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(71) Applicant *(for all designated States except US)*: **DYER HOLDINGS, LLC** [US/US]; 14632 South Halsey Street, Olathe, Kansas 66062 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **DYER, David** [US/US]; 14632 South Halsey Street, Olathe, Kansas 66062 (US).

(74) Agent: **MCKIERNAN, Thomas**; Staas & Halsey LLP, 1201 New York Ave., N.W., Suite 700, Washington, District of Columbia 20005 (US).

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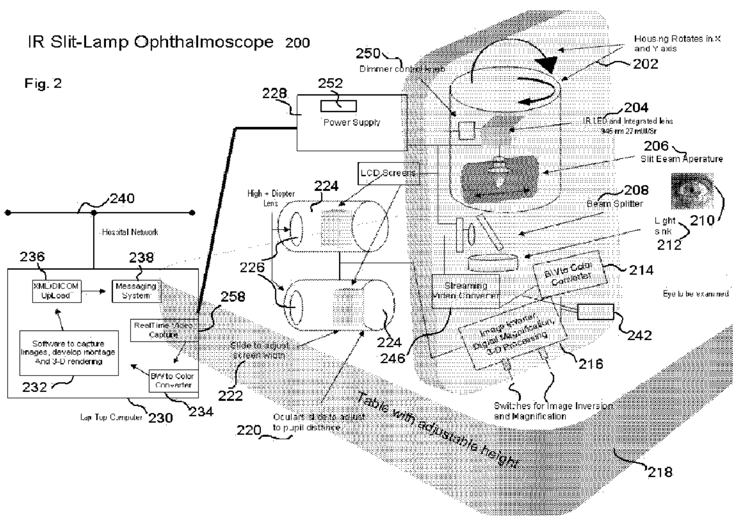
(54) Title: INFRARED SLIT LAMP OPHTHALMOSCOPE



(57) Abstract: A slit-lamp ophthalmoscope includes an adjustable table, a housing rotating on the table, a light source projecting infrared radiation through a slit-beam aperture toward a beam splitter, the beam splitter reflecting the infrared radiation to an eye, a camera collecting radiation reflected by the eye through the beam splitter, an analog to digital convertor receiving a raw signal from the camera based on the collected radiation, the analog to digital convertor converting the raw signal to a digital signal, a black and white to color converter converting the digital signal into a color signal, a streaming video converter processing the color signal into a video signal, a pair of video monitors displaying an image of the eye based on the video signal, a video transmitter transmitting the video signal to a computer over a network, the computer extracting a plurality of images from the video signal.

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INFRARED SLIT LAMP OPHTHALMOSCOPE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Provisional Application Serial No. 61/166,649, filed April 3, 2009 and U.S. Patent Application Serial No. 12/754,301 filed April 5, 2010, the entire disclosure of which are incorporated by reference herein.

BACKGROUND

Field

[0002] A slit lamp ophthalmoscope using an infrared light source.

Description of the Related Art

[0003] An ophthalmoscope is used to examine the interior of the eye. An ophthalmoscope directs a small beam of light through the pupil to the retina, the optic nerve, etc. A patient sits at a slit lamp ophthalmoscope with the chin resting on a pad. The pupil is conventionally dilated during the examination. The eye could be examined without dilating the pupil, but examining a pupil without dilation does not give much detail about the eye. The pupil is normally dilated with eye drops. Eye drops may take some time to act, or may cause allergic reactions in the patient, or nausea, vomiting, dryness of mouth, or dizziness. The eye drops may also interfere with focusing of the eye for several hours after the examination.

SUMMARY

[0004] A slit-lamp ophthalmoscope includes an adjustable table, a housing disposed rotatably on the table, the housing rotating about a substantially vertical axis and a substantially horizontal axis, an infrared light source and a beam splitter disposed in the housing, the light source projecting infrared radiation through a slit-beam aperture toward the beam splitter, the beam splitter reflecting the infrared radiation from the light source to an eye, a camera disposed in the housing, a camera collecting radiation reflected by the eye through the beam splitter, an analog to digital convertor disposed in the housing, the analog to digital converter receiving a raw signal from the camera based on the collected radiation, the analog to digital convertor converting the raw signal to a digital signal, a black and white to color converter disposed in the housing, the black-and-white to color converter converting the digital signal into a color signal, a

streaming video converter disposed on the housing, the streaming video converter processing the color signal into a video signal, a pair of video monitors disposed in the housing, the pair of video monitors displaying an image of the eye based on the video signal, the slit-lamp ophthalmoscope further comprising a video transmitter, the video transmitter transmitting the video signal to a computer over a network, the computer extracting a plurality of images from the video signal.

[0005] The above-described embodiments of the present invention are intended as examples, and all embodiments of the present invention are not limited to including the features described above.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is shown a ray diagram of an ophthalmoscope according to an embodiment of the invention; and

Fig. 2 shows a slit-lamp ophthalmoscope according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0006] Reference may now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0007] In Fig. 1 is shown an ophthalmoscope 100. The ophthalmoscope 100 includes a light source 102, which may be a light emitting diode (LED). The light source 102 emits infrared radiation 114 towards a beam splitter 104, which may be a 50-50 beam splitter. Other proportions could be used for the beam splitter 104, such as 60-40, 70-30, or others, depending on how much radiation is desired to pass through the beam splitter 104, relative to that which should be reflected by the beam splitter 104.

[0008] In the alternative, the light source 102 could emit radiation in the visible and ultraviolet ranges, along with radiation in the infrared range. Appropriate filtering could pass the infrared and block the visible radiation, coupling infrared radiation into the ophthalmoscope 100.

[0009] A first portion 116 of the infrared radiation 114 is reflected by the beam splitter 104 toward a retina 106. If the beam splitter 104 were a 50-50 beam splitter, substantially half of the light would be reflected by the beam splitter 104 towards the retina to 106. If, on the other hand, the beam splitter 104 were a 60-40 beam splitter, then the first portion 116 would amount to substantially 60% of the infrared radiation 114, with the remaining 40% of the infrared radiation 114 passing through the beam splitter 104. Any suitable proportion could be used; depending on how much of infrared radiation 114 ought to be received at the retina 106. A magnifying lens, which may be handheld, focuses the first portion 116 of light on the area of the retina 106.

[0010] A second portion 118 of the infrared radiation 114 passes through the beam splitter 104 to a light sink 108. The second portion 118 is substantially the balance of the infrared radiation 114 that was not reflected by the beam splitter 104.

[0011] The first portion 116 illuminates the retina 106, which is an object of examination. Since the first portion 116 is infrared, and not visible, the pupil does not react to the first portion 116, and so the pupil stays substantially dilated. Infrared radiation 120 is reflected by the retina 106 while it is being examined. The reflected infrared radiation 120 passes back through the beam splitter 104 and a focusing lens 110 to a camera 112. The focusing lens 110 between the beam splitter 104 and the camera 112 focuses the reflected infrared radiation 120.

[0012] The camera 112 may be a charge coupled device, or an array of light emitting diodes collecting radiation instead of emitting it. The camera 112 records the infrared radiation 120 reflected by the retina 106, capturing the features of the retina 106 under examination.

[0013] The camera 112 converts the light to a signal, the signal being sent to a display. The signal may be an electrical or an optical signal. If the signal were an optical signal, the camera may include an optical/electrical converter to convert the signal into a form suitable for a display. An electrical signal may also be processed through an analog/digital converter.

[0014] The display could be a liquid crystal display (LCD), a plasma display, a cathode ray tube, a light emitting diode (LED) display, or an organic semiconductor. The display may include first and second screens. The signal may be divided into a first signal and a second signal, the first signal being sent to the first screen and the second signal sent to the second screen.

[0015] The first and the second signals may each be alternating periods of the signal. If, for example, the signal were digitized, then alternating data points, or groups of data points, could be distributed to each of the first and the second screens, via the first and second signals. Since, during examination, the patient moves slightly, and the handheld lens used by the ophthalmologist to move slightly, individual data points will represent slightly varying points of view. Sending alternating data points, or alternating groups of data points, two separate screens will offer a 3-D effect, allowing the ophthalmologist to view the depth of the retina.

[0016] A light emitting diode is controlled by adjusting the current, instead of the voltage, as might be more customary in, for example, an incandescent or halogen lamp. A current to the LED may be controlled by a rheostat. The rheostat may have a logarithmic scale. The current of the LED, for example, may have a logarithmic relationship with the light outputted from the LED. In other words, the light may vary as the power of the scale of the input current.

[0017] In Fig. 2 is shown an infrared slit-lamp ophthalmoscope 200. The slit-lamp ophthalmoscope 200 includes a housing 202. In one embodiment, the slit-lamp ophthalmoscope 200 includes an adjustable table 218. The housing 202 may be disposed rotatably on the table 218. In one embodiment, the housing 202 rotates about a substantially vertical X (azimuth) axis or a substantially horizontal (or azimuth) Y axis.

[0018] Within the housing 202 is an infrared light source 204. A lens may be integrated with the infrared light source 204. The infrared light source 204 emits infrared radiation in a wavelength of approximately 800-900 nm. The light source 204 may emit infrared radiation, such as infrared radiation with a wavelength near to that of visible light. One wavelength of the infrared radiation might be 945 nm. The light source 204 may supply power at 27 mW/Sr.

[0019] In several embodiments, the light source 204 may be a light emitting diode, an electric lamp, a mercury vapor lamp, a halogen lamp, or a tungsten filament lamp. In one embodiment, the light source 204 includes a rheostat dimmer circuit.

[0020] The infrared radiation from the infrared light source 204 may be controlled by a dimmer control knob 250. The dimmer control knob 250 may control the output power of the light emitting diode 204. Infrared radiation from the infrared light source 204 may be controlled by a rheostat 252. The rheostat may have a logarithmic scale.

[0021] In one embodiment, the light source 204 includes an infrared filter and a focusing lens. In this embodiment, the infrared filter may substantially block visible and ultraviolet radiation. The focusing lens may focus the infrared radiation from the light source at the beam splitter. In one embodiment, the light source 204 is a halogen lamp with an infrared pass filter, the infrared path filter substantially blocking visible and ultraviolet radiation.

[0022] A beam splitter 208 may be disposed in the housing 202. The light source 204 projects infrared radiation through a slit-beam aperture 206 toward the beam splitter 208. In one embodiment, the beam splitter 208 may be a 50/50 beam splitter. Other proportions may be used as well. A first portion of the infrared radiation emitted by the light source 204 passes through the beam splitter, while a second portion of the infrared radiation, in this case 50% of the infrared radiation, is reflected by the beam splitter 208 towards an eye 210 to be examined. The second portion of infrared radiation may be focused by a magnifying lens, which may be handheld, on its way to the eye.

[0023] A light sink 212 may be disposed of the housing 202 to receive the light passing through the beam splitter 208. The light sink absorbs excess infrared radiation emitted by the light source 204. The first portion of the infrared radiation, i.e., the other 50%, passes through the beam splitter 208, to be collected by a light sink 212.

[0024] In one embodiment, the slit-lamp ophthalmoscope 200 includes a power supply 228. The power supply 228 supplies power to the light source 204. The power supply 228 may be a lithium-ion battery, such as a 9 V battery. The power supply 228 may be a rechargeable lithium ion battery, a nickel cadmium battery, or an alkaline battery.

[0025] The beam splitter 208 reflects the infrared radiation from the light source 204 to an eye 210. The retina of the eye 210 reflects some of the infrared radiation that reaches it back towards the beam splitter 208. The reflected light renders the retina "visible" since different features of the retina reflect the infrared radiation in different ways.

[0026] A camera 248 may be disposed in the housing 202. The camera may be a charge coupled device (CCD) camera, such as a black-and-white charge coupled device. Some of the infrared radiation reflected by the retina 210 passes back through the beam splitter 208 and is collected by the camera 248. The camera 248 collects radiation reflected by the eye 210 through the beam splitter 208 and forms an image of the retina. The camera 248, and the light source 204, may receive electrical power from the power supply 228. The power supply 228 may be a lithium-ion battery, such as a 9 V battery.

[0027] A black and white to color converter 214 may be disposed in the housing 202. The image may also be sent to the black-and-white to color converter 214. The black-and-white to color converter 214 converts the digital signal into a color signal. In one embodiment, the black and white to color converter 214 maps intensities of grayscale pixels to colors. The black-and-white to color converter 214 scales the individual wavelengths of the infrared image into the visible range. If the individual infrared wavelengths are scaled a substantially similar amount, they will appear to have separate colors in the visible range.

[0028] An analog to digital convertor 256 may be disposed in the housing 202. The analog to digital converter 242 receives a raw signal, such as an analog signal, from the camera 248 based on the collected radiation. The analog to digital convertor 256 converts the raw signal to a digital signal.

[0029] A streaming video converter 246 may be disposed in the housing 202. In one embodiment, the image collected at the camera 248 is fed to the streaming video converter 246 directly. In another embodiment, the streaming video converter 246 receives the digital signal from the analog to digital converter 242, which sends the digital signal to the streaming video converter 246. In still another embodiment, the streaming video converter 246 receives the color signal from the black-and-white to color converter 214.

[0030] The streaming video converter 246 converts the signals from the camera into video. The video from the camera 248 may be scaled into visible light by the streaming video converter 246. If, for example, various wavelengths of infrared light were represented by different signals coming from the camera 248, the different signals could be scaled approximately the same amount, moving them up into the visible range, while still being distinguishable by the eye. The different wavelengths of visible light, once converted by the streaming video converter 246, might also be assigned colors in a black-and-white to color converter 214.

[0031] An image inverter 216 may be disposed in the housing 202. The image from the black-and-white to color converter 214 may be fed to the image inverter, a digital magnifier, or a 2-D processor 218. In the alternative, the image from the streaming video converter 246 or the camera 248 may be fed to the image inverter 216, a digital magnifier, or a 2-D processor 218. The image inverter may be necessary because an inverted image of the retina 210 is received at the camera 248. The image inverter 216 inverts the image received through the lenses so that it is right side up for viewing. The image inverter 216 may also magnify the image, and perform 2-D processing.

[0032] The image inverter 216 may be necessary to invert the image of the retina. This may be so because the magnifying lens inverts the image from the retina when it focuses the reflected infrared radiation. Trained ophthalmologists learn that the image is inverted, and learn to cope with the inversion of the image. The image inverter 216, however, may make such compensating unnecessary, rendering eye examination more accessible to less well-trained individuals.

[0033] Once the image has been re-inverted at the image inverter 216, a user of the infrared ophthalmoscope 200 will see the image in a normal state. Consequently, directing the lens through which the infrared radiation is transmitted to the right of the retina 210, for example, will move the image from the camera to the right as well. This is to be contrasted with a conventional slit-lamp ophthalmoscope, where the direction of "motion" shown to the viewer is reversed from reality. This ought to make the infrared slit-lamp ophthalmoscope 200 more accessible to the layman.

[0034] A display screen 224, such as a pair of video monitors, may be disposed in the housing 202. The image from the image inverter 216 may be applied to the display screen 224. In the alternative, the image from the black-and-white to color converter 214, or the image from the streaming video converter 246 directly, may be applied to the display screen 224. The display screen 224 displays an image of the eye based on the video signal. In one embodiment, the display screen 224 are high-resolution liquid crystal display screens.

[0035] The display screen 224 may, for example, be a pair of liquid crystal display screens. A liquid crystal display screen may have a high diopter lens 226. A pair of liquid crystal display screens 224 offers the advantage of binocular vision to the viewer. Thus, a viewer may view the image of the retina by looking through the lenses 226, even though the image of the retina was collected with infrared radiation. Moreover, since the image of the retina 210 was collected with infrared radiation, the image could be collected without dilating the pupil.

[0036] A spacing of the display screens 224 may be adjustable by an ocular, such as slide-to-adjust oculars adjusting the distance to the pupil. A screen width of the liquid crystal display screens 224 may be adjustable as well, with a slide 222.

[0037] The slit-lamp ophthalmoscope 200 may send the images from the image inverter 216 to a laptop computer 230. The images may be collected at the laptop computer 230, which could be a personal digital assistant (PDA). In the alternative, the image from the black-and-white to color converter 214, or the image from the streaming video converter 242, may be sent to the laptop computer 230 directly. The images received by the computer 230 may be captured in real time.

[0038] The laptop computer 230 may include a wireless transmitter to transmit the images over a hospital network 240. The images from the examination may be transmitted over the hospital network 240 to other individuals, in other offices or at their stations. The images may also be stored. The wireless transmitter may receive power from the power supply 228.

[0039] The laptop computer 230 might include a black-and-white to color converter 234 as well, in a manner similar to the black-and-white to color converter included in the slit-lamp ophthalmoscope 200. The black-and-white to color converter 234 may scale the wavelengths of the signal received from the streaming video converter 246 until they are in the visible range. If the wavelengths are scaled in approximately equal amounts, the effect of color will be assigned to the individual wavelengths.

[0040] The computer 230 may also be equipped with software 232 to capture images, develop montages, and perform 3-D rendering. In one embodiment, images from the black-and-white to color converter 234 may be captured in real time by a real-time video capture 258 included in the laptop computer 230. The software 232 might prepare montages of the images, and render the images in three dimensions.

[0041] The computer 230 may also include software to upload the images to a network, such as XML/DICOM software 236. The computer 230 may, finally, include a messaging system 238. The images could be uploaded to a messaging system 238. In this way, the results of the examination can be transmitted easily to other specialists. The computer 230 may broadcast the images through a hospital network 240 to other equipment, such as storage devices or computers. The hospital network 240 may be a wired or a wireless network.

[0042] Although a few preferred embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

CLAIMS

What is claimed is:

1. A slit-lamp ophthalmoscope, comprising:

an adjustable table;

a housing disposed rotatably on the table, the housing rotating about a substantially vertical axis and a substantially horizontal axis;

an infrared light source and a beam splitter disposed in the housing, the light source projecting infrared radiation through a slit-beam aperture toward the beam splitter;

the beam splitter reflecting the infrared radiation from the light source to an eye;

a camera disposed in the housing, a camera collecting radiation reflected by the eye through the beam splitter;

an analog to digital convertor disposed in the housing, the analog to digital converter receiving a raw signal from the camera based on the collected radiation, the analog to digital convertor converting the raw signal to a digital signal;

a black and white to color converter disposed in the housing, the black-and-white to color converter converting the digital signal into a color signal;

a streaming video converter disposed on the housing, the streaming video converter processing the color signal into a video signal;

a pair of video monitors disposed in the housing, the pair of video monitors displaying an image of the eye based on the video signal;

the slit-lamp ophthalmoscope further comprising a video transmitter, the video transmitter transmitting the video signal to a computer over a network, the computer extracting a plurality of images from the video signal.

2. The slit-lamp ophthalmoscope of claim 1, wherein the video monitors comprise high-resolution liquid crystal display screens.

3. The slit-lamp ophthalmoscope of claim 1, wherein the light source further comprises a rheostat dimmer circuit.

4. The slit-lamp ophthalmoscope of claim 1, wherein the light source further comprises an infrared filter and a focusing lens, the infrared filter substantially blocking visible

and ultraviolet radiation, and the focusing lens focusing the infrared radiation from the light source on the beam splitter.

5. The slit-lamp ophthalmoscope of claim 1, further comprising a power supply to supply power to the light source, the power supply selected from the group consisting of a rechargeable lithium ion battery, a nickel cadmium battery, or an alkaline battery.

6. The slit-lamp ophthalmoscope of claim 1, wherein the network is selected from the group consisting of a wired network, and a wireless network.

7. The slit-lamp ophthalmoscope of claim 1, wherein the computer comprises:

a real-time video capture capturing images from the video signal, a black-and-white to color converter converting the images to color, 3-D rendering software, and a messaging system.

8. The slit-lamp ophthalmoscope of claim 1, wherein the light source is selected from the group consisting of a light emitting diode, an electric lamp, a mercury vapor lamp, a halogen lamp, and a tungsten filament lamp.

9. The slit-lamp ophthalmoscope of claim 1, wherein the light source comprises a halogen lamp with an infrared pass filter, the infrared path filter substantially blocking visible and ultraviolet radiation.

10. The slit-lamp ophthalmoscope of claim 1, wherein the black and white to color converter maps intensities of grayscale pixels to colors.

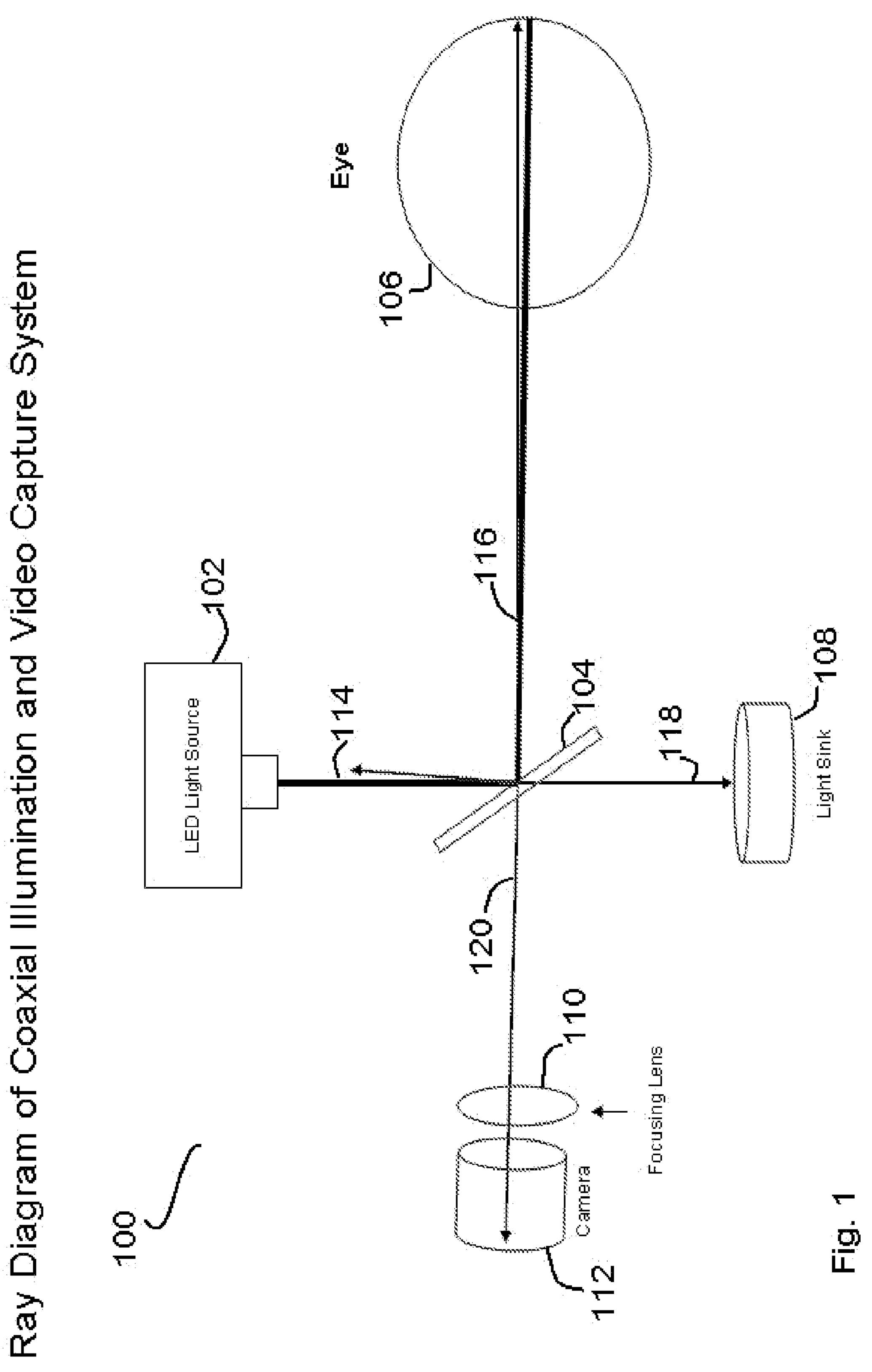
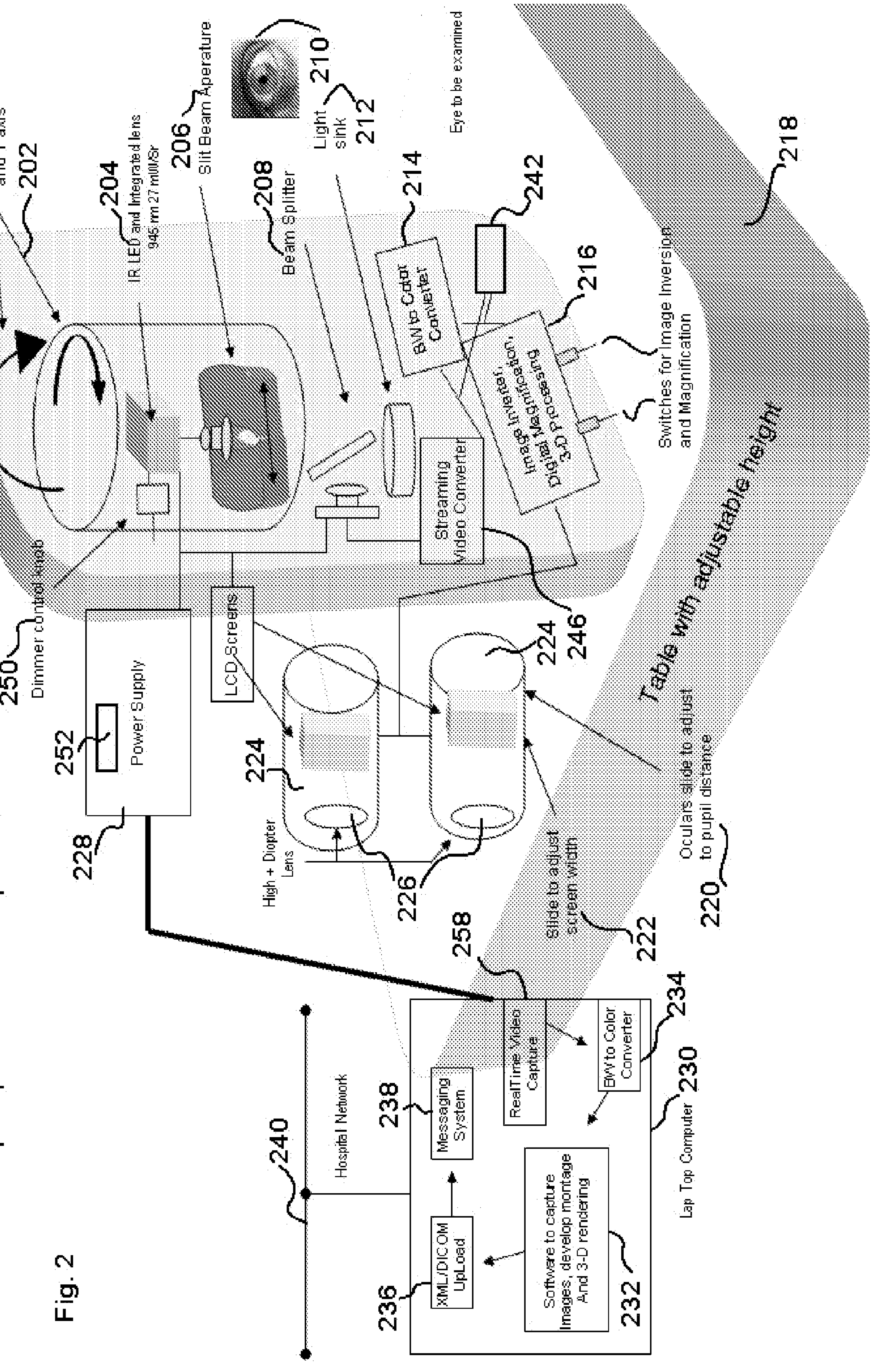

Ray Diagram of Coaxial Illumination and Video Capture System
100
102
LED Light Source
114
104
116
106
Eye
118
108
Light Sink
120
110
Focusing Lens
112
Camera

Fig. 1

IR Slit-Lamp Ophthalmoscope 200

Fig. 2



SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61B 3/10 (2010.01)
USPC - 351/214
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)
IPC(8) - A61B 3/10 (2010.01)
USPC - 351/214

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 practicable, search terms used)
MicroPatent and Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7,338,167 B2 (ZELVIN et al) 04 March 2008 (04.03.2008) entire document	1-10
Y	US 4,772,116 A (SCHRODER et al) 20 September 1988 (20.09.1988) entire document	1-10
Y	US 2008/0281167 A1 (SODERBERG et al) 13 November 2008 (13.11.2008) entire document	1-10
Y	US 6,612,701 B2 (WESTORT et al) 02 September 2003 (02.09.2003) entire document	3

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Date of the actual completion of the international search	Date of mailing of the international search report
22 May 2010	04 JUN 2010

Name and mailing address of the ISA/US	Authorized officer:
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