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(54) **Title:** EYE DETECTION SYSTEM AND METHOD FOR AUTOMATIC ACTIVATION OF A VIEWING DEVICE

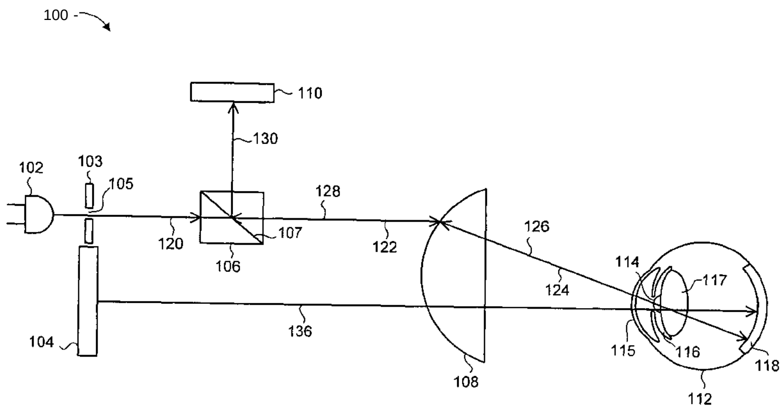

FIG. 1

(57) **Abstract:** Eye detection system integrated within a viewing device, the system including an LED disposed above and adjacent to a display of the viewing device, a viewing lens, a light router disposed on an optical axis between the LED and the viewing lens, and a sensor, the LED emitting eye safe light along the optical axis through the light router and through the viewing lens toward the eye of a user, the light reflecting back from the retina of the eye along the optical axis toward the light router, which directs the reflected light toward the sensor in a direction different from the optical axis, the sensor being monitored to determine if the sensor detected light reflected from the eye of a user, the camera activated when a positive determination is made, and deactivated when a negative determination is made.

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EYE DETECTION SYSTEM AND METHOD FOR AUTOMATIC ACTIVATION OF A VIEWING DEVICE

FIELD OF THE DISCLOSED TECHNIQUE

The disclosed technique relates to an eye-start mechanism for a viewing device.

BACKGROUND OF THE DISCLOSED TECHNIQUE

An eye-start mechanism for a viewing device initiates a particular action or functionality when the eye of a user is brought in proximity to the device, such as when the user looks through the eyepiece of the device. For example, the eye-start mechanism activates the device upon detection of an eye, and deactivates the device when the eye is no longer detected. The eye-start feature thereby provides power conservation and prolongs the battery life, as the device is powered only when necessary, resulting in cost savings, in addition to greater efficiency and convenience.

Night vision imagers, such as forward looking infrared (FLIR) cameras, are commonly used in military applications, such as surveillance or reconnaissance operations. A night vision imager may transmit energy during operation, and it is desirable to limit such transmissions as much as possible, in order to reduce the potential of detection by enemy forces. Consequently, an eye-start mechanism for a night vision imager is particularly valuable in such a scenario. In addition, a night vision imager consumes a large amount of energy during operation, and therefore the power conservation benefits of an eye-start mechanism provide a further advantage in this respect.

Certain eye-start mechanisms may be triggered upon detection of a random object or body other than the eye of a user, thereby unnecessarily activating the device. Some eye-start mechanisms are operative to detect facial features other than the eye, and have an increased likelihood of false activations. The optical elements that constitute the eye-start mechanism may result in added weight to the device as well as increased costs, and may be difficult to integrate with already existing camera architectures.

US Patent No. 7,167,201 to Stavely et al, entitled "Device incorporating eye-start capability", is directed to an eye-start system for a device, such as a digital still camera, which detects when the device viewfinder is being held up to the eye of the user, before activating a device functionality (e.g., autofocusing, autoexposure, automatic white-balancing). The viewfinder includes a magnifying lens disposed at the view window, a microdisplay, red, green and blue light emitting diodes (LEDs), a beam splitter, and a sensor, disposed inside the viewfinder housing. An image is generated on the microdisplay by sequentially pulsing the LEDs. The light from the LEDs travels through the beam splitter and onto the microsdisplay, where it is reflected through the beam splitter and toward the magnifying lens. When the user places his or her eye near the magnifying lens to view the image on the microdisplay, a portion of the light reflected from the microdisplay is reflected back from the eye (e.g., from the retina or the cornea), through the magnifying lens along the same optical axis, and then reflected from the beam splitter toward the sensor. The sensor transmits a corresponding digital signal to a processor, which analyzes the signal to determine if the eye of the user was brought to the view window of the device, based on whether the brightness of the light signal exceeds a predetermined minimum threshold. If the brightness of the light incident on the sensor exceeds the threshold, then the device functionality is activated. According to one embodiment, the viewfinder includes an additional infrared (IR) LED, and an IR-pass filter. The IR LED illuminates the eye of the user directly, and the reflected IR light is collected by the sensor after passing through the IR-pass filter, which filters out visible light. The IR LED may emit light continuously or be pulsed at a specific frequency, independent of the other LEDs. According to a further embodiment, the IR LED, the IR-pass filter, and the sensor are oriented at an oblique angle relative to the microdisplay, so as to also receive reflections from the flesh surrounding the eye of the user (e.g., the eyelid, cheek or brow).

SUMMARY OF THE DISCLOSED TECHNIQUE

In accordance with the disclosed technique, there is thus provided an eye detection system integrated within a viewing device, for activating the viewing device upon detection of the eye of a user. The viewing device includes a display. The system includes an LED, a viewing lens, a light router, and a sensor. The LED is disposed on an optical axis, above and adjacent to the display. The viewing lens is disposed on the optical axis. The light router is disposed on the optical axis between the LED and the viewing lens. The LED emits eye-safe light along the optical axis, through the light router and through the viewing lens, toward the eye of a user. The light is reflected from the retina of the eye, through the viewing lens along the optical axis toward the light router, and reflected from the light router toward the sensor in a direction different from the optical axis. A processor monitors the sensor, to determine if the sensor detected light reflected from an eye of a user. The viewing device is activated if a positive determination is made, and deactivated if a negative determination is made.

In accordance with the disclosed technique, there is further provided a method for activating a viewing device upon detection of the eye of a user. The method includes the procedure of emitting eye-safe light along an optical axis from an LED, through a light router, and through a viewing lens, toward the eye of a user, the LED disposed above and adjacent to a display of the viewing device. The method further includes the procedure of receiving light reflected from the retina of the eye, the reflected light travelling through the viewing lens along the optical path toward the light router, and reflected from the light router toward a sensor, in a direction different from the optical axis. The method further includes the procedures of monitoring the sensor to determine if the sensor detected light reflected from an eye of a user, and activating the viewing device when a positive determination is made, and deactivating the viewing device when a negative determination is made.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosed technique will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Figure 1 is a schematic illustration of a side view of an eye detection system for activating a camera upon detection of the eye of a user, constructed and operative in accordance with an embodiment of the disclosed technique;

Figure 2 is a schematic illustration of a frontal view of the optical projection through the viewing lens of the eye detection system of Figure 1; and

Figure 3 is a schematic illustration of a method for activating a camera upon detection of the eye of a user, operative in accordance with an embodiment of the disclosed technique.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The disclosed technique overcomes the disadvantages of the prior art by providing a novel eye detection system and method, integrated within a viewing device, which activates the viewing device when the eye of a user is detected and deactivates the viewing device when the eye is not detected. A light emitting diode (LED) transmits eye-safe light toward an eye brought in proximity to the viewing lens, and the light is reflected from the retina of the eye toward a sensor. The transmission and reflection of the eye-safe light does not interfere with the view of the display as seen by the user through the viewing lens.

The term "viewing device" referred to herein includes all such devices that display an image to the eye (or both eyes) through an eyepiece. Such viewing devices include, for example, cameras, binoculars, weapon sights, head mounted displays (with a display on a visor or an eyepiece), and the like. The image displayed for viewing may be reproduced by a camera, such as a charge-coupled display (CCD), a digital camera, a night vision imager, a forward looking infrared (FLIR) camera, a thermal imager, and the like. For the sake of simplicity, the term "camera" is used herein by way of example only, but the disclosed technique is further applicable to any such viewing device, with or without "camera" operational capabilities.

Reference is now made to Figure 1, which is a schematic illustration of a side view of an eye detection system, generally referenced

100, for activating a camera upon detection of the eye of a user, constructed and operative in accordance with an embodiment of the disclosed technique. System 100 includes an LED 102, a diaphragm 103, a display 104, a light router 106, a viewing lens 108, and a sensor 110. LED 102 is disposed above and adjacent to display 104. Light router 106 is disposed between LED 102 and viewing lens 108 along an optical axis. Diaphragm 103 is disposed above display 104, between LED 102 and light router 106 on the optical axis. Sensor 110 is optically coupled with light router 106. Diaphragm 103 includes an aperture 105. Light router 106 includes a beam splitter represented by a partially transparent mirror 107, in the context of an exemplary implementation of light router 106.

System 100 is integrated within a camera, such as a night vision imager or a FLIR camera. In general, the camera includes a viewfinder which incorporates elements of system 100. The viewfinder may include further elements that convey a view from real scenery or from another source to display 104. Viewing lens 108 constitutes part of the eyepiece on the camera exterior, which the user looks through to compose and focus an image with the camera. When the user brings his or her eye, referenced 112, in close proximity to viewing lens 108, system 100 detects the presence of an eye and activates the camera. When the user removes eye 112 away from viewing lens 108, system 100 detects the absence of an eye, and deactivates the camera. For example, activating the camera may involve opening a camera shutter to expose an imaging lens and enable image capturing, as well as activating the display and other camera components. In general, camera activation includes activating any camera functionality, for which deactivation is desired when the display image is not being viewed by the user. Eye 112 includes a pupil 114, a cornea 115, an iris 116, an eye lens 117, and a retina 118.

Display 104 may be any display element capable of projecting an image to the user, for composing and focusing an image with the camera. For example, display 104 is an organic light emitting diode (OLED) display, an LED with an electroluminescent emissive layer made up of organic compounds, and which does not require a backlight. Alternatively, display 104 may be a liquid crystal display (LCD), or another type of transmissive or reflective display.

LED 102 emits eye-safe light, preferably at a wavelength selected in the range of approximately 750-900nm. This wavelength range is preferable because wavelengths within this range are eyesafe, and because they can pass through the various optical elements of system 100 in the desired optical path (i.e., transmitted through or reflected from the optical elements in the desired directions), without interfering with the visible light path of the displayed image. Accordingly, other eye-safe wavelengths (i.e., in the visible or infrared spectral ranges), which enable the light to pass through the various optical elements of system 100, in the desired optical paths, may also be used.

Partially transparent mirror 107 may be any optical element that provides the necessary reflection and transmission of light, such as an optical waveguide, a lens or a prism with a reflective coating, and the like. The reflectivity of mirror 107 can be achieved with a reflective coating (e.g., silver coating, aluminum coating, and the like). Viewing lens 108 magnifies the image displayed on display 104. Diaphragm 103 regulates the amount of light passing through, by adjusting the size of aperture 105. Diaphragm 103 and display 104 are each disposed at the same focal length respective of viewing lens 108.

Sensor 110 is a sensor device, which detects light at a wavelength selected in the range of approximately 750-900nm. Sensor 110 may be operative to detect light only at the desired wavelength (i.e., a narrow band sensor). If necessary, a bandpass filter may be used to block light outside the desired wavelength from reaching sensor 110. Sensor 110 may be, for example, a photodiode, a CCD, or another type of light detection element.

The user activates eye-start system 100, such as by pressing a button or toggling a switch (not shown), which directs the camera to operate in a "standby mode" or "eye-start mode". Once system 100 has been activated, LED 102 emits eye-safe light. The emission of light from LED 102 may be continuous or pulsed, and may be emitted intermittently, according to a predetermined frequency or a particular timing schedule. The light from LED 102 passes through aperture 105 and travels along path 120 toward partially transparent mirror 107, which passes through the light toward viewing lens 108, along path 122. Viewing lens 108 directs the light along path 124 toward retina 118 of eye 112 (through pupil 114 and cornea 115). As a result of the retroreflective characteristics of the retina, a portion of the received light is reflected back along path 126 toward viewing lens 108. Viewing lens 108 directs the reflected light toward partially transparent mirror 107 along path 128. Partially transparent mirror 107 diverts the reflected light along path 130 toward sensor 110. It is noted that optical path 126 is collinear with optical path 124, and similarly, optical path 128 is collinear with optical path 122 (both are depicted in Figure 1 as double ended arrows).

A processor (not shown) monitors sensor 110, and determines if sensor 110 received light reflected from an eye. For example, if sensor 110 receives light at a wavelength selected in the range of approximately 750-900nm, and at an intensity level above a certain threshold, the processor determines that sensor 110 received light reflected from eye 112, and sends a signal to activate the camera. The camera is directed to operate in "viewing mode", in which full power is supplied to all the camera components and the user may proceed to utilize various camera functions. Sensor 110 may be monitored continuously or periodically (e.g., according to a predetermined frequency). If the processor determines that sensor 110 has not received light reflected from eye 112, then a signal is sent to deactivate the camera after a certain time period has elapsed. This delay, which may range from a few seconds up to a minute, prevents undesired deactivation of the camera (e.g., if the user glances away from the eyepiece for a brief instant or momentarily).

When the camera is operating in "viewing mode", display 104 is activated, and projects an image to the user (representing an image to be captured by the camera, or an image that has already been captured). Light from display 104 travels along path 136, through viewing lens 108, toward eye 112. It is noted that the display light does not interfere with the light emitted by LED 102. The user is able to view the display image, while the eye-start mechanism remains unaffected. Similarly, the light emitted by LED 102 does not obstruct the image from display 104. Since LED 102 is disposed adjacent to, but separate from, display 104, the light emitted by LED 102 reaches eye 112 of the user at a separate location on retina 118, respective to the display light from display 104. The geometric separation between the light from LED 102 and the display light from display 104 is maintained throughout the optical paths of system 100.

Reference is now made to Figure 2, which is a schematic illustration of a frontal view of the optical projection through the viewing lens of the eye detection system of Figure 1. The display light projection, referenced 142, represents the light from display 104 passing through viewing lens 108. Display light projection 142 encompasses a large rectangular region in the center of viewing lens 108, due to the rectangular shape of display 104. The LED light projection, referenced 144, represents the light emitted by LED 102 passing through viewing lens 108. LED light projection 144 encompasses a small region above the display light projection 142, due to the size and shape of LED 102, which is relatively smaller than display 104 and which is disposed above display 104.

There is no need to enlarge the diameter of viewing lens 108, since LED 102 projects an image which takes up a region that is not otherwise utilized by the lens, due to the shape of the display image. An already existing and available region of viewing lens 108 is used to transmit optical data for the eye detection mechanism. Eye detection system 100 makes use of the existing architecture and configuration of the various optical elements of the camera.

It is noted that LED may also emit visible light. The geometric configuration of system 100 ensures that the display light projected by display 104 does not interfere with the light emitted by LED 102. However, if LED 102 emits eye-safe IR light, it is further advantageous in that the light emitted by LED 102 does not interfere with the image from display 104, and provides minimal distraction or disturbance to the user when viewing the display image, as the user is oblivious to the presence of the LED 102 light.

Reference is now made to Figure 3, which is a schematic illustration of a method for activating a camera upon detection of the eye of a user, operative in accordance with an embodiment of the disclosed technique. In procedure 152, eye-safe light is emitted from a light emitting diode, along an optical axis, through a light router and through a viewing lens, toward the eye of a user, the LED disposed above and adjacent to a display of the viewing device. With reference to Figure 1, LED 102 emits eye-safe light along path 120 to partially transparent mirror 107 of light router 106, which directs the light along path 122 to viewing lens 108, which in turn directs the light toward eye 112 along path 124. LED 102 is disposed above and adjacent to display 104.

In procedure 154, light reflected from the retina of the eye is received, the reflected light travelling through the viewing lens along the optical axis toward the light router, and reflected from the light router toward a sensor, in a direction different from the optical axis. With reference to Figure 1, retina 118 of eye 112 reflects the light back toward viewing lens 108 along path 126, and viewing lens 108 directs the light along path 128 toward partially transparent mirror 107 of light router 106, which reflects the light along path 130 toward sensor 110.

In procedure 156, the sensor is monitored to determine if the sensor detected light reflected from an eye of a user. With reference to Figure 1, a processor (not shown) monitors sensor 110, and determines if light reflected by eye 112 was received by sensor 110.

In procedure 158, the viewing device is activated when a positive determination is made, and the viewing device is deactivated when a negative determination is made.

It will be appreciated by persons skilled in the art that the disclosed technique is not limited to what has been particularly shown and described hereinabove. Rather the scope of the disclosed technique is defined only by the claims, which follow.

CLAIMS

1. An eye detection system integrated within a viewing device, for activating said viewing device upon detection of the eye of a user, said viewing device includes a display for displaying an image, the system comprising:

a light emitting diode (LED), disposed on an optical axis, above and adjacent to said display, for emitting eye-safe light;

a viewing lens, disposed on said optical axis;

a light router, disposed on said optical axis between said LED and said viewing lens; and

a sensor, for receiving light diverted by said light router in a direction different from said optical axis,

wherein said LED emits light along said optical axis, through said light router and through said viewing lens, toward the eye of a user, said light reflected from the retina of said eye, through said viewing lens along said optical axis toward said light router, and reflected from said light router toward said sensor, and

wherein said sensor is monitored to determine if said sensor detected light reflected from an eye of a user, said viewing device is activated when a positive determination is made, and deactivated when a negative determination is made.

2. The eye detection system according to claim 1, wherein said viewing device is selected from the list consisting of:

a night vision imager; and

a forward looking infrared (FLIR) camera.

3. The eye detection system according to claim 1, wherein said eye-safe light is selected from the list consisting of:

infrared (IR) light; and

visible light.

4. The eye detection system according to claim 3, wherein said IR light has a wavelength of 750-900nm.

5. The eye detection system according to claim 1, wherein said display is an organic light emitting diode (OLED).

6. The eye detection system according to claim 1, wherein said light router includes a partially transparent mirror.

7. The eye detection system according to claim 1, further comprising a diaphragm having an aperture, disposed on said optical axis between said LED and said light router, for regulating the amount of light form said LED passing through.

8. A viewing device, comprising:

a display, for displaying an image; and

an eye detection system, for activating said viewing device upon detection of the eye of a user, said eye detection system comprising:

a light emitting diode (LED), disposed on an optical axis, above and adjacent to said display, for emitting eye-safe light;

a viewing device lens, disposed on said optical axis;

a light router, disposed on said optical axis between said LED and said viewing device lens; and

a sensor, for receiving light diverted by said light router in a direction different from said optical axis,

wherein said LED emits light along said optical axis, through said light router and through said viewing device lens, toward the eye of a user, said light reflected from the retina of said eye, through said viewing device lens along said optical axis toward said light router, and reflected from said light router toward said sensor; and

a processor, for monitoring said sensor to determine if said sensor detected light reflected from an eye of a user, and activating said viewing device when a positive determination is made, and deactivating said viewing device when a negative determination is made.

9. A method for activating a viewing device upon detection of the eye of a user, the method comprising the procedures of:

emitting eye-safe light along an optical axis from an LED, through a light router, and through a viewing lens, toward the eye of a user, the LED disposed above and adjacent to a display of the viewing device;

receiving light reflected from the retina of said eye, the reflected light travelling through said viewing lens along said optical path toward said light router, and reflected from said light router toward a sensor, in a direction different from said optical axis;

monitoring said sensor to determine if said sensor detected light reflected from an eye of a user; and

activating said viewing device when a positive determination is made, and deactivating said viewing device when a negative determination is made.

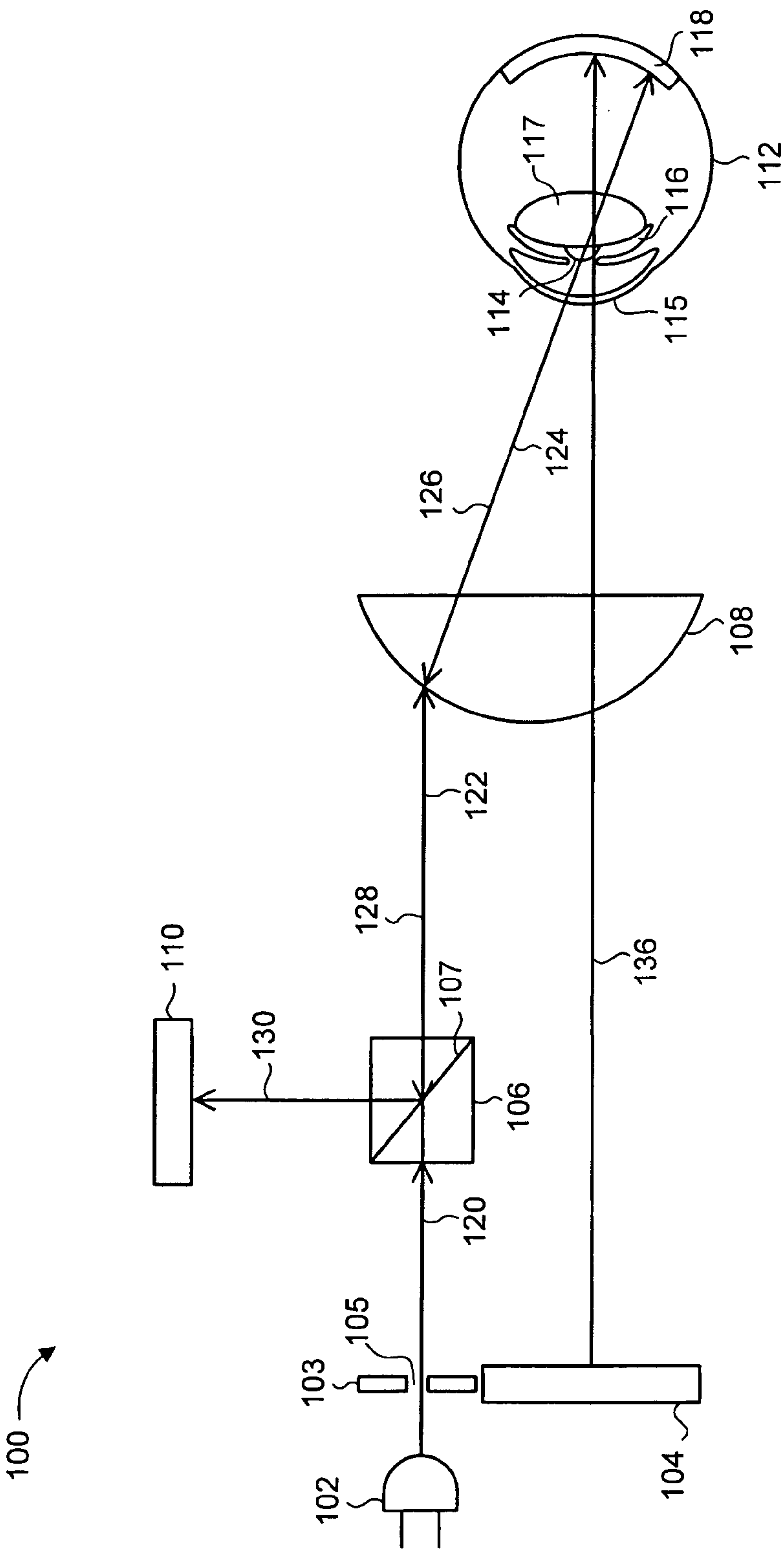
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FIG. 1

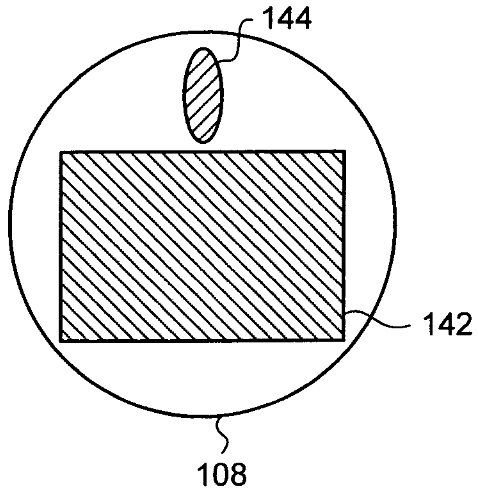

FIG. 2

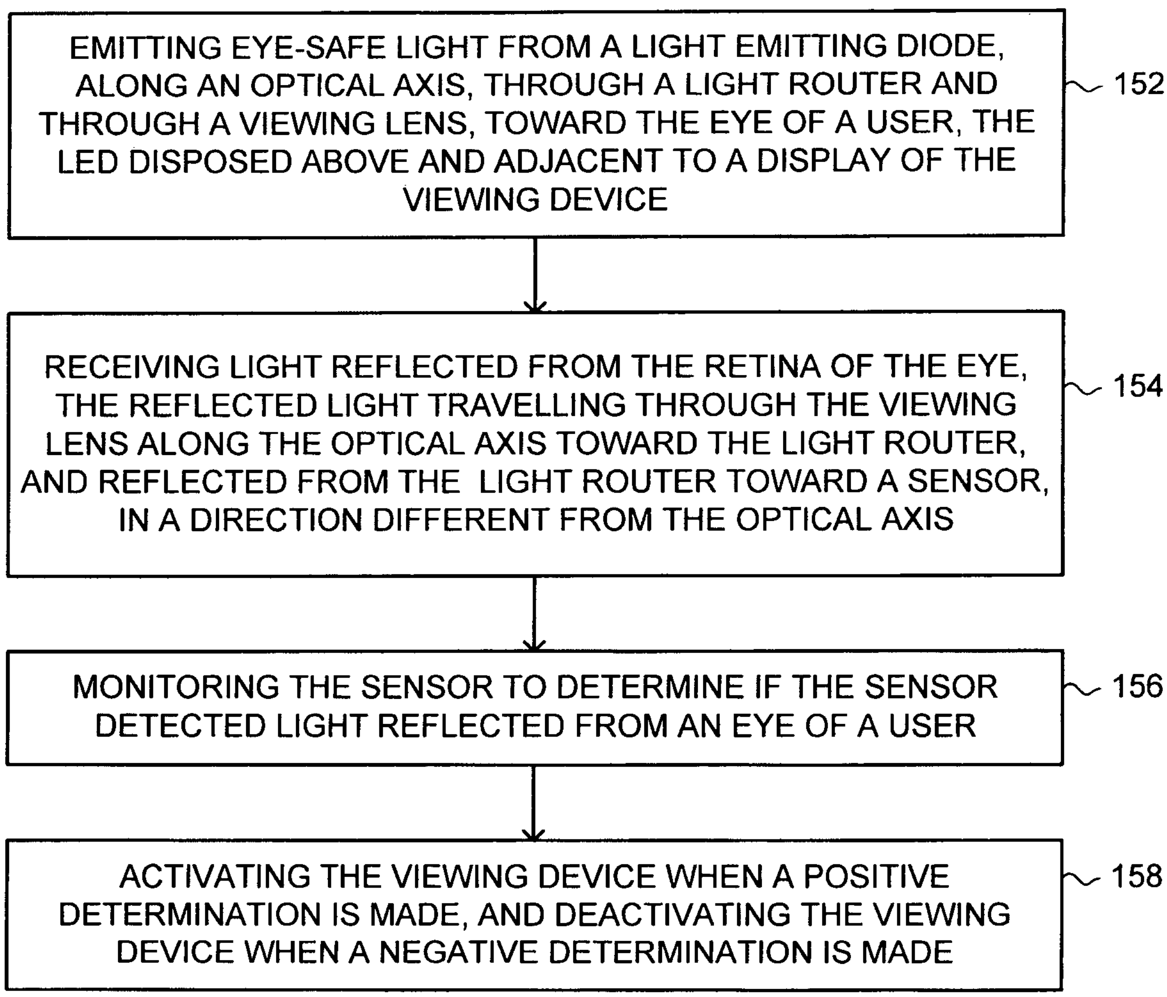
EMITTING EYE-SAFE LIGHT FROM A LIGHT EMITTING DIODE, ALONG AN OPTICAL AXIS, THROUGH A LIGHT ROUTER AND THROUGH A VIEWING LENS, TOWARD THE EYE OF A USER, THE LED DISPOSED ABOVE AND ADJACENT TO A DISPLAY OF THE VIEWING DEVICE
152
RECEIVING LIGHT REFLECTED FROM THE RETINA OF THE EYE, THE REFLECTED LIGHT TRAVELLING THROUGH THE VIEWING LENS ALONG THE OPTICAL AXIS TOWARD THE LIGHT ROUTER, AND REFLECTED FROM THE LIGHT ROUTER TOWARD A SENSOR, IN A DIRECTION DIFFERENT FROM THE OPTICAL AXIS
154
MONITORING THE SENSOR TO DETERMINE IF THE SENSOR DETECTED LIGHT REFLECTED FROM AN EYE OF A USER
156
ACTIVATING THE VIEWING DEVICE WHEN A POSITIVE DETERMINATION IS MADE, AND DEACTIVATING THE VIEWING DEVICE WHEN A NEGATIVE DETERMINATION IS MADE
158

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2008/001280

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N5/232

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

B. RELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04N G06F G06K

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropnate, of the relevant passages	Relevant to claim No
Y	US 2004/212711 Al (STAVELY DONALD J [US] ET AL) 28 October 2004 (2004-10-28) paragraph [0006] paragraph [0029] - paragraph [0030] paragraph [0034] paragraph [0038] figures 5,8A,8B -----	1-9
Y	EP 0 657 767 A (CANON KK [JP]) 14 June 1995 (1995-06-14) column 10, line 15 - line 26 column 11, line 23 - line 31 column 12, line 40 - line 53 column 14, line 21 - line 45 figure 12 -----	1-9

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

[X] See patent family annex

* Special categories of cited documents

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

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Date of the actual completion of the international search	Date of mailing of the international search report
16 February 2009	23/02/2009

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
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(^Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 00/54134 A (SIEMENS AG [DE]; HOFMANN JUERGEN [DE]; MAYERLE WOLFGANG [DE]) 14 September 2000 (2000-09-14) page 3, line 21 - page 4, line 28 figure 1 -----	1-9

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Information on patent family members

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