(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
9 October 2008 (09.10.2008)

PCT

(10) International Publication Number
WO 2008/120152 A1

(51) International Patent Classification:
A61B 6/00 (2006.01)

(21) International Application Number:
PCT/IB2008/051162

(22) International Filing Date: 28 March 2008 (28.03.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
07105161.9 29 March 2007 (29.03.2007) EP

(71) Applicant (*for all designated States except US*): **KONINKLIJKE PHILIPS ELECTRONICS N.V.** [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **KOIJK, Johannes Ferdinand** [NL/NL]; C/o. Philips Intellectual Property &, Standards, High Tech Campus 44, NL-5656AE Eindhoven (NL). **SINNEMA, Dirk** [NL/NL]; C/o. Philips Intellectual Property &, Standards, High Tech Campus 44, NL-5656AE Eindhoven (NL).

(74) Common Representative: **KONINKLIJKE PHILIPS ELECTRONICS N.V.**; c/o Hema Sridhar, Philips Intellectual Property &, Standards Philips Electronics India Ltd., Manyata Tech Park, Nagavara, Bangalore 560045 (IN).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:
— *with international search report*

[Continued on next page]

(54) Title: OPTICAL-IMAGE TRANSMISSION DEVICE

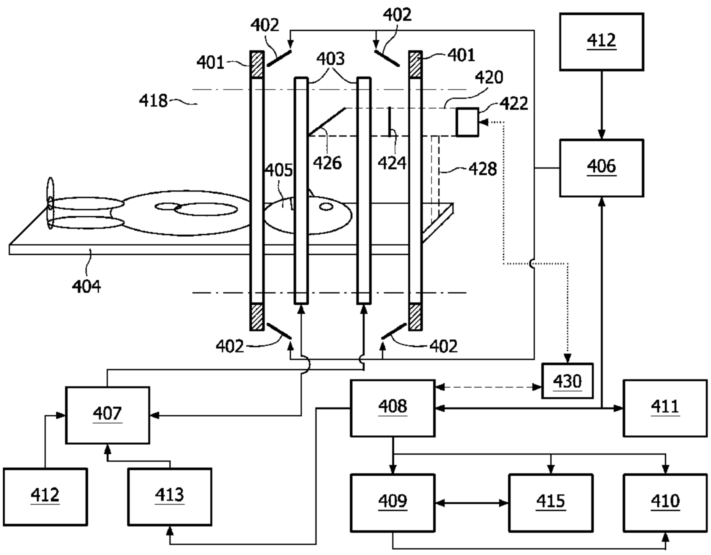

FIG. 4

(57) Abstract: A compact optical-image transmission device for transmitting optical images within a diagnostic medical imaging system is disclosed herein, wherein the diagnostic medical imaging system includes a receiving space (418) for receiving a subject (405) for examination. The optical-image transmission device comprises an optical-image source unit (422) capable of generating an optical image inside the receiving space (418) and a positive optical element (424) arranged to transmit the optical image to a reflective element (426) that is arranged to reflect the optical image towards the eyes of the subject (405) when the subject is in the receiving space (418).

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

Optical-image transmission device

FIELD OF THE INVENTION

The invention relates to an optical-image transmission device, particularly for use with a diagnostic medical imaging system.

BACKGROUND OF THE INVENTION

The United States patent application US 2006/0238657 A1 discusses a compact video projection and viewing system for use with a magnetic resonance (MR) imaging apparatus. The compact video system is constructed of materials that are inert to magnetic imaging and does not cause interference with the MR imaging procedure. The system uses a liquid crystal display (LCD) as a source of a viewable image and an optical arrangement to magnify the image and redirect the image in a lateral path to a screen. An adjustable viewing mirror is used to capture the reflection of the screen and transfer the image to a patient.

SUMMARY OF THE INVENTION

The separation between a screen and a patient's eyes, in the optical arrangement of the above-mentioned United States patent application, supplies the necessary eye-relief to the patient for comfortable viewing. However, this separation also tends to increase the size of the optical arrangement, which consequently occupies a larger space inside a diagnostic medical imaging system such as an MR system, computed tomography (CT) system, positron emission technology (PET) system, etc., or combinations thereof.

Therefore, in order to reduce the size of the optical arrangement so that it takes up less room inside the diagnostic medical imaging system, an optical-image transmission device for transmitting optical images within a diagnostic medical imaging system is disclosed herein. The diagnostic medical imaging system includes a receiving space for receiving a subject for examination. The optical-image transmission device comprises an optical-image source unit capable of generating an optical image inside the receiving space and a positive optical element arranged to transmit the optical image to a reflective element that is arranged to reflect the optical image towards the eyes of the subject when the subject is in the receiving space.

By providing at least one positive optical element between the optical image and the eyes of the patient, the image is virtually moved to “infinity”, thereby producing sufficient eye-relief to the subject without the need for a large separation between the optical image and the eye of the subject.

Furthermore, a method of transmitting optical images within a diagnostic medical imaging system is also disclosed herein, wherein the diagnostic medical imaging system includes a receiving space for receiving a subject for examination. The method comprises generating an optical image inside the receiving space and transmitting the optical image, through a positive optical element, to a reflective element that is arranged to reflect the optical image towards the eyes of the subject when the subject is in the receiving space.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects will be described in detail hereinafter, by way of example, on the basis of the following embodiments, with reference to the accompanying drawings, wherein:

FIG. 1 shows an embodiment of the optical-image transmission device disclosed herein, wherein the optical image is produced by a projector projecting an image on a screen;

FIG. 2 shows an embodiment wherein the optical image is produced by a solid-state display device;

FIG. 3 shows an embodiment wherein the optical-image source unit is incorporated into a patient carrier or a patient table of a diagnostic medical imaging system; and

FIG. 4 shows an exemplary setup of the optical-image transmission device in an MR imaging system.

Corresponding reference numerals when used in the various figures represent corresponding elements in the figures.

DETAILED DESCRIPTION OF EMBODIMENTS

The optical-image transmission device disclosed herein aims at displaying image information before a subject’s eyes by projecting an image through a positive optical element and using a reflecting element to reflect the image towards the eyes of the subject. The reflecting element may be an opaque mirror or a partially reflective element like a semi-transparent mirror that reflects only a fraction of the optical radiation incident on its surface.

An advantage of using a partially reflective element is that the device does not obstruct the patient's view of the surroundings, so that eye contact between a healthcare provider or a relative and the patient is possible even when the device is in place.

FIG. 1 shows an embodiment of the optical-image transmission device disclosed herein. An optical-image source unit 102, for example a projector, creates a real image on a real image plane 104, for example a screen. The real image is transmitted from the screen 104 to the eyes of a subject 118 by passing the light through a positive optical element 106 and reflecting it using a reflecting element 108. The optical-image source unit 102, real image plane 104, positive optical element 106 and reflecting element 108 are held in optical alignment by a device frame 110, which is connected to a part of the diagnostic medical image system, for example the patient table or cradle 120, by a support structure 112. Assuming the diagnostic medical imaging system in this embodiment to be an MR imaging system, the subject 118 views the reflected image from the reflecting element 108 through an opening in a head coil 114 that is used to transmit radio-frequency signals to the subject and/or acquire MR signals from the subject. An optional camera 116 may also be provided as part of the optical-image transmission device.

The real image can be formed by projection of a still or a moving picture (video) using a small light emitting diode (LED) or laser projector 102 on the real image plane 104. If necessary, an additional optical element (not shown), for example a convex lens or other positive optical element, may be inserted in between the projector 102 and the screen 104 to allow the image to be focused on the screen at a shorter distance from the projector. The reflecting element 108 may be almost transparent such as acrylic glass or a glass plate, which reflects a small part of the light to the subject 118. For example, it may be sufficient to reflect only about 1.5% of the light falling on the reflecting element, towards the subject 118 for the image to be viewed clearly by the subject. The advantage of using such a setup is that the subject 118 can observe the screen 104 via an optical device that is hardly visible to the subject. Furthermore, a healthcare provider, for example a clinical technician, could continue to monitor the face of the patient even with the optical setup in place. Thus, the optical-image transmission device as disclosed herein enhances the feeling of "openness" inside a diagnostic medical imaging system, thereby increasing the comfort level of a patient inside the imaging system. Thus, the embodiments disclosed herein contribute to alleviating anxiety associated with claustrophobia in some patients. The optical-image transmission device as shown is supported by a support structure 110, 112 mounted directly on the patient table 120, though the device may be supported on other parts of the medical imaging diagnostic system as required. Attaching the optical-image transmission device to the patient transport 120 allows the size of the image as seen by the subject to remain constant when the patient is moved together with the patient table, which further adds to patient comfort.

A Fresnel lens is a good choice for the positive optical element 106 placed between the screen 104 and the reflecting element 108. The Fresnel lens moves the image to virtual infinity, thus obviating the need for a large separation between the real image plane 104 and the eyes of the patient 118 in order to provide sufficient eye-relief to the patient. Alternative to a Fresnel lens, other converging lenses or combinations of lenses may also be used.

It is also conceivable to combine the functions of the positive optical element and the reflective element into a single optical element, and thereby reduce the total number of component parts in the optical-image transmission device.

One or more optional cameras may be attached to the optical-image transmission device, as shown in the figure. In a particular embodiment, the optional camera 116 may be arranged to travel along with the patient table. A point to be noted is that the usage of one or more cameras is facilitated by the transparent nature of the reflecting element 108 (which may additionally be coated with anti-glare materials in order to reduce stray reflections from the environment), and therefore such an arrangement of using one or more cameras would inhibit the use of an opaque reflecting element such as a fully reflecting mirror. However, if a camera is not required to be used and if there is no need to see through the optical device, then an opaque mirror may be used as the reflecting element instead of acrylic glass or other semi-transparent reflecting elements. If the camera were combined with headphones and/or a microphone in close proximity to the patient, it would be possible to have two-way video communication between the patient and the healthcare provider or a concerned person such as a relative (e.g., a parent), which may be particularly useful in imaging children.

In order to enhance the subject's viewing experience, the subject may be instructed to hold his head still while viewing the images. Alternatively, the position of the subject's head, and therefore the position of the patient's eyes, may be fixed within specified tolerances, e.g., ± 2 cm in all directions. Thus, the optical-image transmission device disclosed herein could also be useful in neuro-imaging studies, like functional MR imaging (fMRI), which often requires a subject being examined to hold their head still.

FIG. 2 shows an embodiment of the optical-image transmission device 200 disclosed herein, wherein an optical-image source unit 202 is placed at the position of the real image plane (104 of FIG. 1). The optical-image source unit 202 may be a solid-state display device such as an LCD screen, plasma screen, thin film transistor LCD (TFT) monitor, a fluorescent light display such as a vacuum fluorescent display (VFD), LED display, organic light emitting diode (OLED) display, translucent LCD screen, etc. These display technologies are only quoted as examples, and it is to be noted that other methods of creating or displaying images will work just as well. A positive optical element 206 transmits the image to a reflecting element 208, which in turn reflects the image towards the eyes of the patient 218. The optical-image source unit 202, positive optical element 206 and reflecting element 208 are held in optical alignment by a device frame 210, which is connected to a part of the diagnostic medical image system, for example the patient table or cradle 220, by a support structure 212.

The use of a solid-state display device makes the construction of the optical-image transmission device 200 even more compact, thereby making it easier to fit into restricted spaces. Furthermore, the smaller size also makes it easier to provide electromagnetic shielding to the optical-image transmission device if required, especially in an MR environment.

FIG. 3 shows an embodiment wherein the light path between an optical-image source unit 302 and a positive optical element 306 is bent or changed through the use of a first mirror 316, allowing a more compact construction of the complete optical-image transmission device. As shown in the figure, the optical-image source unit is a projector 302 that projects an image on to a screen 304 via the first mirror 316. A positive optical element 306 relays the images to a reflecting element 308, which reflects the images towards the eyes of the patient 318.

Due to the compact nature of the construction, it is conceivable to integrate the optical-image transmission device into the patient table 320. Instead of using a projector 302 in combination with a screen 304 to produce a real image, it is conceivable to use a high-brightness solid-state display device as the optical-image source unit 302 and to use a second mirror 304 in addition to the first mirror 316 to relay the images from the optical-image source unit 302. The semi-transparent reflecting element may be coated with anti-glare materials in order to reduce stray reflections from the environment.

The proposed embodiments permit the patient or other subject being examined in the diagnostic medical imaging system to have an unobstructed view of the surroundings (i.e., outside the diagnostic medical imaging system) when the subject is being imaged. Reciprocally, it also allows a healthcare technician to monitor the face of the subject during the imaging process. Furthermore, as the optical system is practically invisible to the patient, it produces an immersive cinema-like experience which allows the patient to forget the scanning process underway. This is further aided by the fact that the optical setup also has a large solid image angle, which allows the subject to have a 'wide screen' experience, since the image covers a relatively large part of the viewing field of the subject. Additionally, the optical image is not obstructed by objects located or moving outside the receiving space like the bore of an MR system or the gantry of a CT system, and no special siting measures are needed for the disclosed optical-image transmission device.

The embodiments proposed herein are compact in construction, thereby making it easier to provide electromagnetic shielding, if required for example in the case of use in an MR system. By projecting the virtual image at infinity, subjects being examined can focus on the image without further optical aids such as spectacles, goggles, etc. In the embodiments shown in the figures, wherein the optical-image transmission device is attached to the patient transport table, the device is easier to service, since it can be pulled out of the receiving space of the diagnostic medical imaging device to provide easy access for service personnel. As the device travels with the patient table, the image can be viewed at all table positions by the subject and not just with the head in a specific location, for example the isocentre position of an MR system. Furthermore, by mechanically shifting the position of the real image plane with respect to the positive optical element, it is possible to compensate for an eye-defect such as myopia or hypermetropia of the patient, without using optical glasses or spectacles. In practical terms, it may be possible to correct for such eye-defects up to a strength of 4 dioptres.

FIG. 4 shows a possible embodiment of an MR system utilizing the optical-image transmission device as disclosed herein. It is to be noted that the disclosed optical-image transmission device may be used in other medical diagnostic imaging systems such as CT systems, PET systems, X-ray systems, etc. It is to be further noted that the optical-image transmission device is preferably designed to fit inside the limited space inside the diagnostic medical imaging system (e.g., the bore of an MR system, the gantry of a CT or PET system, etc.).

The exemplary MR system shown comprises a set of main coils 401, multiple gradient coils 402 connected to a gradient driver unit 406, and radio-frequency (RF) coils 403 connected to an RF coil driver unit 407. The function of the RF coils 403, which may be integrated into the magnet in the form of a body coil, or may be separate surface coils, is further controlled by a transmit/receive (T/R) switch 413. The multiple gradient coils 402 and the RF coils are powered by a power supply unit 412. A transport system 404, for example a patient table, is used to position a subject 405, for example a patient, in a receiving space 418 within the MR imaging system. An optical-image transmission device comprising an optical-image source unit 422, a positive optical element 424 and a reflecting element 426 are held in optical alignment by a device frame 420, which is connected to the transport system 404 by a support structure 428. A control unit 408 controls the RF coils 403 and the gradient coils 402. The control unit 408, though shown as a single unit, may be implemented as multiple units as well. The control unit 408 further controls the operation of a reconstruction unit 409. The control unit 408 also controls a display unit 410, for example a monitor screen or a projector, a data storage unit 415, and a user input interface unit 411, for example, a keyboard, a mouse, a trackball, etc. An optional optical-image feeder unit 430 located outside the MR system supplies images to the optical-image source unit 422 and is optionally controlled by the control unit 408.

The main coils 401 generate a steady and uniform static magnetic field, for example, of field strength 1T, 1.5T or 3T. The disclosed optical-image transmission device may be employed at other field strengths as well. The main coils 401 are arranged in such a way that they typically enclose a tunnel-shaped examination space, into which the subject 405 may be introduced, which is also referred to as a receiving space in this document. Another common configuration comprises opposing pole faces with an air gap in between them into which the subject 405 may be introduced by using the transport system 404, in which case, the air gap may be construed to be the receiving space mentioned herein. To enable MR imaging, temporally variable magnetic field gradients superimposed on the static magnetic field are generated by the multiple gradient coils 402 in response to currents supplied by the gradient driver unit 406. The power supply unit 412, fitted with electronic gradient amplification circuits, supplies currents to the multiple gradient coils 402, as a result of which gradient pulses (also called gradient pulse waveforms) are generated. The control unit 408 controls the characteristics of the currents, notably their strengths, durations and directions, flowing through the gradient coils to create the appropriate gradient waveforms. The RF coils 403 generate RF excitation pulses in the subject 405 and receive MR signals generated by the subject 405 in response to the RF excitation pulses. The RF coil driver unit 407 supplies current to the RF coil 403 to transmit the RF excitation pulse, and amplifies the MR signals received by the RF coil 403. The transmitting and receiving functions of the RF coil 403 or set of RF coils are controlled by the control unit 408 via the T/R switch 413. The T/R switch 413 is provided with electronic circuitry that switches the RF coil 403 between transmit and receive modes, and protects the RF coil 403 and other associated electronic circuitry against breakthrough or other overloads, etc. The characteristics of the transmitted RF excitation pulses, notably their strength and duration, are controlled by the control unit 408.

It is to be noted that though the transmitting and receiving coil are shown as one unit in this embodiment, it is also possible to have separate coils for transmission and reception, respectively. It is further possible to have multiple RF coils 403 for transmitting or receiving or both. The RF coils 403 may be integrated into the magnet in the form of a body coil, or may be a head coil, or separate surface coils. They may have different geometries, for example, a birdcage configuration or a simple loop configuration, etc. It should be noted that the disclosed optical-image transmission device may be used with any RF coil configuration that allows a subject to view the reflective element 426.

The control unit 408 is preferably in the form of a computer that includes a processor, for example a microprocessor. The control unit 408 controls, via the T/R switch 413, the application of RF pulse excitations and the reception of MR signals comprising echoes, free induction decays, etc. User input interface devices 411 like a keyboard, mouse, touch-sensitive screen, trackball, etc., enable an operator to interact with the MR system.

The optional optical-image feeder unit 430 may be configured to transmit the optical images to the optical-image source unit 422. For example, the optical-image feeder unit 430 may be a DVD player, a VCD player, a TV tuner, a video cassette player, a video camera, etc. The images may be transmitted to the optical-image source unit 422 either wirelessly or over wires carrying audio and video signals. The control unit 408 may be configured to control the optical-image feeder unit 430, for example in cases where the images need to be synchronized to the data acquisition, as in the case of an fMRI study. It is also conceivable that the optical-image feeder unit 430 is operated independently of the MR system.

The MR signal received with the RF coils 403 contains the actual information concerning the local spin densities in a region of interest of the subject 405 being imaged. The received signals are reconstructed by the reconstruction unit 409, and displayed on the display unit 410 as an MR image or an MR spectrum. It is alternatively possible to store the signal from the reconstruction unit 409 in a storage unit 415, while awaiting further processing. The reconstruction unit 409 is constructed advantageously as a digital image-processing unit that is programmed to derive the MR signals received from the RF coils 403.

It is to be noted that in addition to the various methods of producing real images mentioned herein, other methods may also be possible and will work with the optical-image transmission device disclosed herein. It is to be further noted that in order for use in an MR environment, the optical-image transmission device has to be made MR-compatible. This can be achieved by a combination of techniques including using non-metallic materials in the construction of the device and/or moving metallic objects to locations sufficiently far away such that they do not interfere with the MR imaging.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The disclosed method can be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the system claims enumerating several means, several of these means can be embodied by one and the same item of computer readable software or hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. An optical-image transmission device for transmitting optical images within a diagnostic medical imaging system, wherein the diagnostic medical imaging system includes a receiving space (418) for receiving a subject (405) for examination, the optical-image transmission device comprising:

an optical-image source unit (422) capable of generating an optical image inside the receiving space (418); and

a positive optical element (424) arranged to transmit the optical image to a reflective element (426) that is arranged to reflect the optical image towards the eyes of the subject (405) when the subject is in the receiving space (418).

2. The optical-image transmission device of claim 1, wherein the positive optical element is a Fresnel lens.

3. The optical-image transmission device of claim 1, wherein the reflective element is selected from the group consisting of an acrylic glass sheet, a glass sheet, a semi-reflective mirror and a fully-reflective mirror.

4. The optical-image transmission device of claim 1, wherein the optical-image source unit is selected from the group consisting of a liquid crystal display, a light emitting diode projector and screen system, a fluorescent display system, an organic light emitting diode system, a translucent liquid crystal display system and a laser projector and screen system.

5. The optical-image transmission device of claim 1, wherein the diagnostic medical imaging system includes a patient transport system (404) arranged to transport the subject (405) into and out of the diagnostic medical imaging system, and wherein the optical-image transmission device is attached to the patient transport system (404).

6. The optical-image transmission device of claim 1, including a camera configured to transmit images from inside the receiving space to a location outside the receiving space.

7. The optical-image transmission device of claim 1, including a microphone and a hearing unit configured to enable two-way communication between the subject in the receiving space and a person located outside the receiving space.

8. A magnetic resonance system comprising an optical-image transmission device for transmitting optical images within the magnetic resonance system, wherein the magnetic resonance system includes a receiving space (418) for receiving a subject (405) for examination, the optical-image transmission device comprising:

an optical-image source unit (422) capable of generating an optical image inside the receiving space (418); and

a positive optical element (424) arranged to transmit the optical image to a reflective element (426) that is arranged to reflect the optical image towards the eyes of the subject (405) when the subject is in the receiving space (418).

9. A method of transmitting optical images within a diagnostic medical imaging system, wherein the diagnostic medical imaging system includes a receiving space (418) for receiving a subject (405) for examination, the method comprising:

generating an optical image inside the receiving space (418); and

transmitting the optical image, through a positive optical element (424), to a reflective element (426) that is arranged to reflect the optical image towards the eyes of the subject (405) when the subject is in the receiving space (418).

10. A method of transmitting optical images as claimed in claim 9, wherein the method involves compensating for an eye-defect of the subject (405) by shifting the position of the real image plane (422) with respect to the positive optical element (424).

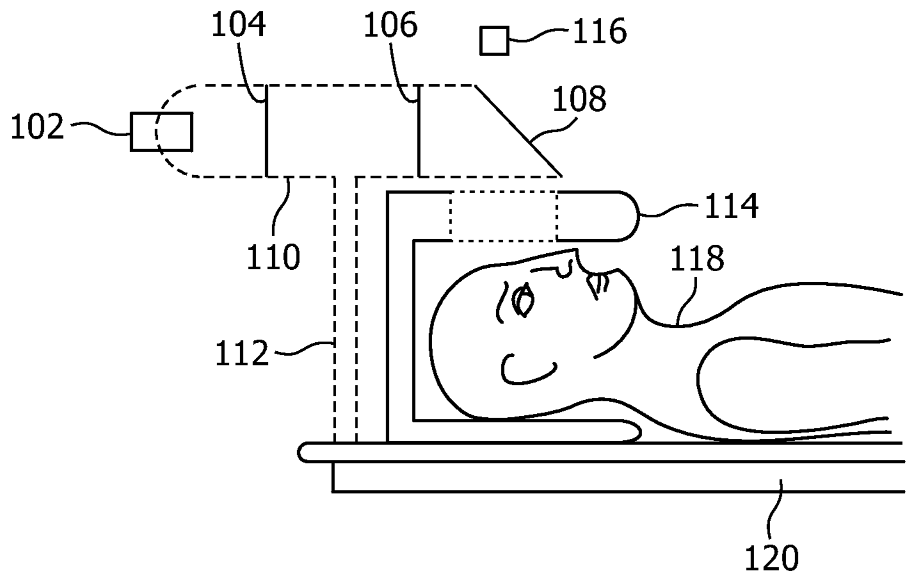
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FIG. 1

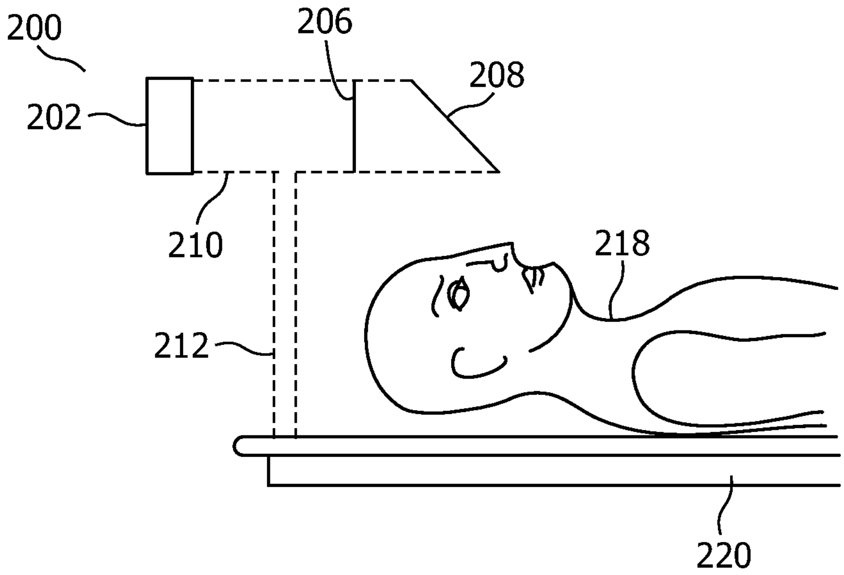
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FIG. 2

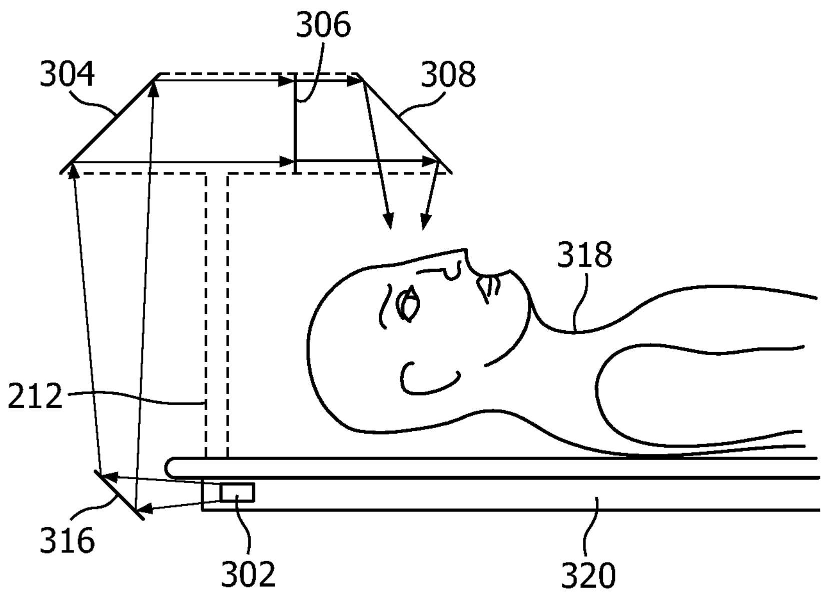
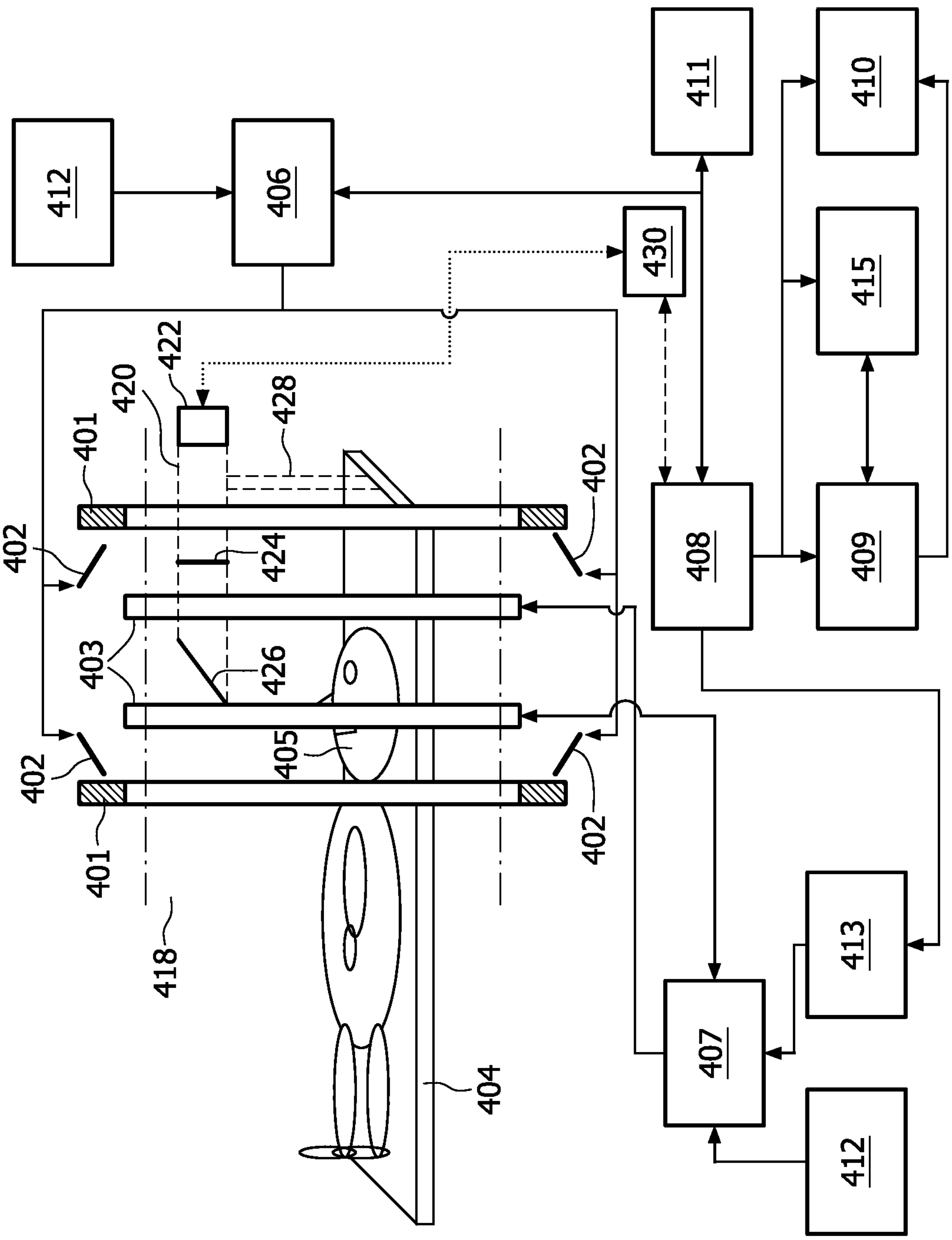


FIG. 3

FIG. 4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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/051162

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B6/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G03B G01R A61B G01N H04N

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, WPI Data, BIOSIS, COMPENDEX, EMBASE, FSTA, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/101545 A (AVOTEC INC [US]; BULLWINKEL PAUL [US]) 28 September 2006 (2006-09-28) page 3, line 27 - page 5, line 11; figures 1-3	1-10
X	US 5 414 459 A (BULLWINKEL PAUL [US]) 9 May 1995 (1995-05-09) column 3, line 51 - column 5, line 39; figures 1-6	1-10
A	US 5 134 373 A (TSURUNO DAIHACHIRO [JP] ET AL) 28 July 1992 (1992-07-28) column 2, line 55 - column 4, line 67; figures 1-3	1-10

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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 :

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Date of the actual completion of the international search	Date of mailing of the international search report
12 August 2008	21/08/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Tomezzoli, Giancarlo

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/051162

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 901 141 A (COSTELLO JAMES G [US]) 13 February 1990 (1990-02-13) column 4, line 13 - column 5, line 36; figures 1,2	1-10
A	US 4 804 261 A (KIRSCHEN DAVID G [US]) 14 February 1989 (1989-02-14) column 4, line 5 - column 5, line 20; figures 1-3	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

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