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PATENT APPLICATION

Title: A FUNDUS IMAGING DEVICE AND METHOD

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Dated 6 April 2018

Applicant(s): STELLENBOSCH UNIVERSITY

Inventor(s): SWART, Wayne, FOURIE, Pieter Rousseau

Von Seidels Ref No: P3524ZA01

Postal Address: PO Box 440, Century City (Cape Town) 7446, South Africa
Tel: +27 21 526 2800
Fax: +27 86 660 6208
E-mail: service@vonseidels.com

www.vonseidels.com

Von Seidels
Intellectual Property
Attorneys

FORM P1

REPUBLIC OF SOUTH AFRICA

PATENTS ACT, 1978

APPLICATION FOR A PATENT AND ACKNOWLEDGEMENT OF RECEIPT

[Section 30 (1)-Regulation 22]

The granting of a patent is hereby requested by the undermentioned applicant on the basis of the present application.

Official Application No.		
21	01	**2019/02107**

Applicant's or Agent's Reference
P3524ZA01SMDnp

71	Full Name(s) of Applicant(s)

STELLENBOSCH UNIVERSITY
Admin B, Victoria Street,, Stellenbosch, Western Cape Province, 7600, South Africa

54	Title of invention

A FUNDUS IMAGING DEVICE AND METHOD

The applicant claims priority as set out on the accompanying Form P.2. The earliest priority claimed is
COUNTRY: ZA NUMBER: 2018/02249 DATE: 2018/04/06

~~This application is for a patent of addition to patent application No.~~

21	01	

~~This application is a fresh application in terms of section 37 and based on Application No.~~

21	01	

This application is accompanied by:

X	1.	A single copy of a complete specification of 10 pages.
X	2.	Drawings of 5 sheet(s).
X	3.	Publication particulars and Abstract(Form P8)
X	4.	A copy of a figure of the drawing (if any) for the abstract
	5.	Assignment of invention
	6.	Certified priority document(s)
	7.	Translation(s) of the priority document(s)
	8.	Assignment of priority rights
X	9.	A copy of the Form P.2 and the specification of S.A Patent Application (if applicable).
	10.	A declaration and power of attorney on Form P3
	11.	Statement on the use of indigenous Biological Resource, Genetic Resource, Traditional Knowledge or Use on Form P26

74	Address of Service:

Von Seidels
4 East Park, Central Park on Park Lane, Century City, Cape Town, 7441
SOUTH AFRICA

Dated this 4th day of April 2019

Submitted online by : Von Seidels

....

Signature of Applicant(s)

This is returned to the applicant's
address for service as proof of lodging.

RECEIVED
Official Date Stamp
.... Registrar of Patents

FORM P2

REPUBLIC OF SOUTH AFRICA		REGISTER OF PATENTS		PATENTS ACT, 1978	
Official application No.		Lodging date: Provisional		Acceptance date	
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71	Full name(s) of applicant(s)/Patentee(s):
	STELLENBOSCH UNIVERSITY Admin B, Victoria Street,, Stellenbosch, Western Cape Province, 7600, South Africa

71	Applicant substitued:	Date registrered
71	Assignee(s):	Date registrered

72	Full name(s) of inventor(s):
	SWART, Wayne FOURIE, Pieter Rousseau

Priority claimed:	Country		Number		Date	
	33	ZA	31	2018/02249	32	2018/04/06

54	Title of invention
	A FUNDUS IMAGING DEVICE AND METHOD

Address of applicant(s)/patentee(s):

Admin B, Victoria Street,, Stellenbosch, Western Cape Province, 7600
SOUTH AFRICA

74 Address for service

Von Seidels
4 East Park, Central Park on Park Lane, Century City, Cape Town, 7441
SOUTH AFRICA
Reference No. P3524ZA01SMDnp

61	Patent of addition No.	Date of any change
	Fresh application based on.	Date of any change

P7

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978
COMPLETE SPECIFICATION
[Section 30(1) – Regulation 28]

OFFICIAL APPLICATION NO.		
21	01	**2019/02107**

LODGING DATE	
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INTERNATIONAL CLASSIFICATION	
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FULL NAME(S) OF APPLICANT(S)	
71	STELLENBOSCH UNIVERSITY Admin B, Victoria Street,, Stellenbosch, Western Cape Province, 7600, South Africa

FULL NAME(S) OF INVENTORS(S)	
72	1. SWART, Wayne 2. FOURIE, Pieter Rousseau

TITLE OF INVENTION	
54	**A FUNDUS IMAGING DEVICE AND METHOD**

A FUNDUS IMAGING DEVICE AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from South African provisional patent application number 2018/02249 filed on 6 April 2018, which is incorporated by reference herein.

FIELD OF THE INVENTION

This invention relates generally to the fields of Optometry and Ophthalmology (human and animal) and, particularly to a fundus imaging device and associated method.

BACKGROUND TO THE INVENTION

Fundus photography involves capturing a photograph of the fundus and typically makes use of specialized fundus cameras. Fundus photography finds particular application in screening for diabetic retinopathy, amongst other conditions.

Traditionally, non-mydratic fundus cameras (cameras that do not require the patients' pupils to be dilated via drugs) make use of two illumination systems. One system is in the near-infrared (IR) spectrum in which the light illuminated is not visible to the human eye and is used to enable the photographer to guide the camera to the target location. The second is in the visible spectrum in which light illuminated is visible in order to illuminate the fundus for image capture. Illumination provided by the second illumination system is usually a flash for a fraction of a second to allow the image to be captured before the pupil constricts.

Some fundus cameras split off the infrared wavelengths to a second infrared sensitive image sensor to be used for focusing, and send the visible wavelength light to a separate visible light sensitive image sensor for final image capture. This may be to achieve proper colour balance on the final image recorded on the camera.

Requiring two separate illumination systems for observation and photography respectively has disadvantages of adding cost, complexity in manufacture, and size to the overall fundus camera design. This may restrict access to these cameras and may hinder portability.

Further, such fundus cameras are complex and typically require extensive training and the need for specialists to obtain adequate images of the fundus. This again limits the reach of these cameras beyond tertiary level health care facilities.

There is accordingly scope for improvement.

The preceding discussion of the background to the invention is intended only to facilitate an understanding of the present invention. It should be appreciated that the discussion is not an acknowledgment or admission that any of the material referred to was part of the common general knowledge in the art as at the priority date of the application.

SUMMARY OF THE INVENTION

In accordance with an aspect of the technology there is provided a device comprising a light source configured to illuminate at least a portion of a patient's fundus with light and a lens arrangement configured to be interposed between an eye of a patient and an image sensor, wherein the lens arrangement includes an eyepiece and a display which is located in an optical path extending between the eyepiece and the image sensor and which is configured to display a visual target, wherein the visual target is displayed at a focal length selected to cause cooperation of the eye with the lens arrangement to thereby focus light reflecting off the fundus for acquisition by the image sensor.

Further features provide for the device to include a projection unit and a video generation unit; for the projection unit to include an optical element and a visual transducer arranged to cooperate to project an image onto the display, for light forming the image to be collimated; for the display to be in the form of a combiner unit configured to redirect the image projected from the projection unit along the optical path towards the eye of the patient; for the visual transducer to be selected from the group of a cathode ray tube, a light emitting diode display, or a liquid crystal display; for the optical element to be one of a convex lens or a concave mirror; and for the video generation unit to render images for projection by the projection unit, the images including the visual target.

A still further feature provides for the display to include a coating configured to reflect monochromatic light projected onto it from the projection unit while allowing other wavelengths of light to pass through.

A yet further feature provides for the display to include a curved surface to refocus the image from the projection unit.

An even further feature provides for the device to include a housing which houses the lens arrangement, the display and, optionally, the projection unit and the video generation unit.

Further features provide for the device to include the image sensor and a controller configured to control operation of the light source and the image sensor and to control movement of the visual target; and for the controller to cause the image sensor to record image data representing the light reflecting off the fundus in one or more frames while the fundus is illuminated with light emitted from the light source.

Still further features provide for the controller to control movement of the visual target along a predetermined route along the display, and for the controller to cause the image sensor to record image data while the visual target moves along the display so as to acquire image data of different portions of the fundus.

Further features provide for the display to permit light travelling along the optical path from the eyepiece to the image sensor therethrough; and for the light source to be a visible light source which emits visible light.

A yet further feature provides for the image sensor to output one or more frames of image data representing the light reflecting off the fundus.

In accordance with a further aspect of the technology there is provided a method comprising: displaying a visual target via a display which is located in an optical path extending between an image sensor and an eyepiece of a lens arrangement configured to be interposed between an eye of a patient and the image sensor; illuminating at least a portion of the patient’s fundus with light using a light source; and, acquiring, via the image sensor, light reflecting off the fundus, wherein the visual target is displayed at a focal length selected to cause cooperation of the eye with the lens arrangement to thereby focus the light reflecting off the fundus for acquisition by the image sensor.

Example embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 is a schematic diagram which illustrates an exemplary fundus imaging device according to aspects of the present disclosure;

Figure 2 is a flow diagram which illustrates an exemplary fundus imaging method according to aspects of the present disclosure;

Figure 3 is a schematic diagram which illustrates one example embodiment of a fundus imaging device;

Figure 4 is a schematic diagram which illustrates another example embodiment of a fundus imaging device; and,

Figure 5 illustrates an example of a computing device in which various aspects of the disclosure may be implemented.

DETAILED DESCRIPTION WITH REFERENCE TO THE DRAWINGS

The present disclosure relates to a fundus imaging device and associated method. The described device may provide a patient guided, non-mydriatic fundus imaging device. Aspects of the disclosure may provide a head-up display-type display in the fundus imaging device which provides a patient under examination with a visual cue on which to focus. The visual cue may be in-line with the optical path (or axis) of the imaging device. As will be explained in greater detail below, automatic focus by the patent under examination, on the correct optical plane may be achieved by appropriately projecting the visual cue. This automatic focussing may obviate the need for infrared (IR) guidance functionality typically included in fundus imaging devices and may also lower the skill set level required to operate the imaging device. It is for example anticipated that rather than highly trained specialist doctors being required to image the fundus, non-specialist, and hence more readily available, health professionals may be able to operate the device. Dispensing with IR guidance functionality may significantly reduce the cost of the device, making it more accessible.

Figure 1 is a schematic diagram which illustrates an exemplary fundus imaging device (100). The device (100) is configured for capturing image data of a fundus (101) of a patient's eye (103).

The device (100) may include a light source (102) configured to illuminate at least a portion of the fundus (101) with light. The light source may be a visible light source configured to emit visible light. The light source may be a visible flash light source or a high output visible light source. Several choices of the visible light source may be suitable, for example, ultra bright LEDs, xenon light sources, or supercapacitor-based LED flash systems. The visible flash light source may be of sufficient luminosity to produce high contrast images.

The device (100) may include an image sensor (105) configured to acquire (or capture) light reflecting off the fundus (101). The image sensor may be any suitable sensor, such as a CMOS sensor, CCD sensor or the like. In some implementations, the image sensor may be provided by a separate device sold and distributed separately from the fundus imaging device. The image sensor may be configured to output one or more frames of image data representing the light reflecting off the fundus. Where multiple frames are output, the image data may be in the form of a video signal.

The device (100) may include a lens arrangement (106). The lens arrangement may include an eyepiece (108) and a number of lenses and/or mirrors (110) configured to provide an optical path (111) between the eyepiece (and hence the patient's eye when in use) and the image sensor (105). Exemplary lens/mirror arrangements are illustrated in greater detail in Figures 3 and 4. The lens arrangement is thus configured to be interposed between the eye (103) of the patient and the image sensor during use of the device.

The lens arrangement (106) may further include a display (112). The display may be located in the optical path (111) extending between the eyepiece (108) and the image sensor (105). The display may be configured to display a visual target (114). The visual target may be displayed by the display (112) at a focal length selected to cause cooperation of the eye (or the lens (116) of the eye) with the lens arrangement (106) (and its associated lenses and mirrors) to thereby focus light reflecting off the fundus for acquisition by the image sensor (105).

In the described embodiment, the display (112) may form a part of a head-up display (HUD) unit.

The display (112) may for example be in the form of an angled flat piece of glass (which may be referred to as a combiner unit) and the device (100) may further include components of a HUD unit including for example a projection unit (118) and a video generation unit (120).

The projection unit (118) may include an optical element and a visual transducer arranged to cooperate with each other to project an image in which light is collimated. The projection unit may project the image using monochromatic light (e.g. light of a single, predetermined wavelength). Exemplary visual transducers may be selected from the group of a cathode ray tube, light emitting diode display, or liquid crystal display. The optical element to be one of a convex lens or a concave mirror.

The display may include or be in the form of a beam splitter (an optical device that splits a beam of light in two) and may be configured to redirect an image projected from the projection unit (118) onto the display along the optical path (111) towards the eyepiece and hence the eye of the patient in operation.

In some implementations, the display may include a coating configured to reflect monochromatic light projected onto it from the projection unit while allowing other wavelengths of light to pass through. Monochromatic light may refer to light of color or a single wavelength and the coating may be selected to reflect light of that selected wavelength and allow for light (or visible light) of all other wavelengths to pass through. In some cases, the display may include a curved surface arranged to refocus the image from the projection unit.

The video generation unit (120) may be configured to render images for projection by the projection unit (118). The rendered images may include the visual target which is ultimately displayed by the display.

In the described embodiment, the image projected by the projection unit and redirected by the display along the optical path (111) towards the eye of the patient is composed of collimated light, which can be said to be focused at infinity. The image, and hence the visual target, may therefore be displayed by the display at a focal length which approximates infinity and the eye (103) of the patient, when focussing on the visual target, may therefore focus at infinity.

In such an embodiment, the visual target is displayed by the display (112) at a focal length selected at infinity and the lenses/mirrors of the lens arrangement may be configured such that, when the lens (116) of the patient's eye is focussing at infinity, light reflecting off the fundus (101) and travelling along the optical path (111) for acquisition by the image sensor (105) will be in focus from the perspective of the image sensor.

It should be appreciated that in other embodiments, different head-up display configurations may be used. In some implementations, for example, a CRT may be used to generate an image on a phosphor screen. In other implementations, a solid state light source, for example LED, which is modulated by an LCD screen may display the image. In some cases, optical waveguides may be used to produce images directly in the combiner unit, rather than using a projection system. Further, in some cases, a scanning laser may be used to display images and even video imagery on a clear transparent medium. In some cases, micro-display imaging technologies may be used for example, liquid crystal display (LCD), liquid crystal on silicon (LCoS), digital micro-mirrors (DMD), organic light-emitting diode (OLED) and the like.

The device (100) may include a controller (122) configured to control operation of the light source (102), image sensor (105) and video generation unit (120). The controller (122) may include a processor for executing the described functionality, which may be provided by hardware or by software units executing on the processor. The software units may be stored in a memory component and instructions may be provided to the processor to carry out the described functionality.

The controller (122) may for example be configured to cause the image sensor (105) to record image data representing the light reflecting off the fundus in one or more frames while the fundus is illuminated with light emitted from the light source (102). The controller (122) may further be configured to control movement of the visual target (114) along a predetermined route along the display (112). This may be effected by controlling operation of the video generation unit (120) and/or the projection unit (118). The controller (122) may be configured to cause the image sensor (105) to record image data while the visual target (114) moves along the display so as to acquire image data of different portions of the fundus.

The device (100) may include a housing which houses one or more of the lens arrangement, display, projection unit, video generation unit, controller and the like.

The device (100) described above may implement a fundus imaging method. An exemplary fundus imaging method is illustrated in the flow diagram of Figure 2. The method may for example be performed by a controller of the device (100).

The method may include displaying (202) a visual target via a display which is located in an optical path extending between an image sensor and an eyepiece of a lens arrangement configured to be interposed between an eye of a patient and the image sensor. The visual target is displayed at a focal length selected to cause cooperation of the eye with the lens arrangement to thereby focus the light reflecting off the fundus for acquisition by the image sensor. It should be appreciated that light reflecting off the fundus of the patient’s eye and towards the eyepiece will travel through the lens of the eye, through the eyepiece and onwards through the lens arrangement towards the image sensor.

The method may include illuminating (204) at least a portion of the patient’s fundus with light using a light source. The light source may be a visible light source which emits visible light.

The method may include acquiring (206), via the image sensor, light reflecting off the fundus. The acquiring operation (206) may be performed substantially in parallel to (i.e. at the same time as) the illuminating operation (204).

The image sensor may output one or more frames of image data representing the light reflecting off the fundus. The image data may be output to one or both of a memory component for subsequent access and a display unit for view by a healthcare practitioner.

Embodiments of the described device and method are configured to use light rays which are parallel to display a visual target which, when focused on the by the patient will cause the patient to focus on infinity to get a clear image. The lens arrangement can be configured to cooperate with this focal point such that when the fundus is viewed by the image sensor through the lens arrangement and lens of the eye, it will be in focus. As the patient’s eye is performing the focussing procedure, it may be said that the described device and method provide a “patient-focused” fundus imaging device. It should be appreciated that in other implementations, other focal lengths may be used and the lens arrangement and its associated components may be adjusted accordingly.

Two example embodiments of fundus imaging devices are illustrated in Figures 3 and 4. The example embodiments illustrated in these Figures elaborate on the arrangement of components of the lens arrangement, light source and display.

Figure 3 is a schematic diagram which illustrates one example embodiment of a fundus imaging device (300). The device (300) may include a lens arrangement including an objective lens (301), a magnification lens (302) and a focus lens (303). The device may further include a visible light source including a polarizer (305), illumination focus lens (306), flash tube (307) and a mirror / beam splitter (308). The lens arrangement may further include a display (311) in the form of a beam splitter and the device may include associated projection components, including an optical element in the form of a projector lens (309) and image / video projector module (310), including for example a visual transducer and/or a video generation unit. The device may include an image sensor (312) which may be connected to a suitable computing device and/or display unit.

Figure 4 is a schematic diagram which illustrates another example embodiment of a fundus imaging device (400). The device (400) may include a lens arrangement including an objective lens (401), a magnification lens (402) and a focus lens (403). The device may further include a visible light source including a polarizer (405), illumination focus lens (406), flash tube (407) and a mirror / beam splitter (408). The lens arrangement may further include a display (411A) in the form of a beam splitter and the device may include associated projection components. The projection components may include a second mirror / beam splitter (411B) as well as an optical element in the form of a projector lens (409) and image / video projector module (410) (which may include, for example, a visual transducer and/or a video generation unit). The display (411A) and the mirror / beam splitter (411B) may be arranged parallel to one another. The display may be located along the axis of the objective lens, with its axis at an acute angle relative to that of the objective lens. The mirror / beam splitter (411B) may be located along the axis of the projector lens (409), with its axis at an acute angle relative to that of the projector lens. The display and mirror / beam splitter may be arranged such that light (412) projected by the projection module travels through the projector lens, reflects off the mirror / beam splitter (411B), travels towards the display (411A) and reflects off the display towards and through the objective lens so as to be visible to a patient looking through the objective lens. By using multiple reflectors, i.e. the display (411A) and the mirror / beam splitter (411B), image warping (where parts of the image are in focus and others are not) may be avoided. The device may include an image sensor (413) which may be connected to a suitable computing device and/or display unit.

Generally, in use a patient may place an eye on the eyepiece. The display may display a visual target simulating a focal length which causes cooperation of the lens of the patient’s eye with the lens arrangement so as to focus light travelling from the fundus through the lens of the patient’s eye and the lens arrangement for acquisition by the image sensor. The visible light source illuminates the patient's fundus and light reflected therefrom is acquired by the image sensor. The image sensor may then provide an image of the patient's fundus to an external display unit for viewing by a healthcare practitioner. It is appreciated that the multiple images may be acquired for compiling a mosaic image of the patient's fundus.

A fundus imaging device as disclosed herein provides a self (patient) guided feature for a patient and may be more user friendly. The self (patient) guided feature provides a patient with something to look at in order to automatically focus the patient's eye correctly for the image sensor to image the part of the fundus that is of interest. This may eliminate the need for the infrared illumination of the fundus and may provide an imaging device that is less costly in the sense of optics (e.g. because specially coated optics typically required to handle both the infrared and visible light spectrum may be obviated).

A fundus imaging device as disclosed herein may also provide a patient with something (a visual cue) to focus on, which may negate the need for the extensive training and practice required by specialists to obtain adequate images of the fundus. Such a device may for example find application in both primary and tertiary care situations. For example, at primary care levels, less experienced medical personnel may be able to capture images of a patient's fundus with greater ease than might be expected with alternative available equipment, while trained physicians may be more successful with less cooperative patients such as infants.

A fundus imaging device as disclosed herein may find application in clinical ophthalmology. Fundus screening in rural areas is considered as a major issue in certain regions and can result in unnecessary referrals. This may place unnecessary economic strain on the community and the health care system in these regions. The usability and cost of the fundus imaging device described herein may alleviate this strain, at least to some extent.

It can be that some patients having their fundus imaged are not fully cooperative. It may be that providing a patient with something to focus during fundus imaging may negate to some extent any requirement for an examining healthcare practitioner to guide the direction of the camera with the patient's fundus, a difficult procedure requiring extensive training and practice. Giving patients something to focus on may facilitate cooperation of patients.

It will be appreciated that numerous variations may be made to method and devices described herein without departing from the scope hereof. For example, the fundus imaging device may be part of a part of an imaging system that includes a base station. The base station may exchange data with the fundus imaging device and may receive image data from the image sensor of the fundus imaging device. The base station may also include a networking capability, such that image data can be distributed over a network or to other communication or computing devices. In some implementations the fundus imaging device may be handheld, portable, and/or wearable on a patient's head.

In some embodiments, the display may be selectively located in the optical path. For example, a switching mechanism may be provided to switch the display into and out of the optical path. The switching mechanism may operate sufficiently quickly to enable the image sensor to capture light reflecting off the fundus before the eye's focus changes.

The term "fundus" is used herein with reference to the eye, and is meant to indicate the interior surface of the eye, opposite the lens, including the retina, optic disc, macula and fovea, and posterior pole.

Figure 5 illustrates an example of a computing device (500) in which various aspects of the disclosure (e.g. the controller and/or video generation unit) may be implemented. The computing device (500) may be embodied as any form of data processing device including a personal computing device (e.g. laptop or desktop computer), a server computer (which may be self-contained, physically distributed over a number of locations), a client computer, or a communication device, such as a mobile phone (e.g. cellular telephone), satellite phone, tablet computer, personal digital assistant or the like. Different embodiments of the computing device may dictate the inclusion or exclusion of various components or subsystems described below.

The computing device (500) may be suitable for storing and executing computer program code. The various participants and elements in the previously described system diagrams may use any suitable number of subsystems or components of the computing device (500) to facilitate the functions described herein. The computing device (500) may include subsystems or components interconnected via a communication infrastructure (505) (for example, a communications bus, a network, etc.). The computing device (500) may include one or more processors (510) and at least one memory component in the form of computer-readable media. The one or more processors (510) may include one or more of: CPUs, graphical processing units (GPUs), microprocessors, field programmable gate arrays (FPGAs), application specific integrated circuits

(ASICs) and the like. In some configurations, a number of processors may be provided and may be arranged to carry out calculations simultaneously. In some implementations various subsystems or components of the computing device (500) may be distributed over a number of physical locations (e.g. in a distributed, cluster or cloud-based computing configuration) and appropriate software units may be arranged to manage and/or process data on behalf of remote devices.

The memory components may include system memory (515), which may include read only memory (ROM) and random access memory (RAM). A basic input/output system (BIOS) may be stored in ROM. System software may be stored in the system memory (515) including operating system software. The memory components may also include secondary memory (520). The secondary memory (520) may include a fixed disk (521), such as a hard disk drive, and, optionally, one or more storage interfaces (522) for interfacing with storage components (523), such as removable storage components (e.g. magnetic tape, optical disk, flash memory drive, external hard drive, removable memory chip, etc.), network attached storage components (e.g. NAS drives), remote storage components (e.g. cloud-based storage) or the like.

The computing device (500) may include an external communications interface (530) for operation of the computing device (500) in a networked environment enabling transfer of data between multiple computing devices (500) and/or the Internet. Data transferred via the external communications interface (530) may be in the form of signals, which may be electronic, electromagnetic, optical, radio, or other types of signal. The external communications interface (530) may enable communication of data between the computing device (500) and other computing devices including servers and external storage facilities. Web services may be accessible by and/or from the computing device (500) via the communications interface (530).

The external communications interface (530) may be configured for connection to wireless communication channels (e.g., a cellular telephone network, wireless local area network (e.g. using Wi-Fi™), satellite-phone network, Satellite Internet Network, etc.) and may include an associated wireless transfer element, such as an antenna and associated circuitry.

The computer-readable media in the form of the various memory components may provide storage of computer-executable instructions, data structures, program modules, software units and other data. A computer program product may be provided by a computer-readable medium having stored computer-readable program code executable by the central processor (510). A computer program product may be provided by a non-transient computer-readable medium, or may be provided via a signal or other transient means via the communications interface (530). Interconnection via the communication infrastructure (505) allows the one or more processors (510) to communicate with each subsystem or component and to control the execution of instructions from the memory components, as well as the exchange of information between subsystems or components. Peripherals (such as printers, scanners, cameras, or the like) and input/output (I/O) devices (such as a mouse, touchpad, keyboard, microphone, touch-sensitive display unit, input buttons, speakers and the like) may couple to or be integrally formed with the computing device (500) either directly or via an I/O controller (535). One or more display units (545) (which may be touch-sensitive display units) may be coupled to or integrally formed with the computing device (500) via a display or video adapter (540).

The foregoing description has been presented for the purpose of illustration; it is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Persons skilled in the relevant art can appreciate that many modifications and variations are possible in light of the above disclosure.

Any of the steps, operations, components or processes described herein may be performed or implemented with one or more hardware or software units, alone or in combination with other devices. In one embodiment, a software unit is implemented with a computer program product comprising a non-transient computer-readable medium containing computer program code, which can be executed by a processor for performing any or all of the steps, operations, or processes described. Software units or functions described in this application may be implemented as computer program code using any suitable computer language such as, for example, Java™, C++, or Perl™ using, for example, conventional or object-oriented techniques. The computer program code may be stored as a series of instructions, or commands on a non-transitory computer-readable medium, such as a random access memory (RAM), a read-only memory (ROM), a magnetic medium such as a hard-drive, or an optical medium such as a CD-ROM. Any such computer-readable medium may also reside on or within a single computational apparatus, and may be present on or within different computational apparatuses within a system or network.

Flowchart illustrations and block diagrams of methods, systems, and computer program products according to embodiments are used herein. Each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, may provide functions which may be implemented by computer readable program instructions. In some alternative implementations, the functions identified by the blocks may take place in a different order to that shown in the flowchart illustrations.

The language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the inventive subject matter. It is therefore intended that the scope of the invention be limited not by this detailed description, but rather by any claims that issue on an application based hereon. Accordingly, the disclosure of the embodiments of the invention is intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the following claims. Throughout the specification and claims unless the contents requires otherwise the word ‘comprise’ or variations such as ‘comprises’ or ‘comprising’ will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

CLAIMS:

1. A device comprising a light source configured to illuminate at least a portion of a patient's fundus with light and a lens arrangement configured to be interposed between an eye of a patient and an image sensor, wherein the lens arrangement includes an eyepiece and a display which is located in an optical path extending between the eyepiece and the image sensor and which is configured to display a visual target, wherein the visual target is displayed at a focal length selected to cause cooperation of the eye with the lens arrangement to thereby focus light reflecting off the fundus for acquisition by the image sensor.

2. The device as claimed in claim 1, including a projection unit and a video generation unit, wherein the projection unit includes an optical element and a visual transducer arranged to cooperate to project an image onto the display.

3. The device as claimed in claim 2, wherein light forming the image is collimated, and wherein the display is in the form of a combiner unit configured to redirect the image projected from the projection unit along the optical path towards the eye of the patient.

4. The device as claimed in claim 2 or claim 3, wherein the visual transducer is selected from the group of a cathode ray tube, a light emitting diode display, or a liquid crystal display.

5. The device as claimed in any one of claims 2 to 4, wherein the optical element is one of a convex lens or a concave mirror.

6. The device as claimed in any one of claims 2 to 5, wherein the video generation unit renders images for projection by the projection unit, and wherein the images include the visual target.

7. The device as claimed in any one of claims 2 to 6, wherein the display includes a coating configured to reflect monochromatic light projected onto it from the projection unit while allowing other wavelengths of light to pass through.

8. The device as claimed in any one of claims 2 to 7, wherein the display includes a curved surface to refocus the image from the projection unit.

9. The device as claimed in any one of the preceding claims, including a housing which houses the lens arrangement and the display.

10. The device as claimed in claim 9 when dependent on any one of claims 2 to 8, wherein the housing further houses the projection unit and the video generation unit.

11. The device as claimed in any one of the preceding claims, including the image sensor and a controller configured to control operation of the light source and the image sensor and to control movement of the visual target.

12. The device as claimed in claim 11, wherein the controller causes the image sensor to record image data representing the light reflecting off the fundus in one or more frames while the fundus is illuminated with light emitted from the light source.

13. The device as claimed in claim 11 or claim 12, wherein the controller controls movement of the visual target along a predetermined route along the display, and wherein the controller causes the image sensor to record image data while the visual target moves along the display so as to acquire image data of different portions of the fundus.

14. The device as claimed in any one of the preceding claims, wherein the display permits light travelling along the optical path from the eyepiece to the image sensor therethrough.

15. The device as claimed in any one of the preceding claims, wherein the light source is a visible light source which emits visible light.

16. The device as claimed in any one of the preceding claims, wherein the image sensor outputs one or more frames of image data representing the light reflecting off the fundus.

17. A method comprising:

displaying a visual target via a display which is located in an optical path extending between an image sensor and an eyepiece of a lens arrangement configured to be interposed between an eye of a patient and the image sensor;

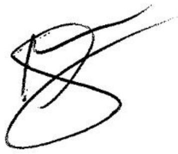
illuminating at least a portion of the patient’s fundus with light using a light source; and,

acquiring, via the image sensor, light reflecting off the fundus,

wherein the visual target is displayed at a focal length selected to cause cooperation of the eye with the lens arrangement to thereby focus the light reflecting off the fundus for acquisition by the image sensor.

18. A device substantially as described herein with reference to Figures 1, 3 or 4.

Dated this 4th day of April 2019



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Von Seidels Intellectual Property Attorneys

for the applicant

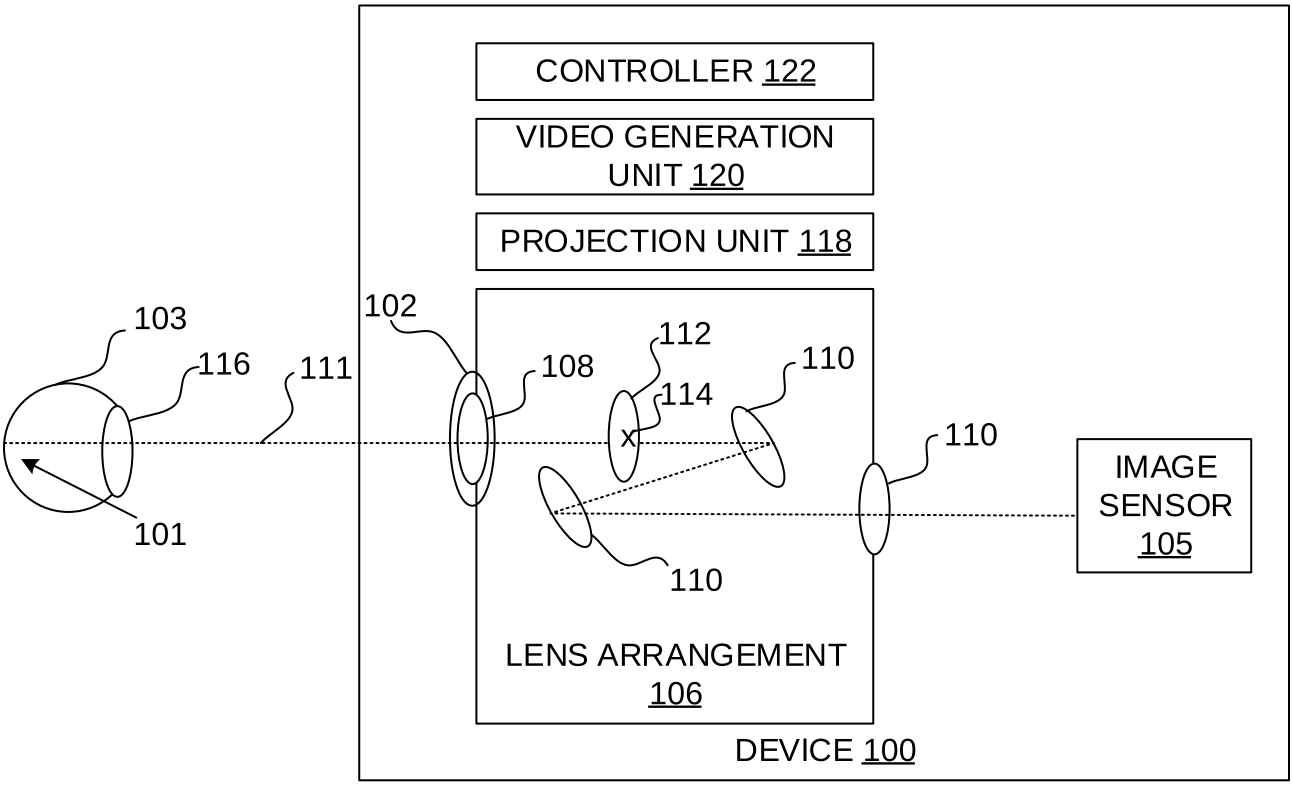

FIGURE 1

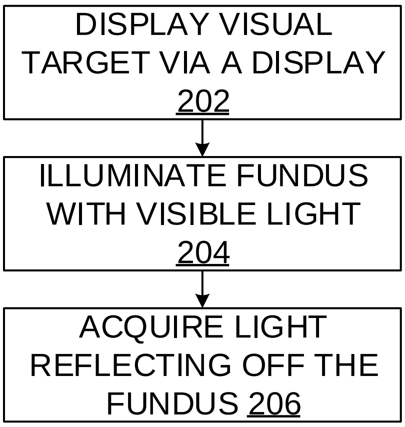

FIGURE 2

VON SEIDELS
FOR THE APPLICANT

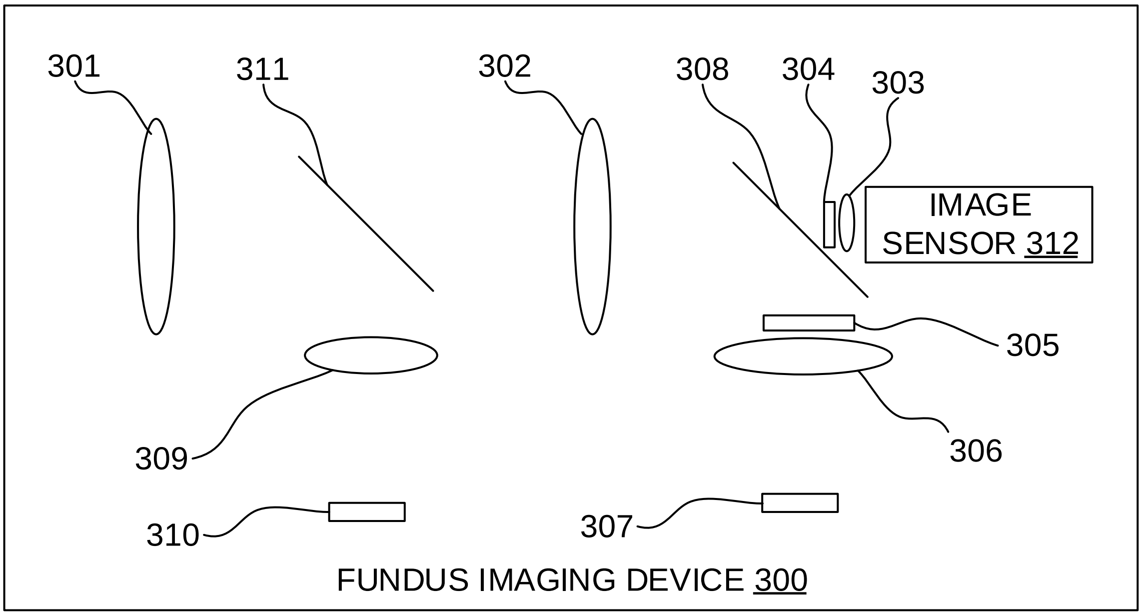

FIGURE 3

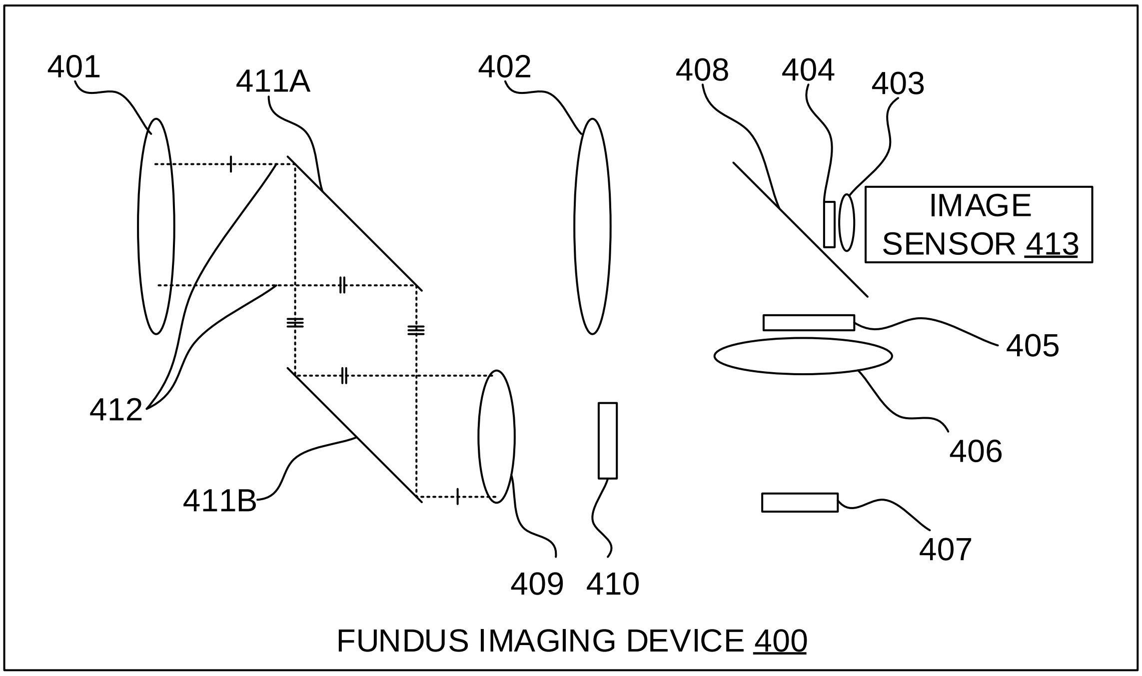

FIGURE 4

VON SEIDELS
FOR THE APPLICANT

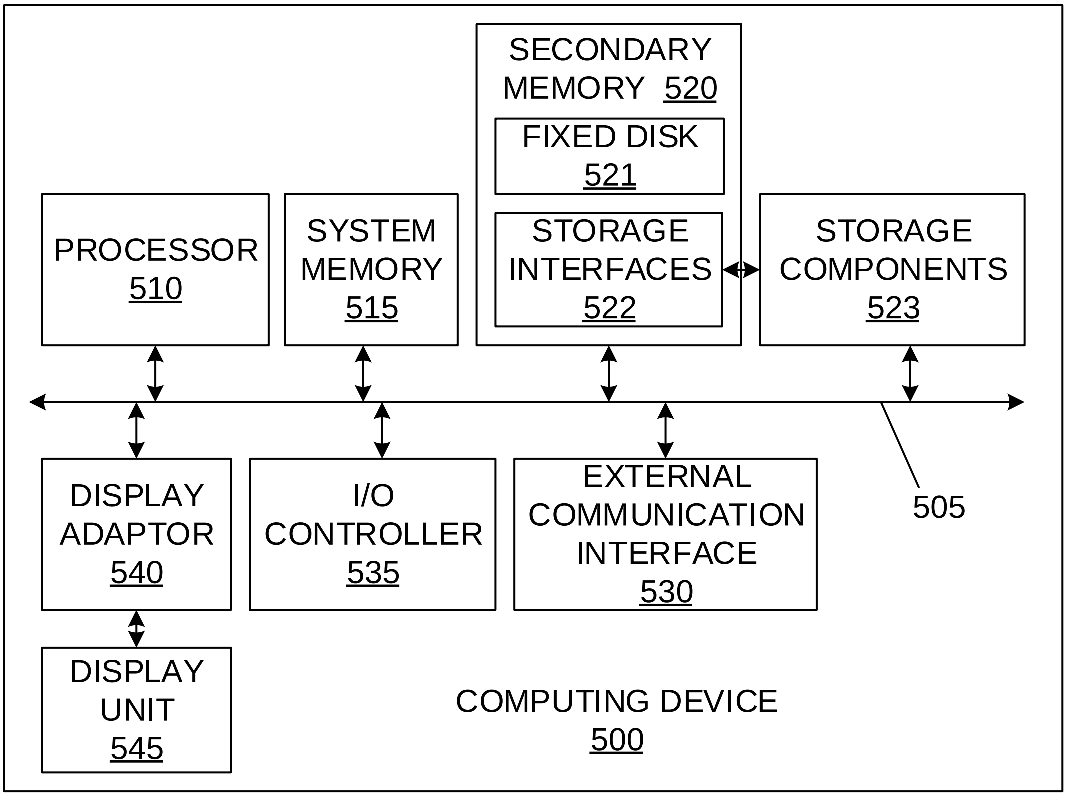

FIGURE 5

VON SEIDELS
FOR THE APPLICANT