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(73) Patenthaver: **Optos PLC, Queensferry House , Carnegie Business Campus , Queensferry Road, Dunfermline, Fife KY11 8GR, Storbritannien**

(72) Opfinder: **WALL, Robert, c/o Optos Plc., Queensferry House, Carnegie Business Campus, Queensferry Road, Dunfermline, Fife KY11 8GR, Storbritannien**
SWAN, Derek, 18 Viewforth Place, Anstruther, Pittenweem, Fife KY10 2PZ, Storbritannien
GRAY, Dan, c/o Optos Plc., Queensferry House, Carnegie Business Campus, Queensferry Road, Dunfermline, Fife KY11 8GR, Storbritannien

(74) Fuldmægtig i Danmark: **Plougmann Vingtoft A/S, Strandvejen 70, 2900 Hellerup, Danmark**

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DESCRIPTION

[0001] The present invention relates to an apparatus for illuminating, imaging and treating the retina of a human eye.

[0002] Imaging systems, such as scanning laser ophthalmoscopes (SLOs), may comprise a large number of optical components, such as laser scanning elements, scan transfer mirrors, laser sources and detectors. The laser scanning arrangement consists of first and second orthogonal scanning elements, which typically include a high speed rotating polygonal mirror and a motor driven slow speed mirror. These elements are used to create a raster scan pattern of the human retina. The polygon mirror has a plurality of facets and typically provides the vertical scanning of the laser beam, and the slow speed mirror typically provides the horizontal scanning of the laser beam. The scan transfer mirror transfers the two dimensional laser scan pattern created by the scanning elements to the retina of the eye.

[0003] GB 2 440 163 A discloses a scanning ophthalmoscope and method is provided for scanning the retina of an eye comprising a source of collimated light, a first scanning element, a second scanning element and scan compensation means. The source of collimated light, the first and second scanning elements and the scan compensation means combine to provide a two-dimensional collimated light scan from an apparent point source, and the scanning ophthalmoscope further comprises scan transfer means, wherein the scan transfer means has two foci and the apparent point source is provided at a first focus of the scan transfer means and an eye is accommodated at the second focus. The scan transfer means transfers the scan from the apparent point source into the eye and the rotational axis of the second scanning element is substantially parallel to a line joining the two foci. In the provision of the two-dimensional collimated light scan from the apparent point source, the scan compensation means produces a one-dimensional collimated light scan and the line joining the foci lies substantially on a plane defined by the one-dimensional scan. The arrangement reduces or eliminates shear distortions in the scanned images of prior art devices.

[0004] US 5,815,242 discloses a scanning ophthalmoscope which produces images of the rear surface of the human eye, and particularly of the retina, by utilising an aspherical mirror to reflect light beams, produced by multiple scanning laser light sources, into the retina. The described ophthalmoscope is said to incorporate dynamic systems for the compensation of focus and residual astigmatisms in addition to providing accurate wide field images with adequate resolution and contrast which can be displayed and stored in standard computer systems.

[0005] While such imaging systems provide acceptable images of the retina of the eye, they are limited in that they are expensive to manufacture (the laser scanning elements and scan transfer mirror are particularly expensive components), large in size and, due to the large number of optical components, have low optical efficiency.

[0006] According to the present invention, there is provided an apparatus for imaging the retina of an eye as set out in Claim 1.

[0007] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic side view of an apparatus for illuminating, imaging and treating the retina of an eye according to an embodiment of the present invention;

Figure 2 is a schematic view of a light source and detector of figure 1; and

Figure 3 is a schematic side view of an alternative apparatus for illuminating, imaging and treating the retina of an eye.

[0008] There is described below an apparatus for illuminating the retina of an eye comprising:

at least one light source,

wherein the at least one light source is adapted to provide collimated light from a plurality of point sources,

and wherein each point source lies on an arc,

and wherein the at least one light source is configured to direct collimated light from each point source along the radius of the arc towards a centre point of the arc,

and wherein, in use, the apparatus is arranged such that the centre point of the arc is substantially coincident with the pupillary point of the eye, such that collimated light is transmitted from the point source through the pupillary point of the eye to illuminate the retina.

[0009] The apparatus may comprise a plurality of light sources, wherein each light source is adapted to provide collimated light from each point source.

[0010] The centre of the arc may be coincident with the first nodal point of the eye.

[0011] The plurality of collimated light point sources may be arranged in an array such that each point source is equidistant from its adjacent point source. Alternatively, the collimated light point sources may be arranged such that they adjoin one another along the arc.

[0012] The radius of the arc may be between 3mm and 500mm. Preferably, the radius of the arc may be between 5mm and 200mm. More preferably, the radius of the arc is 25mm.

[0013] The apparatus may comprise between 1 and 16,000,000 light sources. Preferably, the apparatus comprises between 100 and 16,000,000 light sources. More preferably, the apparatus comprises 4000 light sources.

[0014] The light sources may include a laser, a light emitting diode (LED), a Vertical Cavity Surface Emitting Laser (VCSEL), a super luminescent diode, a diode laser or a collimated incandescent lamp.

[0015] Each light source may be adapted to provide light at a wavelength between 450nm and 1000nm. Preferably, each light source may be adapted to provide light at a wavelength between 488nm and 700nm. More preferably, each light source provides light at a wavelength between 515nm and 650nm.

[0016] Each light source may be adapted to provide light at a power of between 500nW and 1W.

[0017] Each light source may include one or more light sources of differing wavelengths.

[0018] Each light source may be configured such that the wavelength of light provided is variable.

[0019] Each light source may be configured such that the power of light provided is variable.

[0020] Each light source may be positioned at or adjacent the point source.

[0021] Each light source may include a collimating lens to provide the collimated light from the point source.

[0022] Each light source may be positioned remotely from the point source. In this arrangement light is transferred from each light source to the point source via a light transfer device, such as a light guide, optical fibre, or the like. In this arrangement each light source may include a first collimating lens provided at an input to the light transfer device to provide collimated light to the input to the light transfer device and a second collimating lens provided at the output of the light transfer device to provide collimated light at the point source.

[0023] Each light source may include a power monitor to monitor the power of the light source.

[0024] Each light source may include a polarising element, such as a linear polariser or waveplate.

[0025] The apparatus may be configured such that each light source is independently operable. The apparatus may be configured such that each light source is operated sequentially.

[0026] The apparatus may be configured such that the operation of each light source is automated. The operation of each light source may be computer-controlled.

[0027] The apparatus may be rotatable about an axis which substantially lies on a plane defined by the plurality of point sources and the centre point of the arc. In this arrangement the apparatus may be used to illuminate the surface of the retina, as opposed to a line on the retina. That is, without rotation the apparatus illuminates a line on the retina and with rotation the apparatus illuminates the surface of the retina.

[0028] The axis of rotation of the apparatus may be located around the pupillary point of the eye. The axis of rotation of the apparatus may be coincident with the pupillary point of the eye.

[0029] The apparatus may be configured such that its rotation about the axis is automated. The rotation of the apparatus may be computer-controlled.

[0030] The apparatus may comprise a plurality of collimated point sources lying on a plurality of concentrically aligned arcs. Each arc may have the same radius and centre point. In this arrangement collimated light from each point source is directed radially inwardly along the radius of each arc towards the centre point. In use, the apparatus is arranged such that the centre point is substantially coincident with the pupillary point of the eye, such that collimated light is transmitted from each point source through the pupillary point of the eye to illuminate the retina. The effect of this arrangement is that the apparatus provides a two-dimensional semi-spherical illuminating surface for directing collimated light from each point source through the centre point and to the retina of the eye.

[0031] The apparatus may be pivotable between a first position, in which the apparatus may be used to illuminate the first retina of a first eye, and a second position, in which the apparatus may be used to illuminate the second retina of a second eye.

[0032] The apparatus may further comprise a light detector for detecting light reflected from the retina to produce an image of the retina. In this arrangement the apparatus illuminates the retina and obtains an image of the illuminated part of the retina. This image is a one-dimensional image. When the apparatus is rotated about the axis described above, a plurality of one-dimensional images of the retina may be obtained and combined to obtain a two-dimensional image of the retina.

[0033] Each light source may include a light detector for detecting light reflected from the retina to produce an image of the retina.

[0034] The light detector(s) may include fast photo detectors, such as avalanche photo diodes (APDs), PIN diodes, photomultiplier tubes (PMTs), silicon photo multipliers (SPMs), or similar single point detectors.

[0035] The light detectors may be located with the light sources.

[0036] The apparatus may be configured such that the operation of each light detector is automated. The operation of each light detector may be computer-controlled. The operation of each light detector is synchronised with each light source.

[0037] Each detector may include a lens which focuses the reflected collimated light from the retina to the detector. The detector is preferably a point detector and the lens focuses the reflected collimated light to a point on the point detector.

[0038] The apparatus may include a single lens which functions as the collimating lens of each light source and the focussing lens of each detector.

[0039] The apparatus may include a beam splitter positioned between each light source and each detector. In this arrangement the beam splitter reflects a portion of the light from the light source to the collimating lens. The remaining portion of the light from the light source is transmitted through the beam splitter and towards the power monitor. The majority of the reflected collimated light from the retina is transmitted through the beam splitter to the detector.

[0040] The apparatus may further comprise one or more data processing devices for displaying, storing and/or combining the obtained images of the retina.

[0041] There is also described below a system for illuminating the retina of each eye of a patient comprising two apparatuses according to the first aspect of the present invention, wherein each apparatus may be capable of illuminating the retina of one eye.

[0042] There is also described below a method of illuminating the retina of an eye according to a background example not forming an embodiment of the invention, the method comprising the steps of:

providing at least one light source, wherein the at least one light source is adapted to provide collimated light from a plurality of point sources;

arranging each point source on an arc;

arranging the apparatus such that the centre point of the arc is substantially coincident with the pupillary point of the eye; and

using the at least one light source to direct collimated light from each point source along the radius of the arc towards the centre point of the arc, such that collimated light is transmitted from the point source through the pupillary point of the eye to illuminate the retina.

[0043] The apparatus may comprise a plurality of light sources, wherein each light source is adapted to provide collimated light from each point source.

[0044] Each light source may be configured such that the wavelength of light provided is variable and the method may include the further step of varying the wavelength of light from the source.

[0045] Each light source may be configured such that the power of light provided is variable and the method may include the further step of varying the power of light from the source.

[0046] Each light source may be independently operable and the method may include the further step of operating each light source sequentially.

[0047] The operation of each light source may be automated. The operation of each light source may be computer-controlled.

[0048] The apparatus may be rotatable about an axis which substantially lies on a plane defined by the plurality of point sources and the centre point of the arc and the method may include the further step of rotating the apparatus about the axis to illuminate the surface of the retina. The axis of rotation of the apparatus may be located around the pupillary point of the eye. The axis of rotation of the apparatus may be coincident with the pupillary point of the eye.

[0049] The rotation of the apparatus may be configured such that its rotation about the axis is automated. The rotation of the apparatus may be computer-controlled.

[0050] The method may comprise the further step of providing a light detector and using the light detector to detect light reflected from the retina to produce an image of the retina. In this arrangement the method performs the steps of illuminating the retina and obtaining an image of the illuminated retina. Without rotation of the apparatus the image obtained is a one-dimensional image, with rotation of the apparatus the image obtained is a two-dimensional image. The two-dimensional image may be obtained by combining a plurality of one-dimensional images together.

[0051] The operation of each light detector may be automated. The operation of each light detector may be computer-controlled.

[0052] There is also described below an apparatus for imaging the retina of an eye comprising:

at least one light source and a plurality of light detectors,

wherein the at least one light source is adapted to provide collimated light from a plurality of point sources and each light detector is adapted to detect light reflected from the retina,

and wherein each point source lies on an arc,

and wherein the at least one light source is configured to direct collimated light from each point source along the radius of the arc towards a centre point of the arc, and wherein, in use, the apparatus is arranged such that the centre point of the arc is substantially coincident with the pupillary point of the eye, such that collimated light is transmitted from the point source through the pupillary point of the eye to illuminate the retina and reflected back to the light detector to produce an image of the retina.

[0053] The apparatus may comprise a plurality of light sources, wherein each light source is adapted to provide collimated light from each point source.

[0054] There is also described below an apparatus for treating the retina of an eye with collimated light comprising:

at least one light source,

wherein the at least one light source is adapted to provide collimated light from a plurality of point sources,

and wherein each point source lies on an arc,

and wherein the at least one light source is configured to direct collimated light from each point source along the radius of the arc towards a centre point of the arc,

and wherein, in use, the apparatus is arranged such that the centre point of the arc is substantially coincident with the pupillary point of the eye, such that collimated light is transmitted from the point source through the pupillary point of the eye to the retina.

[0055] Treatment of the retina is interpreted here to include photodynamic therapy, photo-ablation, photoporation, photoactivation or other methods where the interaction of the light is used to alter the state or structure of the retina or to alter the state of chemicals within the retinal structure.

[0056] There is also described below a method of imaging the retina of an eye according to a background example, the method comprising the steps of:

providing at least one light source, wherein the at least one light source is adapted to provide collimated light from a plurality of point sources;

providing a plurality of light detectors, wherein each light detector is adapted to detect light reflected from the retina;

arranging each point source on an arc;

arranging the apparatus such that the centre point of the arc is substantially coincident with the pupillary point of the eye; and using the at least one light source to direct collimated light from each point source along the radius of the arc towards the centre point of the arc, such that collimated light is transmitted from the point source through the pupillary point of the eye to illuminate the retina; and

using each light detector to detect light reflected from the retina to produce an image of the retina.

[0057] There is also described below a method of treating the retina of an eye with collimated light according to a background example, the method comprising the steps of:

providing at least one light source, wherein the at least one light source is adapted to provide collimated light from a plurality of point sources;

arranging each point source on an arc;

arranging the apparatus such that the centre point of the arc is substantially coincident with the pupillary point of the eye; and

using the at least one light source to direct collimated light from each point source along the radius of the arc towards the centre point of the arc, such that collinnated light is transmitted from the point source through the pupillary point of the eye to the retina.

[0058] Treatment of the retina is interpreted here to include photodynamic therapy, photo-ablation, photoporation, photoactivation or other methods where the interaction of the light is used to alter the state or structure of the retina or to alter the state of chemicals within the retinal structure.

[0059] The method of treating the retina may comprise an initial step of indentifying a region of the retina for treatment. This would be performed by imaging the retina.

[0060] The method of treating the retina may include obtaining an image of the retina at any point of the treatment process.

[0061] The method of treating the retina may comprise the further step of specifying the size and/or location of a treatment area.

[0062] The method of treating the retina may comprise the further step of controlling the operation of the plurality of light sources to select the area of the retina which is illuminated by the collimated light.

[0063] The method of treating the retina may comprise the further step of viewing an image of the retina. This may be performed at any point during the treatment process.

[0064] Figure 1 illustrates an apparatus 10 for illuminating the retina 12 of an eye 14. The apparatus 10 includes a plurality of light sources 16 arranged in an arc 18. Each light source 16 is adapted to provide collimated light 20 from a point source 22 and to direct the collimated light 20 from the point source 22 along the radius 24 of the arc 18 towards a centre point 26 of the arc 18.

[0065] The apparatus 10 may comprise between 100 and 16,000,000 light sources 16 arranged along the arc 18. However, it should be appreciated that the apparatus 10 may have less than 100 or more than 16,000,000 light sources 16. The apparatus 10 may also include any number of light
sources 16 between 100 and 16,000,000 depending on the operating requirements of the apparatus 10.

[0066] The light sources 16 may be mounted to a frame (not shown), or the like. The frame may be in the shape of the arc 18.

[0067] The radius of the arc 18 may be between 3mm and 500mm. Preferably, the radius of the arc 18 may be between 5mm and 200mm. More preferably, the radius of the arc is 25mm. However, is should be appreciated that the radius of the arc may be less than 3mm or greater than 500mm.

[0068] Each light source 16 may include a laser, light emitting diode (LED), Vertical Cavity Surface Emitting Laser (VCSEL), super luminescent diode, diode laser or a collimated incandescent lamp. Each light source 16 may also be adapted to provide light at a wavelength between 450nm and 1000nm. Preferably, each light source may be adapted to provide light at a wavelength between 488nm and 700nm. More preferably, each light source provides light at a wavelength between 515nm and 650nm. Each light source 16 may also be adapted to provide light at a power of between 500nW and 1W.

[0069] The wavelength of collimated light 20 of each light source 16 may be variable. Similarly, the power of each light source 16 may be variable. Each light source 16 may also includes a power monitor (see below) to ensure that the collimated light 20 provided by the light source 16 is safe.

[0070] The construction of each light source 16 is illustrated in figure 2. The light source 16 includes an emitter 28, which may include any one of the laser, light emitting diode (LED), Vertical Cavity Surface Emitting Laser (VCSEL), super luminescent diode, diode laser or a collimated incandescent lamp described above, and a detector 30. The detector 30 detects light reflected from the retina 12 and is used to form an image of the retina 12. The detector 30 may include a fast photo detector, such as an avalanche photo diode (APD), a PIN diode, a photomultiplier tube (PMT), a silicon photo multiplier (SPM), or a similar single point detector. Each detector 30 is a point detector.

[0071] Light from the emitter 28 is polarised by a polarising element 32 and directed towards a beam splitter 34. A portion of the light is reflected by the beam splitter 34 towards a collimating lens 36, with the remainder being transmitted towards a power monitor 38. The beam splitter 34 is a plate glass beam splitter and is oriented at 45 degrees to the collimating lens 36. The beam splitter 34 may be uncoated and provides approximately 90/10 splitting ratio by utilising polarisation specific Fresnel reflections. Approximately 90% of the light from the emitter 28 is transmitted through the beam splitter 34, with the remaining 10% going towards the collimating lens 36. The light transmitted through the beam splitter 34 may be used to monitor the power of the light for safety reasons. The collimating lens 36 collimates the light from the emitter 28 to provide the collimated light 20. The result is that the light source 16 provides collimated light 20 from a point source 22. With reference to figures 1 and 2, the point source 22 is coincident with the collimating lens 36.

[0072] The apparatus 10 may be configured such that each light source 16 is independently operable. Furthermore, each light source 16 may be operated sequentially. The operation of each light source 16 may be automated and controlled by a computer, or the like.

[0073] The majority of the reflected light from the retina 12 is focussed by the collimating lens 36 to the detector 30. As described above, the detector 30 is a point detector. The reflected light from the retina 12 is transmitted through the beam splitter 34 to the detector 30 via another polarising element 32. As described above, the detector 30 may include a fast photo detector, such as an avalanche photo diode (APD), a PIN diode, a photomultiplier tube (PMT), a silicon photo multiplier (SPM), or a similar single point detector.

[0074] With reference to figure 1, in use, the apparatus 10 is arranged such that the centre point 26 of the arc 18 is substantially coincident with the pupillary point 40 of the eye 14. In this arrangement collimated light 20 from each of the light sources 16 is transmitted from each of the point sources 22 through the pupillary point 40 of the eye 14 to illuminate the retina 12. Reflected light from the retina 12 is detected by each detector 30 and an image of the retina 12 is obtained. In this arrangement the apparatus 10 illuminates the retina 12 and obtains an image of the illuminated part of the retina 12.

[0075] As illustrated in figure 1, the arrangement of the light sources 16 and the centre point 26 of the arc 18 define a plane 42. Since the collimated light 20 from each light source 16 is transmitted along this plane 42, the apparatus 10 may be considered as providing a plane of collimated light 44. Furthermore, since the collimated light 20 from each light source 16 is transmitted through the pupillary point 40 of the eye 14, the plane of collimated light 44 extends into the eye 14 and illuminates the retina 12.

[0076] The result of this is that the apparatus 10 illuminates and images a one-dimensional line 46 on the retina 12. In the embodiment illustrated in figure 1, the apparatus 10 is arranged such that the line 46 which is being illuminated is orthogonal to the optical axis 48 of the eye 14, i.e. a vertical line.

[0077] In order to facilitate two-dimensional illumination and imaging of the retina 12, the apparatus 10 is rotatable about an axis 50 which lies on the plane 42. The axis 50 may be coincident with the pupillary point 40 of the eye 14. Locating the axis 50 at the pupillary point 40 of the eye 14 avoids clipping of the plane of collimated light 44 at the iris 52 as the light enters the eye 14. This ensures the widest field of illumination of light on the retina 12. Alternatively, the axis 50 may be located around the pupillary point 40 of the eye 14.

[0078] As described above, the light sources 16 may be mounted to a frame (not shown), or the like, in the shape of the arc 18. In this arrangement, the frame is adapted to be rotatable about the axis 50.

[0079] In this arrangement the apparatus 10 may be used to illuminate and image the surface of the retina 12 by rotating the apparatus 10 about the axis 50. It is important to note that, while the apparatus 10 is being rotated about the axis 50, each light source 16 directs the collimated light 20 towards the centre point 26 of the arc 18 and into the eye 14 in the same manner as described above. As the apparatus 10 is rotated about the axis 50 a plurality of one-dimensional lines 46 are illuminated and imaged. These line images are then combined to obtain a two-dimensional image of the retina 12. Thus, the surface of the retina 12 is illuminated and imaged by the apparatus 10.

[0080] The apparatus 10 also includes one or more data processing devices (not shown) for displaying and storing the images obtained. The one or more data processing devices may include one or more computers. The data processing devices are also configured to control the operation of the light sources 16 and the detectors 30. In particular, the data processing devices may be configured to sequentially operate each light source 16. That is, each light source 16 may be operated independently and in sequence to illuminate the retina 12. However, it should be appreciated that this sequential operation of each light source 16 is optional and the operation of the light sources 16 may be modified to suit a particular operational requirement of the apparatus 10.

[0081] The one or more data processing devices may also be configured to control the rotation of the apparatus 10 about the axis 50.

[0082] The apparatus 10 may be pivotable between a first position, in which the apparatus 10 may be used to illuminate the first retina 12 of a first eye 14, and a second position, in which the apparatus 10 may be used to illuminate a the second retina (not shown) of a second eye (not shown). The apparatus 10 can therefore illuminate and image both eyes of a patient.

[0083] Figure 3 illustrates an alternative embodiment of the apparatus 10. The arrangement and operation of the apparatus 100 of figure 3 is essentially identical to the apparatus 10 of figure 1, the only difference being that the light sources 116 are located remotely from the point source 122. As illustrated in figure 3, each light source 116 includes an additional collimating lens 136a which focuses the collimated light 20 to the input of an optical fibre 154 (an example of a light transfer device). Light from each light source 116 is transferred through the optical fibres 154 to a further collimating lens 136b which provides the collimated light 120 from the point source 122. The arrangement and operation of the light sources 116 is identical to the light sources 16 described above. The apparatus 100 operates in the same manner as the apparatus 10 to illuminate and image the retina 12 of the eye 14. Locating the light sources 1 16 remotely from the arc 18 simplifies the construction of the apparatus 100, reduces the size of the apparatus 100 and allows the use of larger collimated light sources, which can be housed separately. With this arrangement it is also possible to achieve a high density of input of collimated light without the physical restriction incurred by the source(s) themselves.

[0084] The apparatus 10, 100 of embodiments of the present invention can be manufactured at a lower cost than known retinal illuminating and imaging apparatuses, such as scanning laser ophthalmoscopes (SLOs), as the apparatus 10, 100 does not require conventional laser scanning elements, such as polygon mirrors. The apparatus 10, 100 can be made more compact than known retinal imaging apparatuses, since the apparatus uses a smaller number of components than known retinal imaging apparatuses. The apparatus 10, 100 of embodiments of the present invention also includes a smaller number of optical surfaces, which increases the optical efficiency of the apparatus. The result of this is that total power at the imaging detector is higher than known methods. Also, the apparatus 10, 100 may be capable of performing "wide field" illumination and imaging or "narrow field" illumination and imaging. Therefore, the apparatus 10,100 is scalable for different markets.

[0085] Modifications and improvements may be made to the above without departing from the scope of the present invention. For example, it should be appreciated that the apparatus 10, 100 may also be used for fluorescence imaging by imaging at one wavelength and detecting at another, as is common in applications such as angiography and auotofluorescence imaging. It should therefore be appreciated that the apparatus 10, 100 may obtain an image of the retina by receiving light
reflected from the retina or fluorescent light emitted by the retina on excitation thereof. Also, the apparatus 10, 100 may use a combination of reflection and fluorescence imaging and treatment.

[0086] Furthermore, although the emitter 28 and detector 30 have been illustrated and described above as operating with a single collimating lens 36, it should be appreciated that the emitter 28 and detector 30 may have independent lenses, with a beam splitter, or the like, positioned after the lenses to combine them into a single optical path.

[0087] Also, although the plurality of light sources 16 have been illustrated and described above as being arranged on an arc 18 having a radius 24, it should be appreciated that the arc 18 does not necessarily have to be circular. The plurality of light sources 16 may be arranged in any suitable shape, so long as the collimated light from the point source 22 is directed towards a centre point of the shape, and that, in use, the centre point of this shape is coincident with the pupillary point 40 of the eye 14. For example, the arc 18 could be elliptical, or any other suitable non-circular shape.

[0088] Furthermore, although each light source 16, 116 has been illustrated and described above as comprising a single emitter 28, it should be appreciated that each light source 16, 116 may include one or more emitters of differing wavelengths.

[0089] Also, although the centre of the arc 18 has been illustrated and described above as being coincident with the pupillary point 40 of the eye 14, it should be appreciated that the centre of the arc 18 could be located generally around the pupillary point 40 of the eye 14.

[0090] Furthermore, although the apparatus 10, 100 has been illustrated and described above as comprising a single arc of light sources 16, 116, and that the apparatus 10, 100 is rotated about the axis 50 to illuminate and image the surface of the retina 12, it should be appreciated that in an alternate embodiment the apparatus 10, 100 may comprise a plurality of collimated point sources lying on a plurality of concentrically aligned arcs. In this arrangement collimated light from each point source is directed radially inwardly along the radius of each arc towards the centre point. In use, the apparatus 10, 100 is arranged such that the centre point of each arc is substantially coincident with the pupillary point of the eye, such that collimated light is transmitted from each point source on each arc through the pupillary point of the eye to illuminate the retina. The apparatus 10, 100 in this form takes the shape of a two-dimensional semi-spherical illuminating and detecting surface for directing collimated light from each point source through the centre point and to the retina, and detecting the reflected light.

[0091] Also, although the apparatus 10, 100 has been described above as for illuminating and imaging the retina 12 of the eye 14, it should be appreciated that the apparatus 10, 100 may also be used to administer treatment to the retina 12 by illuminating the retina 12 with collimated light of a suitable wavelength and/or power. Treating the retina 12 may include the following steps: (i) identifying a region of the retina for treatment, (ii) specifying the size of the treatment area through treatment planning, linked to an imaging system and (iii) guiding the treatment either through manual control or pre-specified automated control to deliver the treatment illumination to single or multiple sites via a common input path to the imaging source(s). This provides a correlation between the treatment geography and treatment planning derived from the imaging system. Treating the retina 12 may also include the optional steps of viewing an image of the retina 12 during the treatment and/or re-imaging the retina to confirm the treatment is successful.

[0092] That is, embodiments of the present invention also provide an apparatus for illuminating the retina with collimated light for use in treating the retina.

[0093] Furthermore, although in the embodiments illustrated and described above the apparatus 10, 100 includes a plurality of light sources 16, 1 16, with each light source 16, 116 providing collimated light from a point source 22, 122, it should be appreciated that the apparatus 10, 100 may only include a single light source, and that this single light source could provide collimated light to the plurality of point sources 22, 122. In this arrangement the collimated light from the single light source could be split into a number of channels which provide the collimated light to point sources.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- GB2440163A [0003]
- US5815242A [0004]

Patentkrav

1. Apparat (10) til afbildning af nethinden (12) af et øje (14) omfattende:

mindst én lyskilde (16) indrettet til at tilvejebringe kollimeret lys (20) fra hver af en flerhed af punktkilder (22) liggende i et plan (42),

hvor det kollimerede lys fra hver punktkilde er rettet radialt mod et midtpunkt (26), positionerne af punktkilderne og midterpunktet liggende i nævnte plan, for derved at tilvejebringe et plan af kollimeret lys (44); og

en flerhed af lysdetektorer (30) indrettet til at detektere lys fra punktkilderne (22), som er blevet reflekteret fra nethinden (12),

hvor apparatet (10) er indrettet således at nævnte midtpunkt (26) kan anbringes i alt væsentligt sammenfaldende med pupilpunktet (40) af øjet (14) således at planet af kollimeret lys (44) sendes fra punktkilderne (22) igennem pupilpunktet (40) af øjet for at belyse en endimensionel linje (46) på nethinden (12) og reflekteres tilbage til lysdetektorerne (22) for at producere et billede af den endimensionelle linje (46) på nethinden (12), og

hvor apparatet (10) er konfigureret til automatisk rotation omkring en akse (50), der i alt væsentligt ligger på nævnte plan (42) og passerer igennem nævnte midtpunkt (26), for således at belyse og afbilde en flerhed af endimensionelle linjer (46) på nethinden (12), idet apparatet roteres omkring aksen (50) og for således at kombinere de afbildede endimensionelle linjer for at opnå et todimensionelt billede af nethinden (12).

2. Apparat ifølge krav 1, hvor apparatet (10) omfatter en flerhed af lyskilder (16), hvor hver lyskilde er indrettet til at tilvejebringe det kollimerede lys (20) fra en respektiv en af nævnte punktkilder (22).

3. Apparat (10) ifølge krav 1 eller krav 2, hvor flerheden af punktkilder (22) ligger på en bue (18), og hvor radius af buen er mellem 3 mm og 500 mm.

4. Apparat (10) ifølge krav 2 eller krav 3, hvor hver lyskilde (16) inkluderer en eller flere lyskilder af forskellige bølgelængder.

5. Apparat (10) ifølge et hvilket som helst af kravene 2 til 4, hvor hver lyskilde (16) er konfigureret således at bølgelængden af tilvejebragt lys er variabel.

6. Apparat (10) ifølge et hvilket som helst af kravene 2 til 5, hvor hver lyskilde (16) er konfigureret således at effekten af tilvejebragt lys er variabel.

7. Apparat (10) ifølge krav 2, hvor hver af flerheden af lyskilder (16) er positioneret tilstødende den respektive ene af nævnte punktkilder (22).

8. Apparat (10) ifølge krav 2 eller krav 7, hvor hver lyskilde (16) inkluderer en kollimeringslinse (36) til at tilvejebringe det kollimerede lys (20) fra den respektive punktkilde (22).

9. Apparat (10) ifølge krav 2, hvor hver lyskilde (16) er positioneret fjernt fra den respektive punktkilde (22) og lys overføres fra hver lyskilde til den respektive punktkilde via en lysoverføringsindretning (154).

10. Apparat (10) ifølge et hvilket som helst af kravene 2 til 9, hvor hver lyskilde (16) er uafhængigt funktionel.

11. Apparat (10) ifølge krav 2 eller krav 7, hvor hver lyskilde (16) er forsynet med en af nævnte lysdetektorer (30) til at detektere lys reflekteret fra nethinden (12) for at producere billedet af den endimensionelle linje (46) på nethinden (12).

DRAWINGS

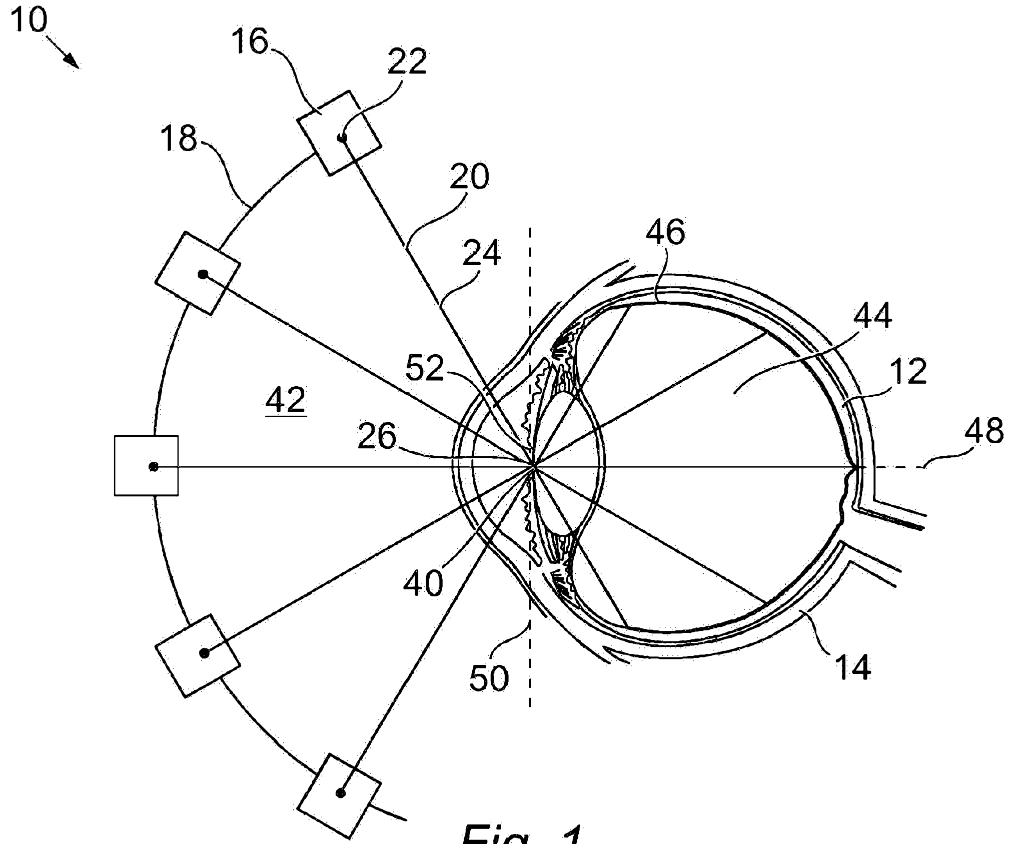

Fig. 1

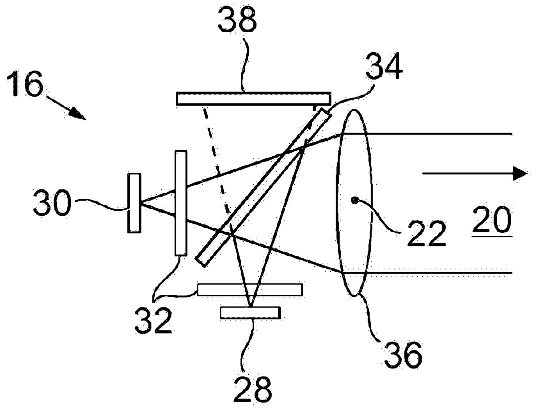

Fig. 2

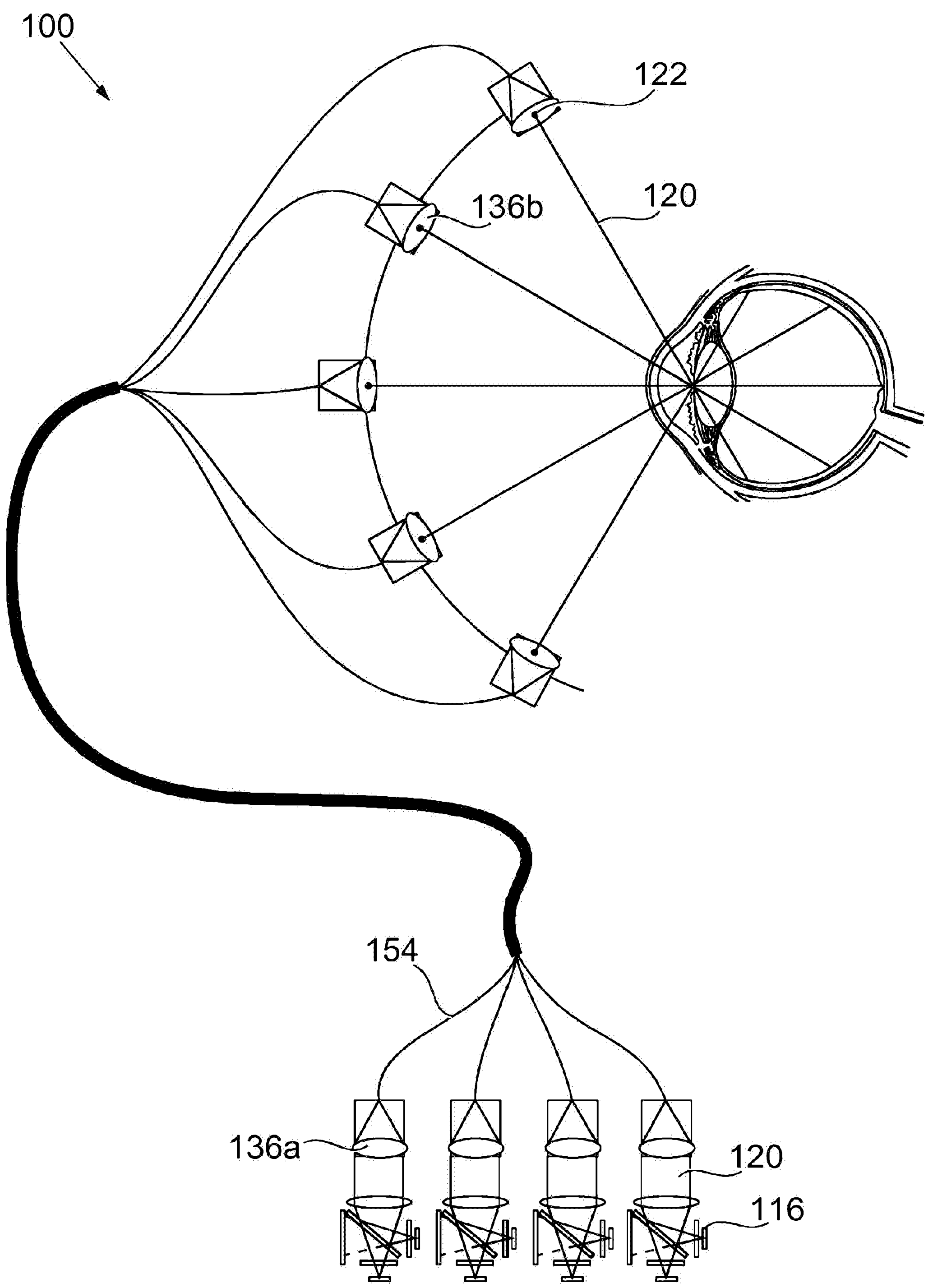

Fig. 3