrowest part in direct contact with a surface of the monitoring foil 110, whereas this narrowest part of each triangular slit structure 113 forms a passage 115 for the guided light G to enter and reach the sensor elements 121. Per triangular slit structure 113 preferably a plurality of sensor elements 121 are present. Between the individual triangular slit structures 113 cut-out areas 114 are present. These cut-out areas 114 are preferably filled with an opaque substance (such as opaque modelling compound), as this configuration drastically reduces stray light which is unwanted and may interfere with the light passing through the passage 115 falsifying the detection of the sensor elements 121.

[0061] It is further conceivable that the aforementioned reflective surface in the edge areas of the monitoring foil 110 is positioned on a surface of the triangular slit structure 113 to improve light guidance within the structure towards the respective sensor elements 121. With an implementation of the sensor elements 121 being positioned on a surface of the monitoring foil 110 that is opposite to the surface of the monitoring foil 110 being in contact with the display surface 130, the reflective surface may also be present underneath the sensor elements 121 at the back of the monitoring foil 110 reflecting light towards the sensor elements 121. The reflective surface hereby leads to a cleaner signal of the sensor elements 121.

[0062] These elements, namely the triangular slit structure 113 and the cut-out areas 114 are part of the monitoring unit 11 and further may also form an individual sub-unit together. This sub-unit might either be associated with the respective sensor units 120 or with the monitoring foil 110 itself.

[0063] As indicated in the embodiment of Figure 5A the monitoring foil 110 may (virtually) be divided into individual cells 112. These cells 112 represent individual pixels 112 of the monitoring foil, as the data gathered by all sensor elements 121 will be evaluated for each of the pixels 112. Hereby, each two opposing triangular slit structures 113 either create a (virtual) column or a (virtual) row of the monitoring foil 110, whereas the (virtual) separation of the monitoring foil 110 allows for a specific addressing of the individual (virtual) pixels 112 of the monitoring foil 110. The term "virtual" herein solely means that the monitoring foil 110 per se does not have any physical grid-like structure per se. This "virtual" zoning merely refers to the respective light entering the monitoring foil 110 in these zones and being redirected towards the edge areas of the monitoring foil 110, where the respective light is detected by the plurality of sensor

elements 121. The evaluation and recreation process of the controller 210 allocates different luminosities back to these virtual cells 112 forming a recreation of the originally displayed image on the display surface 130. Thus, the controller 210 basically evaluates for each virtual pixel 112, i.e., for each respective region of the monitoring foil 110 a certain illumination value preferably by using a respective image reconstruction technique, and based thereon generates a reconstructed image of the image originally being displayed on the display surface 130.

[0064] In particular the end region of the monitoring unit 11 with the above described triangular slit structure 113 and the cut-out areas 114 is such configured that per triangular slit structure 113 only part of the guided light beams G can enter the respective triangular slit structure 113, whereby these different light beams can be categorised into different directions ϕ , as illustrated in Figure 5B by the different light beams $G_{\phi_1}, \dots, G_{\phi_i}, \dots, G_{\phi_m}$ of different directions $\phi, \phi_1, \dots, \phi_i, \dots, \phi_m$ entering the triangular slit structure 113.

[0065] Hereby, as schematically illustrated in Figure 5B, the triangular slit structure 113 may have a specific width w and depth d . The passage 115 also may have a specific width a . Depending on the design of these parameters, the field of view angle α of each triangular slit structure 113 can be tuned. Hereby the number $x, x_1, \dots, x_i, \dots, x_n$ of triangular slit structures 113 per edge of the monitoring foil 110 has to be considered as well, whereas as the slit structures 113 are relevant with regard to the number of rows and columns and thus of the number of virtual pixels 112 the desired the number $x, x_1, \dots, x_i, \dots, x_n$ of triangular slit structures 113 depends on the desired resolution of the monitored area. As found by Koppelhuber et al., the triangular slit structures 113 preferably had a minimum specific width a of 0,5 mm to avoid breakage and preferably the depth d was constrained to a range of 2 to 5 mm. The number n of triangular slit structures 113 per edge preferably are kept below 1,5 times the desired image resolution of the monitoring area (i.e., $n = 24$ for an exemplary desired image resolution of 16×16). Thus, the number of virtual columns and rows created by the triangular slit structures 113 and thus the number of the virtual pixels 112, are not equivalent to the resolution of the reconstructed image, but influence one another. As apparent the number n of triangular slit structures 113 per edge can be different, depending on the width and length of the respective monitoring foil 110.

[0066] Hereby the different sensor elements 121, 121_{ϕ_i} of the different respective numbers $x, x_1, \dots, x_i, \dots, x_n$ of the triangular slit structures 113 provide different signals S to the controller 210 depending on the respectively detected luminosity, as shown in Figure 6. Hereby the provided data by the different sensor elements 121 contains individual information concerning the respective light of the different directions ϕ . The controller 210 hereby processes the vast amount of information and reconstructs, preferably by using SART, NNLS, or BiCGstab as

image reconstruction techniques - as suggested by Koppelhuber et al. -, the image displayed on the display surface 130.

[0067] As not all of the light emitted via the display surface 130 within the respective monitoring area will be redirected within the monitoring foil 110 towards its edges to the respective sensor elements, the controller 210 is configured (in the shown embodiments) to consider the occurring losses and to recreate the respective image based on the received sensor signals. Depending on the embodiment of the monitoring foil different losses are hereby possible.

[0068] The described specific exemplary embodiment of Figures 5A, 5B and 6 concerning the design of the monitoring unit 11 and the evaluation process performed by the controller is further described in detail in Koppelhuber et al. The therein presented specific exemplary embodiment of a monitoring foil 110 has a thin-film luminescent concentrator LC as a monitoring foil 110, whereas the foil 110 comprises fluorescent dye particles 111 that absorb light of a specific wavelength and re-emit it at a longer wavelength. The monitoring foil 110 hereby forwards and thus guides the respective redirected light G to the edges of the monitoring foil 110 by total internal reflection with a non-linear attenuation that depends on the distance of the light travelled. At the edges of the foil 110 the sensor elements 121 are positioned to decouple the respective light from the waveguide of the monitoring foil 110, and generate a corresponding signal that is then sent to the controller 210. The attenuation of the measured light at these different positions of the individual sensor elements 121 allows localization of an incident light point on the monitoring foil 110 via triangulation, which represents the respective light emitted by the display surface 130 and entered into the monitoring foil 110 in the respective monitored area. Hereby reconstruction of the originally displayed image on the display surface 130 is possible.

[0069] Further, it is known that the propagation from the respective light emitted by the display surface 130 and entered into the monitoring foil 110 within the monitoring area at a specific point is subject to losses, wherein these losses can be in general categorized as "cone-loss", "absorption loss" and "scattering and incomplete total internal reflection loss". "Scattering and incomplete total internal reflection loss" is due to imperfections of the surface of the monitoring foil 110, such that light may be not perfectly reflected via total internal reflection but rather scatters to some degree on the surface - under ideal conditions this kind of loss does not occur. "Cone-loss" occurs if the angle between the incident ray of light and the normal of the monitoring foil 110 surface-to-air interface is greater than a critical angle θ_c . The critical angle θ_c can be derived from Snell's law and is given by

$$\theta_c = \arcsin \frac{1}{n}$$
, where n is the respective refractive index. For example, TIR occurs at an angle greater than

39,2° for a monitoring foil 110 made of polycarbonate. The solid angles above and below a fluorescent particle where total internal reflection TIR does not occur are cone-shaped. For a planar luminescent concentrator LC with refractive index n , the fraction of luminescence P that is lost due to cone-loss is given by $P = 1 -$

$$\sqrt{1 - \frac{1}{n^2}}$$

. For a monitoring foil 110 made of polycarbonate ($n = 1,58$), the "cone-loss" is approximately 22,6%, as identified in Koppelhuber et al. Absorption processes are another source of loss along the path from a fluorescent particle to the edges of the monitoring foil 110 where the sensor elements 121 are positioned, whereas these losses are considered as "absorption loss". Hereby, self-absorption is the re-absorption of a fluorescent photon by another dye molecule due to overlapping absorption and emission spectra. The longer the path length (i.e., the longer the distance from the point where the respective light entered E into the monitoring foil 110 from the display surface to the edge area of the monitoring foil), the higher the probability of self-absorption. The polymer host itself is another possible source of absorption. The Beer-Lambert law states that the intensity of light decreases according to $I = I_0 e^{-\mu l}$ when it travels through a homogeneous absorbing substance, where I is the intensity leaving the material, I_0 is the intensity entering the material, μ is the attenuation coefficient that is constant along the transport path, and l is the length of the transport path.

[0070] As the relations for these losses are known, these losses can be considered by the controller 210 upon evaluation of the received signals of the signal elements 121, respectively of the signal units 120. Furthermore, the controller 210 has data of an initial calibration process of the monitoring unit 11, such that relations between emitted light at points of the monitoring foil 110 and a respective detection of each sensor element 121 are known. Hereby also ambient light impact may be taken into account to further improve the evaluation.

[0071] As previously described with regard to Figure 5A the monitoring foil 110 is divided into a virtual grid with respective cells 112. These virtual cells 112 represent the pixels 112 of a respective virtual display. Hereby the amount of transported light at the edges of the monitoring foil 110 is measured by the respective sensor units (which exemplary are realized by contact image sensor line scan cameras), which each consist of a single array of sensor elements (which exemplary are realized by photosensors). With the data of the sensor elements 112 - as exemplary shown in Figure 6 - and the data of the initial calibration process of the monitoring unit 11 and the known losses the controller 210 is able to reconstruct for each virtual pixel 112 (respectively for each cell 112) a respective luminosity value. Depending on the amount of layers 110a, 110b, 110c and the respective lighting char-

acteristics considered by each layer 110a, 110b, 110c different colour intensity values can be achieved, resulting upon combination of the different colour data in a coloured image. With solely one layer at least a grey-scale reconstructed image of the image displayed on the display surface 130 is possible. For reconstruction various techniques, such as BiCGStab, NNLS, QRD, SVD, pseudo-inverse (PINV), SART, filtered backprojection (FBP), are conceivable to be used, whereas preferably SART, NNLS, or BiCGStab are used, as only these provided reasonable reconstruction quality, as shown in Koppelhuber et al.

[0072] With the monitoring foil 110 having no integrated circuits or other structures such as grids of optical fibres or photodiodes the monitoring foil 110 is fully transparent.

[0073] Furthermore, due to the flexibility of the monitoring foil 110, also non-planar display surfaces 130 are conceivable to be monitored by a respective monitoring foil 110.

[0074] The monitoring foil 110 may be attached to the display surface 130 by form fit and/or via force fit. Hereby it is also conceivable that the frame element 160 is used for fixating the monitoring foil 110 to the display surface 130, or other fixation means.

[0075] The monitoring foil 110 may have a thickness of approximately 0,3 mm.

[0076] Herein presented is a luminaire 1, preferably an escape sign luminaire 1, with an integrated monitoring unit 11 that monitors an image displayed via the display surface 130 of the luminaire 1. The controller 210 of the luminaire 1 is configured to generate the image to be displayed by the luminaire 1, wherein the monitoring foil 110 is arranged on the display surface 130 in a monitoring area. The monitoring foil 110 is configured to guide G at least a portion of an emitted light E - emitted by the display surface 130 - towards edge areas of the monitoring foil 110, wherein the edge areas of the monitoring foil 110 have sensor elements 121 surrounding the monitoring foil 110 in a frame-like manner. Each of the sensor elements 121 is configured to detect the respective guided light and to output a corresponding detection signal to the controller 210, wherein the controller 210 is configured to evaluate the signals received from all sensor elements 121 and, based on this evaluation, to generate a reconstruction image, which is a reconstruction of the image actually displayed in the monitoring area of the display surface 130. Furthermore, various embodiments of the luminaire (1) are disclosed, whereas individual features of these embodiments are of course interchangeable, and apply analogously to other embodiments, if not explicitly excluded.

[0077] The presented luminaire 1 allows for an utmost easy and reliable monitoring of a respectively displayed image on a display surface 130. Hereby the actual displayed image is monitored and checked, leading to trustworthy results with regard to the operational condition of the respective luminaire 1. In particular a reliable remote

monitoring of the luminaire 1 is possible, minimising costs of maintenance.

5 Claims

1. Luminaire (1) with integrated monitoring of an image displayed by the luminaire (1), the luminaire (1) comprising

- a plurality of illuminants with a common light emitting surface forming a display surface (130) for displaying an image;

- a monitoring unit (11) arranged on the display surface (130), wherein the monitoring unit (11) is a monitoring foil (110) and the edge areas of the monitoring foil (110) have sensor elements (121) surrounding the monitoring foil (110) in a frame-like manner;

- a controller (210) for controlling the illuminants and for evaluating data generated by the sensor elements (121);

wherein the controller (210) is configured to generate the image to be displayed by the luminaire (1) by corresponding control of the several illuminants;

wherein the monitoring foil (110) is arranged on the display surface (130) in a monitoring area; wherein light emitted within the monitoring area via the display surface (130) enters the monitoring foil (110);

wherein the monitoring foil (110) is configured to guide at least a portion of this entered emitted light towards edge areas of the monitoring foil (110);

wherein each of the sensor elements (121) is configured to detect the respective guided light and to output a corresponding detection signal to the controller (210);

wherein the controller (210) is configured to evaluate the signals received from all sensor elements (121) and, based on this evaluation, to generate a reconstruction image, which is a reconstruction of the image actually displayed in the monitoring area of the display surface (130).

2. Luminaire according to claim 1,

wherein the plurality of illuminants, with the common light emitting surface forming the display surface (130) are realized by a display (130a) for displaying an image via the display surface (130); wherein preferably the display (130a) together with the monitoring unit (11) forms a display unit (10);

wherein further preferably the display (130a) is an OLED display, an LC display, a TFT-LC display or an E-Ink display.

3. Luminaire according to claim 1 or 2, whereby the monitoring area on which the monitoring foil (110) is arranged extends over the entire display surface (130).

4. Luminaire according to any one of the preceding claims,

wherein the controller (210) has data relating to which area of the image to be displayed is located in the monitoring area of the display surface (130);

wherein based thereon the controller (210) is further configured to compare the reconstructed image of the image actually displayed via the display surface (130) in the monitoring area with the corresponding area of the image to be displayed.

5. Luminaire according to any one of the preceding claims,

wherein the luminaire (1) further comprises a communication unit (230) for communicating with external devices, preferably with a luminaire management system;

wherein the communication unit (230) is also used for internal communication of components of the luminaire (1) with the controller (210);

wherein the luminaire (1) is preferably configured to send the reconstructed image of the image actually displayed in the monitoring area to an external device via the communication unit (230), and/or wherein the luminaire (1) is preferably configured to receive an image to be displayed via the communication unit (230) and to transmit it to the controller (210) for controlling the plurality of illuminants.

6. Luminaire according to claim 4 in conjunction with claim 5,

wherein the luminaire (1) is configured to send the result of the comparison of the image actually displayed in the monitoring area with the corresponding area of the image to be displayed to an external device via the communication unit (230).

7. Luminaire according to any one of the preceding claims,

wherein the luminaire (1) further comprises a storage unit (240) in which different images are stored, wherein the controller (210) has access to the images stored in the storage unit (240) and is configured to select an image to be displayed from the storage unit (240) and to control the plurality of illuminants accordingly; wherein preferably, if the luminaire (1) also has a

communication unit (230), the controller (210) can be controlled by an external device via the communication unit (230) to select a specific image from the storage unit (240).

8. Luminaire according to any one of the preceding claims, wherein the monitoring foil (110) is configured for light guidance by means of total internal reflection.

9. Luminaire according to any one of the preceding claims, wherein the monitoring foil (110) is a transparent polymeric foil comprising particles (111) configured to redirect and guide at least a portion of the emitted light from the display surface (130) within the monitoring area towards edge areas of the monitoring foil (110).

10. Luminaire according to claim 9,

wherein the monitoring foil (110) is a luminescent concentrator, LC, and the particles (111) are fluorescent particles (111), in particular fluorescent dye particles (111), which initially absorb light of a certain wavelength and subsequently emit light of a longer wavelength, and wherein a part of the light emitted by a respective particle (111) is guided within the monitoring foil (110) towards the edge areas of the monitoring foil (110).

11. Luminaire according to claim 9 or 10,

wherein the monitoring foil (110) comprises several foil layers (110a, 110b, 110c); wherein the foil layers (110a, 110b, 110c) have different particles (111), in particular different fluorescent dye particles (111), and wherein each foil layer (110a, 110b, 110c) is configured to redirect and guide light of a certain wavelength range, different from the respective other foil layers (110a, 110b, 110c), of the light emitted by the display surface (130) within the monitoring area for displaying the image and entering the monitoring foil (110); wherein preferably the total wavelength range covered by the several foil layers (110a, 110b, 110c) extends substantially from 400 nm to 800 nm, in particular from 490 nm to 800 nm, or 490 nm to 700 nm.

12. Luminaire according to any one of the preceding claims,

wherein the sensor elements (121) are arranged in the edge areas of the monitoring foil (110) on a surface of the monitoring foil (110) opposite to

the surface of the monitoring foil (110) that is in contact with the display surface (130); or wherein the sensor elements (121) are arranged in the edge areas of the monitoring foil (110) on the lateral end faces of the monitoring foil (110). 5

13. Luminaire according to any one of the preceding claims, wherein the monitoring foil (110) has in its edge areas with the sensor elements (121) a reflective surface for light guidance towards the respective sensor elements (121). 10

14. Luminaire according to any one of the preceding claims, 15

wherein the sensor elements (121) are bundled into several sensor units (120), wherein one sensor unit (120) is provided per edge area of the monitoring foil (110); 20

wherein the monitoring foil (110) is preferably rectangular, and a sensor unit (120) is provided on each of the four side surfaces.

15. Luminaire according to any one of the preceding claims, 25

wherein the luminaire (1) further comprises a power unit (250), which is configured to supply power to the luminaire (1), and preferably comprises a power storage, for example an emergency battery for supplying power to the luminaire (1) in an emergency; and/or 30

wherein the luminaire (1) further comprises a housing (21) in which at least the controller (210) is arranged; and/or 35

wherein the luminaire (1) further comprises a frame element (160) which is arranged in the direction of light emission of the illuminants following the sensor elements (121) and covering them. 40

16. Luminaire according to any one of the preceding claims, 45

wherein the luminaire (1) is an escape sign luminaire (1) with integrated monitoring of an image displayed by the escape sign luminaire (1) comprising an escape sign pictogram (131); wherein the image with a respective escape sign pictogram is displayed on the display surface (130); 50

wherein the controller (210) is configured to evaluate the signals received from all sensor elements (121) and, based on this evaluation, to generate a reconstruction image which is a reconstruction of the image of the escape sign pictogram (131) actually displayed in the mon- 55

itoring area of the display surface (130); wherein preferably the plurality of illuminants with the common light emitting surface forming the display surface (130) are realized by a display (130a) for displaying an image via the display surface (130).

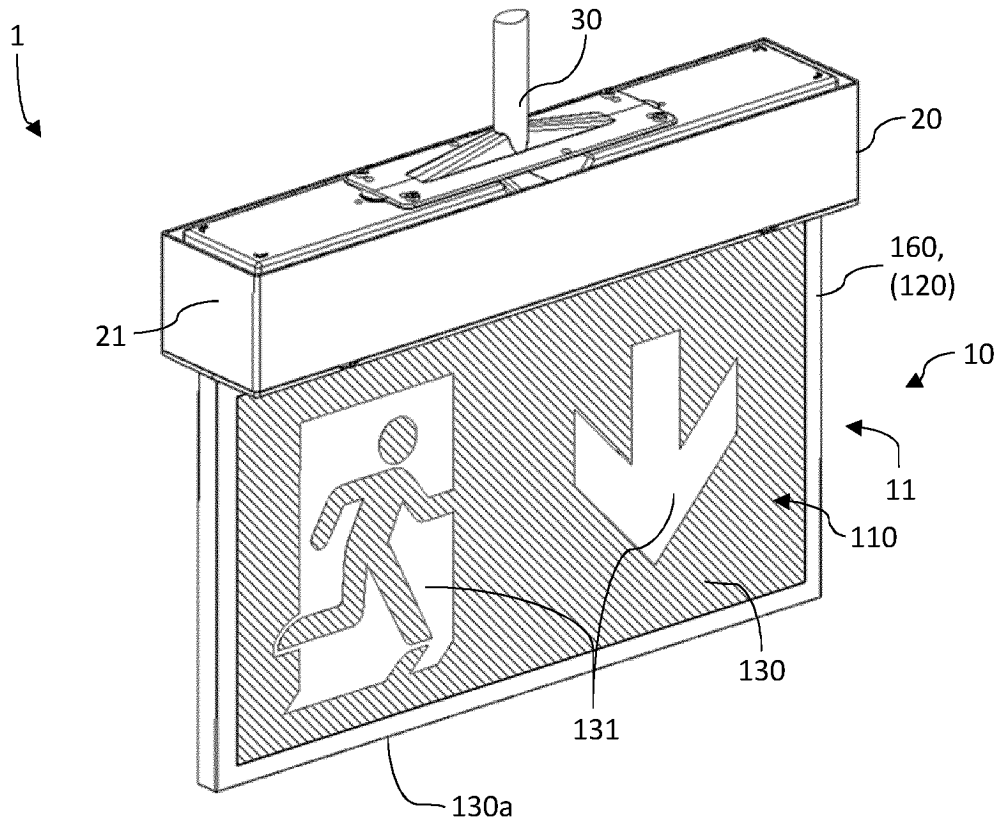


Fig. 1

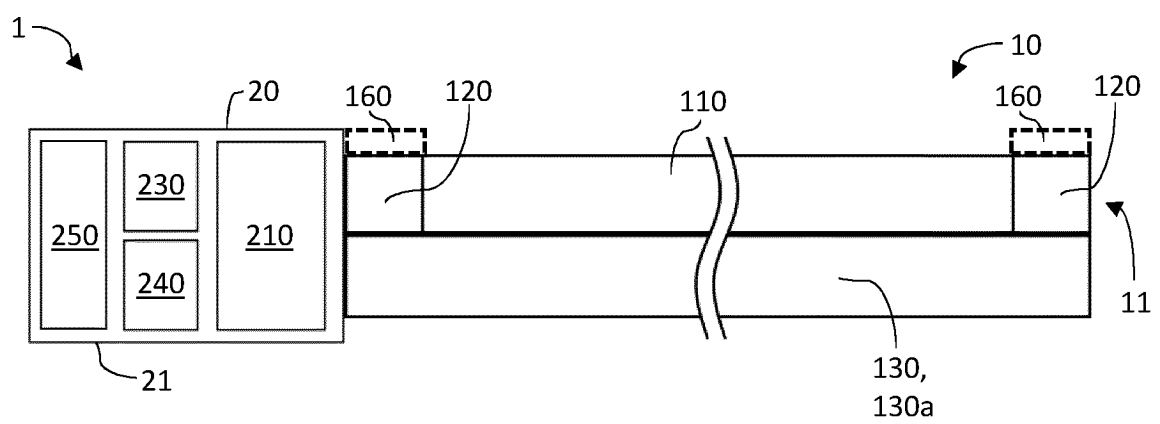


Fig. 2

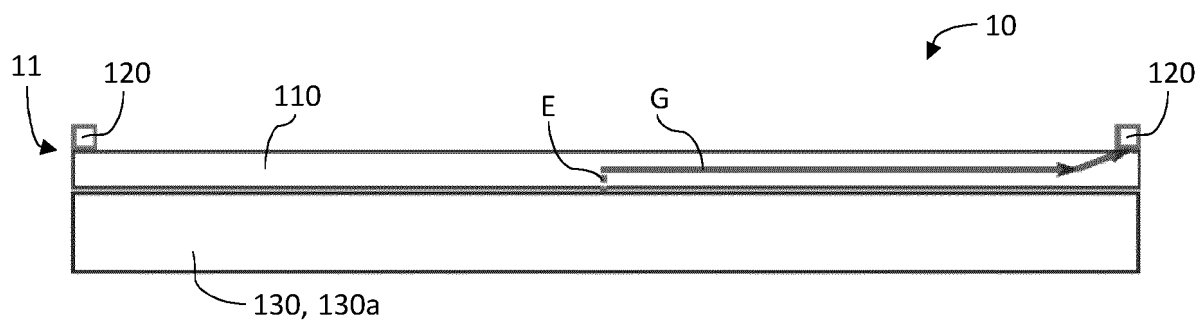


Fig. 3A

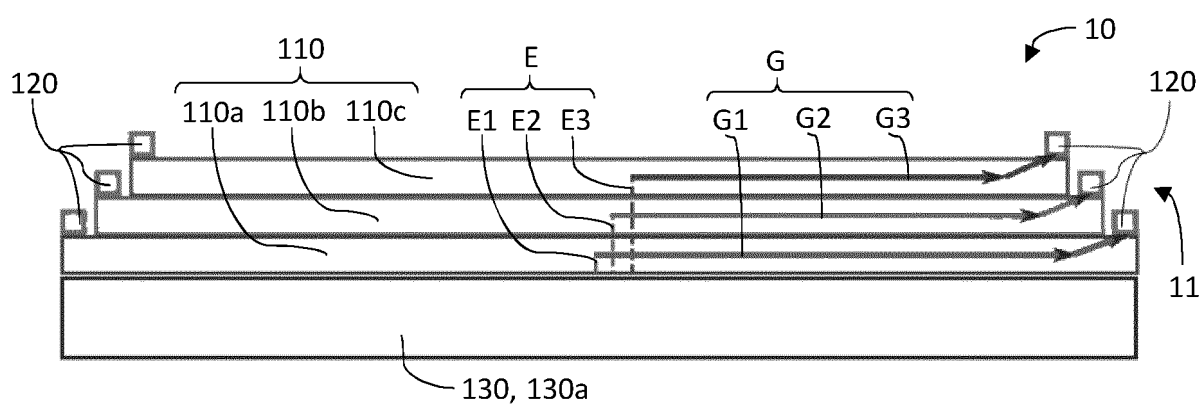


Fig. 3B

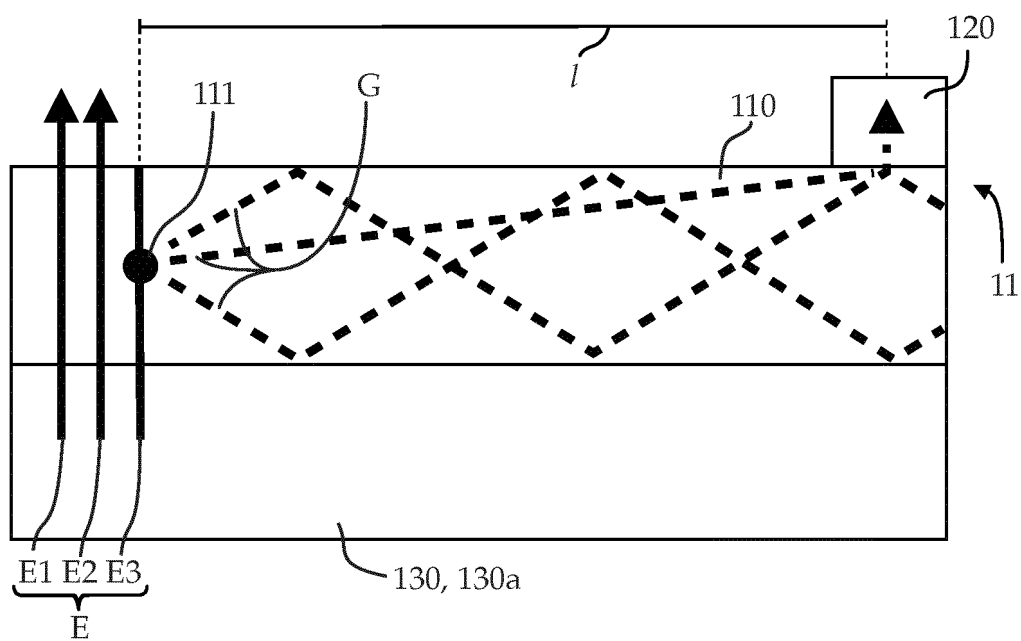


Fig. 4

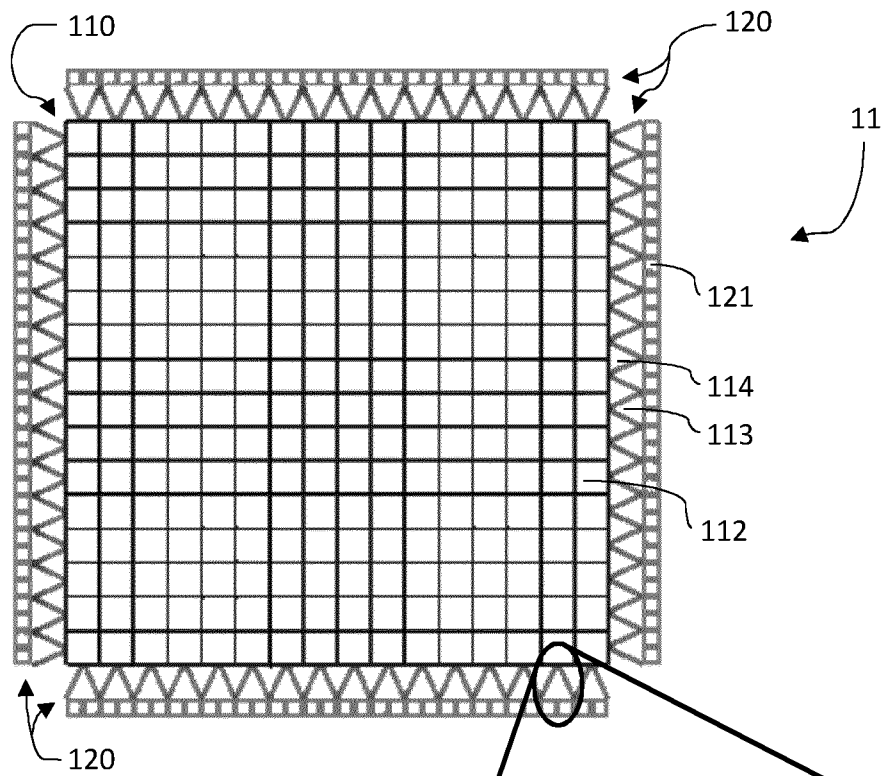


Fig. 5A

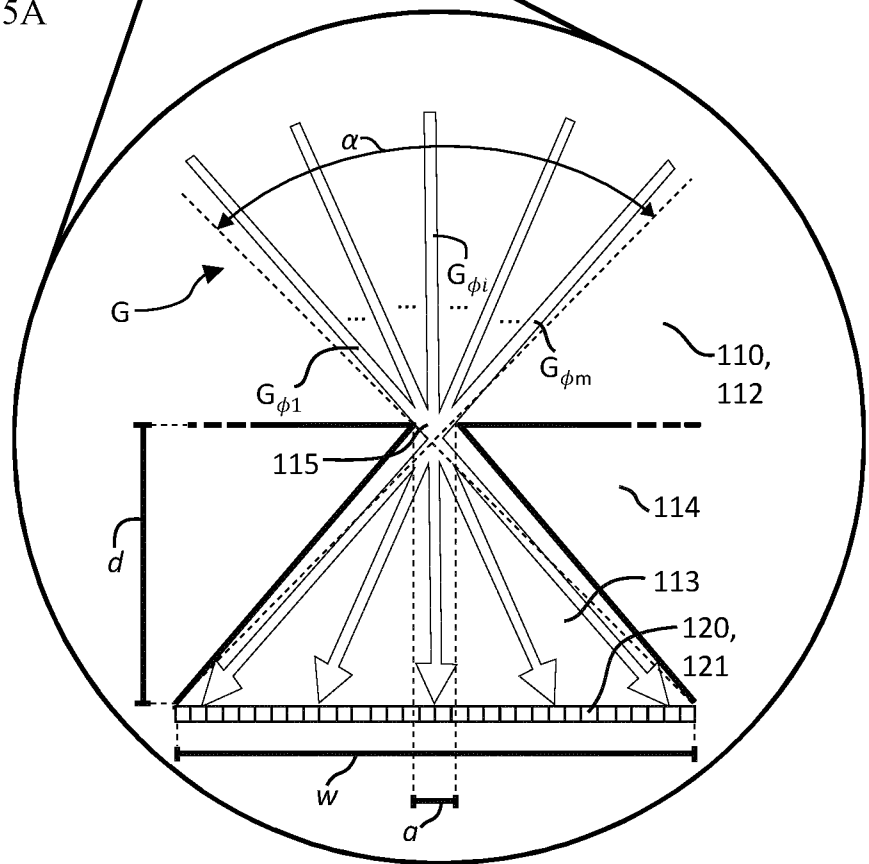


Fig. 5B

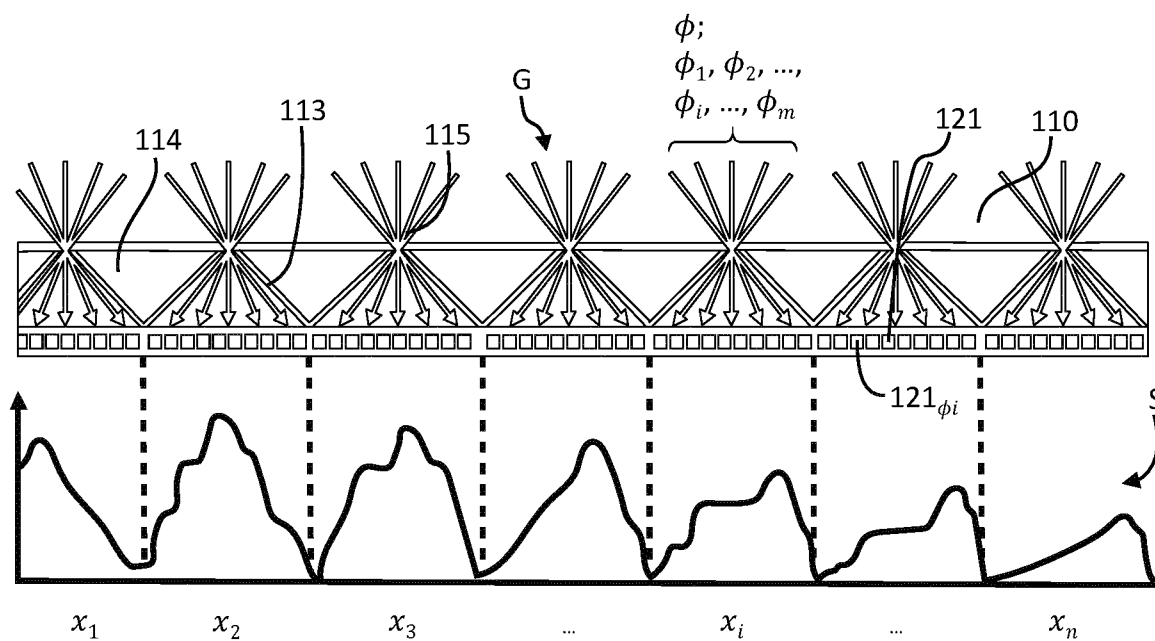


Fig. 6

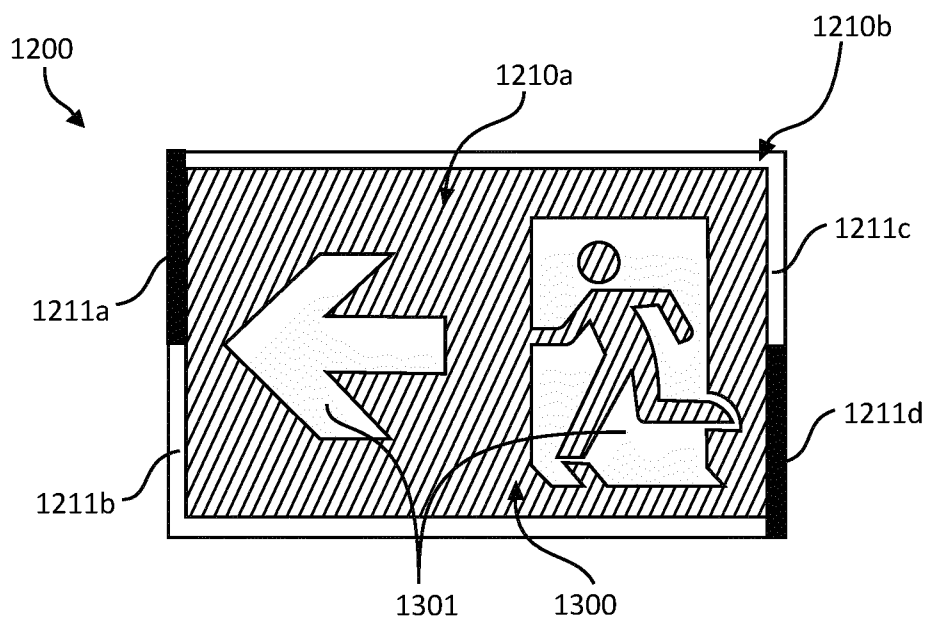


Fig. 7
(prior art)



EUROPEAN SEARCH REPORT

Application Number

EP 23 21 6953

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	DE 10 2012 100348 A1 (P E R FLUCHT UND RETTUNGSLEITSYSTEME GMBH [DE]) 18 July 2013 (2013-07-18)	1-9, 12, 15, 16	INV. G08B7/06 G09G3/00
A	* par[0006]-[0012] and [0018] *	10, 11, 13, 14	H05B45/12 H05B47/20 H05B47/105
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A	* par[0073], [0079]-[0083], [0111], [0126]; figures 2, 6, 16 *	10, 11, 13, 14	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			G08B G09G H05B
Place of search		Date of completion of the search	Examiner
Munich		13 May 2024	Erskine, Andrew
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13-05-2024

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DE 102012100348 A1	18-07-2013	NONE	
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- EP 3428906 B1 **[0003]**

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- Towards a transparent, flexible, scalable and disposable image sensor using thin-film luminescent concentrators. Journal Optics Express. Optical Society of America (OSA), 2013, vol. 21 **[0010]**