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(54) Title: MYOPIA SCAN MODULE FOR OPTICAL COHERENCE TOMOGRAPHY SYSTEM

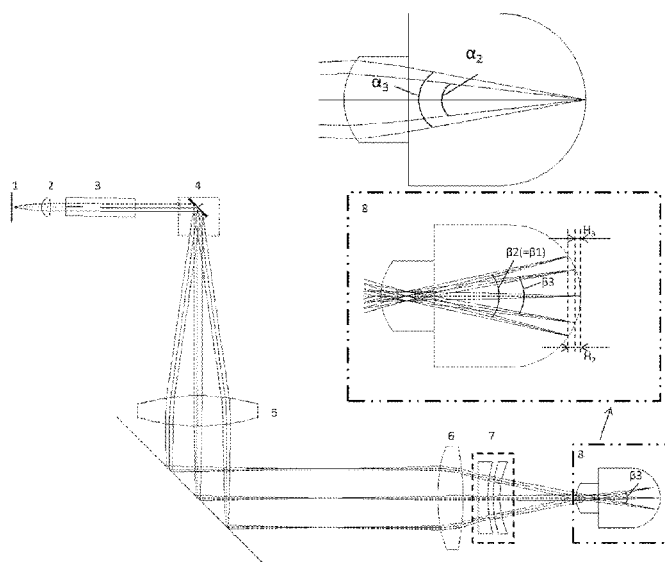


Fig. 7

(57) Abstract: The present invention relates to an OCT system, comprising an OCT scan module for retinal scan; the OCT system further comprises a myopia scan module which can be added to the OCT scan module so as to switch the OCT system from a function of scanning an emmetropic eye to a function of scanning a myopic eye with longer axis length; the myopia scan module has negative power such that a scan beam from the OCT system before entry into a myopic eye with elongated axis length is divergent to increase a focusing angle of the scan beam focused on the retina of the myopic eye with longer axis length and to decrease a maximum OPD spanned by the imaged retina area, thereby obtaining a stronger scan signal and greater signal-to-noise ratio and avoiding false "mirror images".



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MYOPIA SCAN MODULE FOR OPTICAL COHERENCE TOMOGRAPHY SYSTEM

TECHNICAL FIELD

The present invention relates to optical medical field, and more particular to an optical coherence tomography (OCT) system with a myopia scan module.

BACKGROUND OF THE INVENTION

OCT is a method of interferometry that acquires the scattering characteristic of a scanned sample. OCT systems can be categorized into time domain OCT (TD-OCT) systems or frequency domain OCT (FD-OCT) systems. FD-OCT techniques have significant advantages in speed and signal-to-noise ratio in comparison to TD-OCT techniques. The spectral information discrimination in FD-OCT is typically accomplished by using a spectrometer in a detection arm in the case of spectral-domain OCT (SD-OCT) or rapidly changing the frequency of a laser source in the case of swept-source OCT (SS-OCT).

A generalized FD-OCT system used to collect 3-D image data suitable for use with the present invention is illustrated in FIG. 1. A FD-OCT system includes a light source 101, typical sources including, but not limited to, broadband light sources with short temporal coherence lengths or swept laser sources. Light from source 101 is routed, typically by optical fiber 105, to illuminate the sample 110, a typical sample being tissues at the back of the human eye. The light is scanned, typically with a scanner 107 between the output of the fiber and the sample, so that the beam of light (dashed line 108) is scanned over the area or volume to be imaged. Light scattered from the sample is collected, typically into the same fiber 105 used to route the light for illumination. Reference light derived from the same source 101 travels a separate path, in this case involving fiber 103 and retro-reflector 104. Those skilled in the art recognize that a transmissive reference path can also be used. Collected sample light is combined with reference light, typically in a fiber coupler 102, to form light interference in a detector 120. The output from the detector is supplied to a processor

130. The results can be stored in the processor or displayed on display 140. The processing and storing functions may be localized within the OCT instrument or functions may be performed on an external processing unit to which the collected data is transferred. This unit could be dedicated to data processing or perform other tasks which are quite general and not dedicated to the OCT device.

The sample and reference arms in the interferometer could consist of bulk-optics, fiber-optics or hybrid bulk-optic systems and could have different architectures such as Michelson, Mach-Zehnder or common-path based designs as would be known by those skilled in the art. Light beam as used herein should be interpreted as any carefully directed light path. In time-domain systems, the reference arm needs to have a tunable optical delay to generate interference. Balanced detection systems are typically used in TD-OCT and SS-OCT systems, while spectrometers are typically used at the detection port for SD-OCT systems. The invention described herein could be applied to any type of OCT system. The system is typically enclosed in a housing with various patient positioning components including chinrest and headrest.

OCT systems have been used in the prior art to scan the retina of a patient so as to perform medical diagnosis. FIG. 2 shows an embodiment of an OCT scan module of an OCT system for retinal scan in the prior art, the OCT scan module illustrated by FIG. 2 comprising a fiber 1 for providing light from the source, a collimator lens 2, a dispersion compensation rod 3, an X/Y scan-unit 4, a retina scan lens 5, an ocular lens 6, and an optical mirror for optical path folding located between the retina scan lens 5 and the ocular lens 6, to provide collimated incident beam bundles to an eye, here for simplicity shown as a nominal eye 8.

The light source of the OCT system may be a broadband light source with short coherence length or a swept laser source. The light emitted from these light sources is introduced by the fiber 1 into the OCT scan module. The light reflected or scattered from the sample is collected into the same fiber 1. The collected sample light from the OCT scan module is combined in the OCT system with a reference light (not shown) to form light interference in an interference module (not shown), and a light interference signal is received by a detector (not shown). The data output from the

detector is supplied to a processor (not shown). The results can be stored in the processor or displayed on a display. The processing and storing functions may be localized within the OCT system or may be performed on an external processing unit to which the collected data is transferred. This external processing unit could be dedicated to data processing or perform other tasks which are quite general and not dedicated to the OCT device.

The OCT system can be placed in front of the eye 8 at a distance for which an exit pupil of the OCT system (i.e. a pivot point of a single scan beam from the OCT system) lies in the pupil of the patient. The single scan beam from the OCT system, as shown in FIG. 2, is focused on the retina of the eye 8 with a single scan beam focusing angle α_1 , and a corresponding numerical aperture of $N.A. = n_{\text{eyeball}} \cdot \sin(\alpha_1)$ (n_{eyeball} is the refractive index of eyeball) that determines the strength of an acquired scan signal (signal-to-noise ratio). For an emmetropic eye, many single scan beams from different incident angles are focused on different positions of the retina of the eye 8 as the beam is scanned (the term “scan beam(s)” in the present patent refers to a single scan beam or a collection of a plurality of such single scan beams), so that the chief rays of these single scan beams form a field of view β (FOV, i.e. scan angle β) on the retina to cover a certain area of retina in the lateral direction, thereby forming a maximum optical path difference (OPD) $H1$ spanned by the imaged area of retina in depth.

Myopia is a typical refractive error, and patients with myopia are frequently seen in OCT system clinical diagnosis. Furthermore, current researches show that pathological myopia may cause some fundus diseases which may be diagnosed by the OCT system. This increases utilization of the OCT system during clinical diagnosis of patients with myopia.

FIGS. 3(a) and 3(b) show 1st order layouts in which an existing OCT system is used to scan an emmetropic eye and a myopic eye respectively. Compared with the emmetropic eye case, when a myopic eye is scanned in prior arts, the compensation principle is that the scan beam emitted from the OCT system is changed into a corresponding divergent beam according to refractive error of the eye under

investigation, such that the scan beam is re-focused on the myopic retina. The refractive deviation of the eye under investigation can be compensated by, for example, changing the distance between the retinal scan lens 5 and the ocular lens 6 or the distance between the light source and the collimator lens, e.g. ZEISS Cirrus OCT released in 2007. As shown in FIG. 3(b), for instance, the distance between the retinal scan lens (5, f_1) and the ocular lens (6, f_2) may be shortened to change the emitted scan beam into a divergent beam, and locating the pupil of the eye under investigation at the exit pupil of the system to make the pupil of the eye located at the pivot point of a plurality of scan beams of the OCT system. With this adjustment mechanism, it is possible to prove according to principles of Gaussian optics that a cross section diameter, H_{eye} , of the incident single scan beam of the emmetropic eye, is equal to a cross section diameter, H'_{eye} , of incident single scan beam of the myopic eye after adjusting the distance between the retinal scan lens and the ocular lens, i.e. $\frac{H'_{eye}}{H_{eye}} = \frac{f_2^2 + \Delta \cdot (d - f_2)}{f_2^2} = 1 \rightarrow H'_{eye} = H_{eye}$, in which Δ is the adjusted distance between the retinal scan lens and the ocular lens, f_2 is the focal length of the ocular lens and d is the distance between the ocular lens and the pupil and equals to f_2 . Also, as shown in FIG. 3, the spaces between the retinal scan lens and the ocular lens are parallel spaces of the chief rays of the scan beams, and the distance change between the retinal scan lens and the ocular lens will not affect the field of view β of the chief rays of the scan beams behind the ocular lens.

There are two types of myopic eyes, one type is an eye with axial myopia, it is attributed to an increase in the eye's axial length. The eye with axial myopia results in an increase in curvature of the retina. The other type is eye with refractive myopia, it is attributed to the condition of the refractive elements of the eye.

FIGS. 4(a) and 4(b) show an eye with refractive myopia with normal eye axis length and an eye with axial myopia with longer axis length respectively. For an eye with refractive myopia and normal eye axis, the distance L'_{eye} between the retina and the pupil is substantially equal to the distance L_{eye} between the retina of an emmetropic eye and the pupil, which distance is about 20mm. With current

adjustment mechanism, the OCT has a numerical aperture of N.A. in the emmetropic eye case equal to the numerical aperture of N.A' in the case for eye with refractive myopia, i.e.

$N.A.' = n_{\text{eyeball}} \sin(\alpha_1) \approx n_{\text{eyeball}} \tan(\alpha_1) = n_{\text{eyeball}} (H'_{\text{eye}}/L'_{\text{eye}}) = n_{\text{eyeball}} (H_{\text{eye}}/L_{\text{eye}}) = N.A.$ (it has been proved that H'_{eye} and H_{eye} are the same and refer to the beam cross section diameter of an emmetropic eye and the beam cross section diameter of a myopic eye after compensation and adjustment respectively). Furthermore, the maximum OPD spanned by the retina of a myopic eye with normal axis length is the same as for a normal eye because the field of view of the chief rays of the scan beams and the eye axis length do not change.

However, according to medical research, most of high myopic eyes are caused by elongated axial length of the eye axis, i.e. eye with axial myopia. For eyes with axial myopia, the current refractive compensation mechanism is not ideal.

In view of the same principle as FIG. 3, FIG. 5 illustrates use of a currently available OCT system to scan an emmetropic eye and a myopic eye with longer axis length. For the myopic eye with longer axis length, as shown in FIG. 5, the distance between the retinal scan lens 5 and the ocular lens 6 is shortened to refocus the scan beam bundles on the retina to compensate refractive error of the scanned myopic eye. The single scan beam focusing angle α_2 after compensation is smaller than the scan beam focusing angle α_1 for an emmetropic eye case. Consequently, although the beam cross section diameter H_{eye} is unchanged as analyzed above, compared with an emmetropic eye case, because the eye axis is elongated by a factor $(L_{\text{eye}} + \delta L)/L_{\text{eye}}$, in which L_{eye} refers to a standard normal axis length, $\sin(\alpha_2)$ and $\tan(\alpha_2)$ will become smaller than $\sin(\alpha_1)$ and $\tan(\alpha_1)$. Accordingly the numerical aperture $N.A. = n_{\text{eyeball}} \sin(\alpha_2) \approx n_{\text{eyeball}} \tan(\alpha_2)$ of the OCT will be smaller in the case of a myopic eye with longer axis length. Since the OCT system is also collecting the signal from the retina with this reduced numerical aperture, the obtained scan signal strength is reduced compared to the case with no elongated eye axis. This leads to a reduced signal-to-noise ratio of the scan signal compared to the case with no elongated eye axis.

In addition, because during the compensation process, the field of view β_1 of the chief rays of the scan beams does not change, so the maximum OPD H_2 formed by chief rays of the scan beams on the retina of a myopic eye with longer axis length is greater than the maximum OPD H_1 formed by the retina of an emmetropic eye. Since current FD-OCT systems support only limited scan depth ranges, increased maximum OPD spanned by the imaged area of retina in depth which exceeds the maximum scan depth of OCT system would result in false “mirror images” in the OCT system, such as those shown in FIG. 6. In FD-OCT, an energy spectrum density signal obtained by a spectrometer is subject to Fourier transform to obtain a sample depth signal. For any real number signal $a(v)$,

$$a(v) = \frac{1}{2} \{ [a(v) + jb(v)] + [a(v) - jb(v)] \} = \frac{c(v)}{2} (e^{i\omega v} + e^{-i\omega v})$$

If $FT[c(v)] = C(t)$, $FT[a(v)] = \frac{1}{2}C(t - \omega) + \frac{1}{2}C(t + \omega)$. This signal is distributed symmetrical about zero. Because the energy spectrum density is a real number signal, it is known from Fourier transformations that two depth signals symmetrical about zero depth position can be obtained thus when the object being measured crosses over the zero depth position, due to a depth difference larger than scan depth of OCT system, the mirror image of the part of object located beyond (above) the zero depth position is created and folded into the OCT B-scan image as shown in FIG. 6.

In view of the above, the prior art OCT systems for scanning myopic eyes suffer from certain drawbacks. Refractive error correction can be done by adjusting the distance between retinal scan lens and ocular lens, but for myopic eyes with longer axis lengths, the focusing angle of a single scan beam is smaller than that of a scan beam of an emmetropic eye, such that the numerical aperture of the whole system is decreased, which consequently leads to a reduced scan signal strength as well as a decreased signal-to-noise ratio in comparison to the emmetropic eye case. Moreover, due to elongation of the eye axis and increase of retina curvature, the maximum OPD spanned by the imaged retina area in depth will be increased. Since FD-OCT systems support only limited scan depth ranges at present, increased maximum OPD of the imaged retina area result in false “mirror images” in the OCT system.

SUMMARY OF THE INVENTION

In order to solve the above problems, the present invention provides an OCT system comprising: an OCT scan module for retinal scan of an emmetropic eye which includes a myopia scan module that may be added to the OCT scan module so as to switch the OCT system from a function of scanning the emmetropic eye to a function of scanning the myopic eye with longer axis length; the myopia scan module having negative power.

In a preferred embodiment, the myopia scan module diverges a scan beam from the OCT system before entry into a myopic eye with elongated axis length to increase a focusing angle of the scan beam focused on the retina of the myopic eye. Meanwhile, this externally attached myopia scan module with negative power reduces a field of view of the chief rays of the scan beams from the OCT system to decrease a maximum OPD spanned by the imaged retina area.

In a preferred embodiment, the myopia scan module is an independent separable module that can be attached to the exterior of the OCT scan module.

In a preferred embodiment, the myopia scan module includes one or more optical elements (singlet or doublet or multiplets or mirrors or singlets) of fixed or variable focal length.

In a preferred embodiment, the myopia scan module is comprised of a series including a plurality of modules with different fixed focal lengths. Preferably, the module with larger negative power can be used for a myopic eye with longer axis length, and the module with weaker negative power is used for a myopic eye with shorter axis length.

In a preferred embodiment, the myopia scan module includes a zoom lens group having a plurality of lenses such as singlets or doublets or multiplet or mirrors or singlets of variable focal length, wherein the focal length of the zoom lens group is adjustable. Preferably, the focal length of the zoom lens group is adjusted by adjusting the distance between the plurality of lenses thereof or by adjusting the focal length for singlets of variable focal length. Preferably, the distance between the plurality of

lenses of the zoom lens group can be adjusted electrically or manually.

In a preferred embodiment, the distance between the retinal scan lens and the ocular lens of the OCT scan module is adjustable.

In a preferred embodiment, the distance between the light source and the collimator lens of the OCT scan module is adjustable.

The present invention also provides a myopia scan module for OCT system, the OCT system comprising an OCT scan module for retinal scan, wherein the myopia scan module can be attached externally to the OCT scan module so as to switch the OCT system from a function of scanning an emmetropic eye to a function of scanning a myopic eye with longer axis length; the myopia scan module having negative power.

In a preferred embodiment, the myopia scan module diverges a scan beam from the OCT system before entry into the myopic eye with elongated axis length to increase the focusing angle of the scan beam focused on the retina of the myopic eye and to reduce a field of view of the chief rays of the scan beams from the OCT system.

In a preferred embodiment, the myopia scan module is an independent separable module that can be attached to the exterior of the OCT scan module.

In a preferred embodiment, the myopia scan module includes one or more singlets or doublets or multiplet or mirrors or singlets of variable focal length.

In a preferred embodiment, the myopia scan module is comprised of a series of modules, each module having a distinct focal length.

In a preferred embodiment, the myopia scan module with larger negative power is used for a myopic eye with longer axis length, and the myopia scan module with weaker negative power is used for a myopic eye with shorter axis length.

In a preferred embodiment, the myopia scan module includes a zoom lens group having a plurality of lenses such as singlets or doublets or multiplet or mirrors or singlets of variable focal length, wherein the focal length of the zoom lens group is adjustable. Preferably, the focal length of the zoom lens group is adjusted by adjusting the distances between the plurality of lenses thereof or by adjusting the focal length for singlets of variable focal length. Preferably, the distance between the plurality of

lenses of the zoom lens group is adjusted electrically or manually.

Compared with prior arts, the OCT system of the present invention at least has the following advantages: because of the negative power of the myopia scan module in the OCT system, the scan beam(s) from the OCT system are divergent before entry into the myopic eye with longer axis length, and the field of view of the chief rays of scan beams is decreased, so as to increase the focusing angle of the scan beam focused on the retina of the myopic eye with longer axis length and decrease the maximum OPD spanned by the imaged retina area, thereby obtaining stronger scan signals (greater signal-to-noise ratio) and avoiding false “mirror images”.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a prior art OCT system;

FIG. 2 shows a prior art OCT scan module of an OCT system;

FIG. 3(a) shows a view of scanning an emmetropic eye using a prior art OCT system. FIG. 3(b) shows a view of scanning a myopic eye using a prior art OCT system;

FIG. 4(a) shows a myopic eye with normal axis length and FIG. 4(b) shows a myopic eye with longer axis length;

FIG. 5 show another view of scanning an emmetropic eye and a myopic eye with longer axis length by the prior art OCT scan module;

FIG. 6 shows the “mirror image” obtained by scanning a myopic eye with longer axis length by the prior art OCT system;

FIG. 7 shows an OCT system of the present invention having an add-on myopia scan module;

FIG. 8 shows two embodiments of the OCT scan module of the present invention having an add-on myopia scan module. FIG. 8(a) shows a case where the myopia scan module is a doublet module of relatively strong negative power for imaging eyes with longer axis lengths. FIG. 8(b) shows a case where the myopia scan module is a doublet module of relatively weak negative power for imaging eyes with less axial elongation

FIG. 9 shows another embodiment of the OCT system of the present invention having an add-on myopia scan module where the myopia scan module is a zoom system comprising two lenses. FIG. 9(a) shows a first separation between the two lenses. FIG. 9(b) shows a second separation between the two lenses, and FIG. 9(c) shows a third separation between the two lenses.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The following is a description of the OCT system of the present invention with reference to the drawings, especially FIG. 7 - 9. Detailed description is provided below to fully understand the present invention. Nevertheless, it is obvious to those skilled in the art that the present invention can be achieved without some of the details. In addition, it shall be understood that the present invention is not limited to the depicted special embodiments. On the contrary, the following features and elements may be combined to carry out this invention, despite whether they relate to different embodiments. Therefore, the following aspects, features, embodiments and advantages shall only be construed as description but shall not be considered as elements or limitations of the claims unless otherwise provided in the claims. The figures 7 – 9 are focused on the sample arm or OCT scan module of the OCT system. The OCT system of the present invention would also contain the generalized system elements described in reference to FIG. 1 and 2 above. While the embodiments are largely focused on a myopia scan module that is attached to the outside of the OCT system, it is also possible for the myopia scan module to be integrated within the system, e.g. a flip in lens module.

FIG. 7 shows an OCT scan module of the present invention having an add-on myopia scan module. Besides conventional optical elements of an OCT system for retinal scan of an emmetropic eye as described above, the OCT scan module illustrated in FIG. 7 further includes an add-on myopia scan module 7 with negative power, which can be attached to the exterior of a mechanical interface of the prior art OCT system to switch the latter from a function of scanning the emmetropic eye to a function of scanning the myopic eye with longer axis length. The add-on myopia scan

module 7 is positioned on the outside (closer to the patient) of the ocular lens 6 and has negative power, such that each scan beam exiting the ocular lens 6 of the OCT system becomes more divergent after passing through the add-on myopia scan module 7 and such that a beam cross section diameter of the scan beam is increased at the pupil position. Because of the increased beam cross section diameter at the pupil position, a focusing angle of the scan beam focused on the retina of the myopic eye with longer axis length is increased. Meanwhile, the field of view of the chief rays of the scan beams through the add-on myopia scan module 7 with negative power is decreased so that the maximum OPD spanned by the imaged retina area is decreased accordingly. As shown in FIG. 7, since the scan beam focusing angle is increased and the maximum OPD spanned by the imaged retina area is decreased by the attached add-on myopia scan module 7 with negative power, i.e. because of the divergent scan beam, the scan beam focusing angle α_3 with the add-on myopia scan module is larger than the scan beam focusing angle α_2 without the add-on myopia scan module. According to the numerical aperture formula $N.A. = n_{\text{eyeball}} \cdot \sin(\alpha_3)$, the numerical aperture N.A. of the OCT system having the myopia scan module 7 with negative power is increased accordingly, it could be even larger than the numerical aperture N.A. of the OCT system without the add-on myopia scan module for scanning emmetropic eye. Also, with the function of the myopia scan module 7 with negative power, the field of view of the chief rays of the scan beams is decreased, i.e. the field of view β_3 of the chief rays of scan beams with the add-on myopia scan module is smaller than the field of view β_2 of the chief rays of the scan beams without the add-on myopia scan module, such that the maximum OPD H_3 with the add-on myopia scan module is smaller than the maximum OPD H_2 without the add-on myopia scan module. Therefore, because of the add-on myopia scan module with negative power, the focusing angle of the scan beams focused on the retina of the myopic eye with longer axis length returns and is kept approximately equal to those for emmetropic eye scan, such that a stronger scan signal (signal-to-noise ratio) is obtained in comparison to the case where the myopic eye with elongated eye axis is scanned by prior art refractive error compensation methods without using the add-on myopia scan

module and meanwhile since the FOV of the scan beams is reduced by using the add-on myopia scan module, the maximum OPD spanned by the imaged retina area is reduced accordingly, thus the false “mirror images” can be avoided in most cases.

In the present invention, a high myopic eye with longer axis length is scanned to obtain stronger scan signal (signal-to-noise ratio) and to avoid false “mirror images” by the add-on myopia scan module with negative power, without any existing refractive error correction mechanism of an OCT system, i.e. it is not necessary to adjust the distance between the retinal scan lens and the ocular lens of the OCT system. If the technical solution of the present invention is combined with the existing refractive error correction mechanisms of an OCT system, the refractive error correction range can be extended.

In the present invention, the number, type and focal length of the optical elements in the add-on myopia scan module may be variable. For instance, the add-on myopia scan module may include one or more singlets, doublets, multiplets or a lens group composed of several lenses, as long as the equivalent negative power of the add-on myopia scan module composed by the singlet, doublet, multiplet or the lens group can meet scanning requirement of a myopic eye with certain refractive error (diopter) range. Preferably, the myopia scan module can cover a greater range of myopia diopters by using a plurality of fixed focal length lenses or a zoom lens system, wherein the focal length of the zoom lens system is adjustable. The zoom lens system may include singlets, doublets, multiplets, mirrors, singlets of variable focal length (i.e. liquid lense). The myopia scan module for a real product may be a module series in which each module has a distinct negative power.

FIG. 8 shows embodiments of the OCT scan module of the present invention having an add-on myopia scan module 7 having two fixed focal length doublets. FIG. 8(a) illustrates a myopia scan module with a doublet module of stronger negative power which can be used for a myopic eye with longer axis length. In FIG. 8(b) a doublet module of weaker negative power can be used for small axis elongation myopic eye.

FIG. 9 shows another embodiment of the OCT system of the present invention

having an add-on myopia scan module, in which the myopia scan module 7 is a zoom system having two lenses 7-1, 7-2, wherein the lens 7-1 has negative power while the lens 7-2 has positive power, and the zoom system formed thereby has negative power. FIGS. 9(a)-9(c) show different states in which the distance between the two lenses 7-1 and 7-2 varies. The myopia scan module 7 may cover a certain range of myopia refractive errors or diopter values (myopic eye with different axis elongation). Specifically, the two lenses 7-1, 7-2 of the zoom system are adjusted to have a smaller distance in the case of a myopic eye with longer axis length as illustrated in FIG. 9(c), and are adjusted to have a larger distance in the case of a myopic eye with shorter axis length as illustrated in FIG. 9(a). FIG. 9(b) shows an intermediate axis length. Specifically, the movement of the lenses of the zoom system can be adjusted electrically or manually, and the zoom system may include more than two lenses or lens groups.

The OCT system of the invention having the myopic scan module can successfully overcome defects in the prior art without changing the internal structure of any existing OCT system and without increasing cost of the OCT system. Because of the negative power of the myopia scan module, the scan beam from the OCT system is divergent before entering into the pupil of the myopic eye with longer axis length to increase the focusing angle of the scan beam focused on the retina of the myopic eye with longer axis length, and the field of view of the chief rays of the scan beams from the OCT system is decreased to reduce the maximum OPD spanned by the imaged retina area, thereby obtaining stronger scan signal (signal-to-noise ratio) and avoiding false “mirror images”.

In addition, when the myopia scan module of the present invention is used for scanning a normal eye, since the field of view is decreased, the scan range on a normal retina is decreased accordingly. The small scan range of the OCT system is still displayed in the same display area, which functions in magnifying the scan of a normal eye.

The present invention is disclosed with above preferred embodiments but is not limited to these embodiments. Any variation and modifications made by any skilled

person without departing from the spirit and principle of this invention are encompassed within the protection scope of the present invention. Therefore, the protection scope of the invention shall be defined by the annexed claims.

Claims

1. An OCT system with an OCT scan module for retinal scan, characterized in that the OCT system further comprises a myopia scan module which can be attached externally to the OCT scan module so as to switch the OCT system from a function of scanning an emmetropic eye to a function of scanning a myopic eye with longer axis length;

whereby the myopia scan module has a negative optical power.

2. The OCT system with the myopia scan module according to claim 1, characterized in that the myopia scan module diverges a scan beam from the OCT system before entry into the myopic eye with elongated axis length to increase the focusing angle of the scan beam focused on the retina of the myopic eye and to reduce a field of view of the chief rays of the scan beams from the OCT system.

3. The OCT system with the myopia scan module according to claim 1, characterized in that the myopia scan module is an independent separable module that can be attached to the exterior of the OCT scan module.

4. The OCT system with the myopia scan module according to claim 1, characterized in that the myopia scan module includes one or more optical elements.

5. The OCT system with the myopia scan module according to claim 1, characterized in that the myopia scan module is comprised of a series of modules, each module having a distinct focal length.

6. The OCT system with the myopia scan module according to claim 5, characterized in that the myopia scan module with larger negative power is used for a myopic eye with longer axis length, and the myopia scan module with weaker negative power is used for a myopic eye with shorter axis length.

7. The OCT system with the myopia scan module according to claim 1, characterized in that the myopia scan module includes a zoom lens group having a plurality of optical elements, wherein the focal length of the zoom lens group is adjustable.

8. The OCT system with the myopia scan module according to claim 7, characterized in that the focal length of the zoom lens group is adjusted by adjusting the distances between the plurality of optical elements or by adjusting the focal length for singlets of variable focal length.

9. The OCT system with the myopia scan module according to claim 8, characterized in that the distance between the plurality of lenses of the zoom lens group is adjusted electrically or manually.

10. The OCT system with the myopia scan module according to claim 1, characterized in that the distance between the retinal scan lens and the ocular lens of the OCT scan module is adjustable.

11. The OCT system with the myopia scan module according to claim 1, characterized in that the distance between the light source and the collimator lens of the OCT scan module is adjustable.

12. A myopia scan module for an OCT system, the OCT system comprising an OCT scan module for retinal scan, characterized in that the myopia scan module can be attached externally to the OCT scan module so as to switch the OCT system from a function of scanning an emmetropic eye to a function of scanning a myopic eye with longer axis length;

whereby the myopia scan module has negative power.

13. The myopia scan module for an OCT system according to claim 12,

characterized in that the myopia scan module diverges a scan beam from the OCT system before entry into the myopic eye with elongated axis length to increase the focusing angle of the scan beam focused on the retina of the myopic eye and to reduce a field of view of the chief rays of the scan beams from the OCT system.

14. The myopia scan module for an OCT system according to claim 12, characterized in that the myopia scan module is an independent separable module that can be attached to the exterior of the OCT scan module.

15. The myopia scan module for an OCT system according to claim 12, characterized in that the myopia scan module includes one or more optical elements.

16. The myopia scan module for an OCT system according to claim 12, characterized in that the myopia scan module is comprised of a series of modules, each module having a distinct focal length.

17. The myopia scan module for an OCT system according to claim 16, characterized in that the myopia scan module with larger negative power is used for a myopic eye with longer axis length, and the myopia scan module with weaker negative power is used for a myopic eye with shorter axis length.

18. The myopia scan module for an OCT system according to claim 12, characterized in that the myopia scan module includes a zoom lens group having a plurality of optical elements, wherein the focal length of the zoom lens group is adjustable.

19. The myopia scan module for an OCT system according to claim 18, characterized in that the focal length of the zoom lens group is adjusted by adjusting the distances between the plurality of lenses thereof or by adjusting the focal length for singlets of variable focal length.

20. The myopia scan module for an OCT system according to claim 19, characterized in that the distance between the plurality of lenses of the zoom lens group is adjusted electrically or manually.

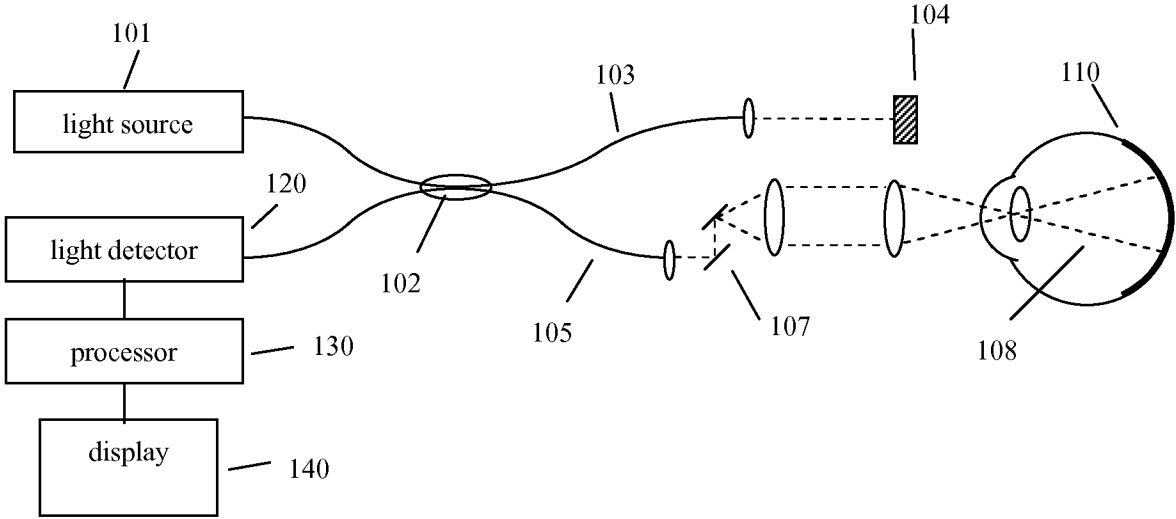
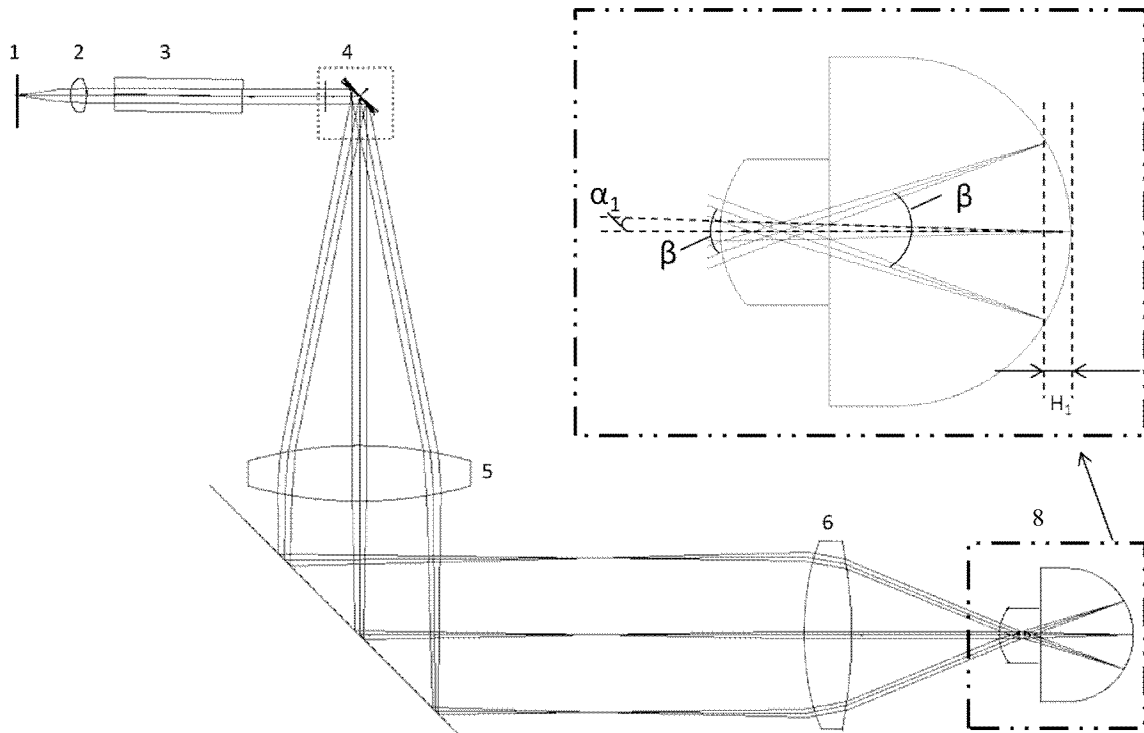


Fig. 1

**Fig. 2**

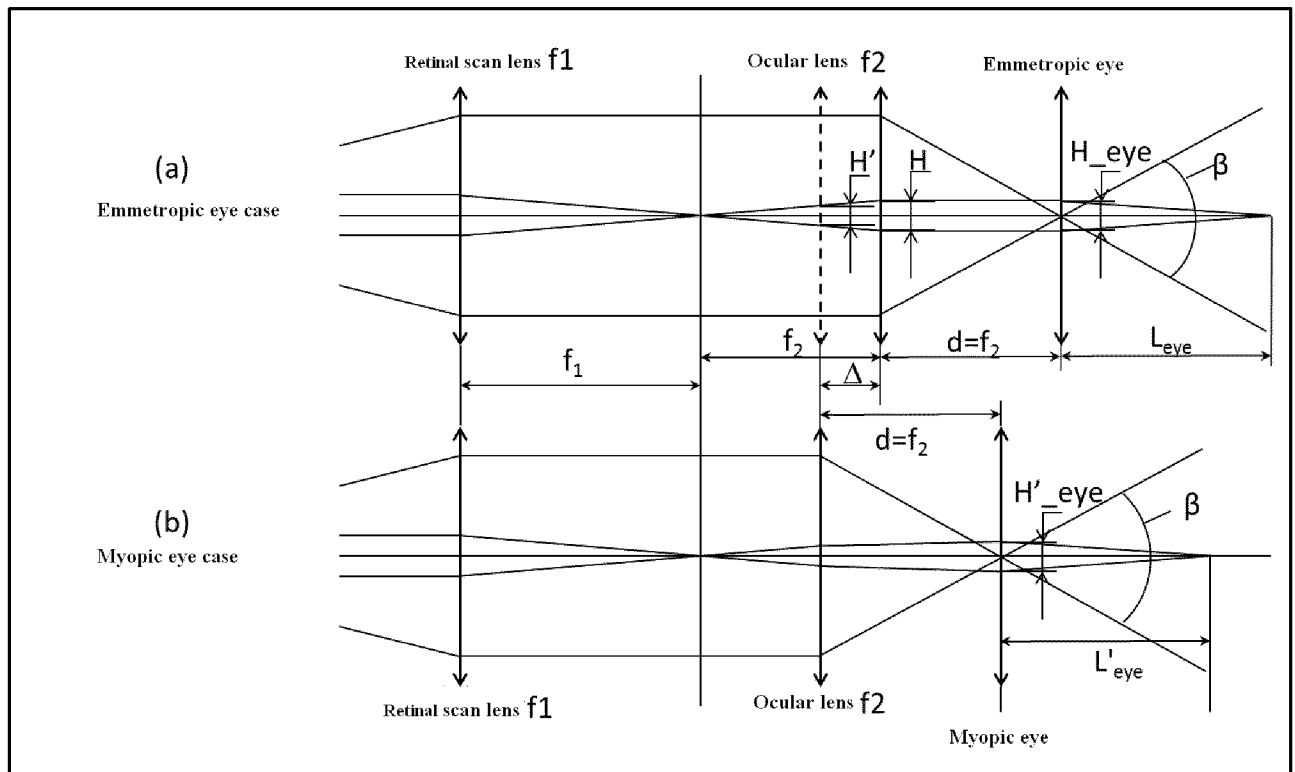


Fig. 3

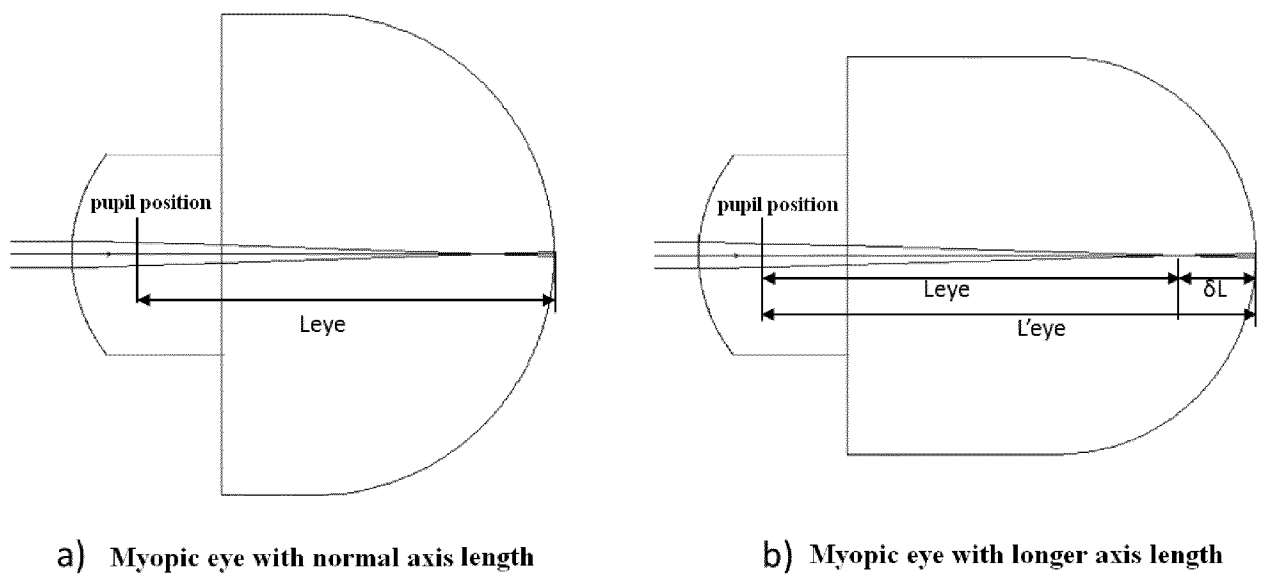


Fig. 4

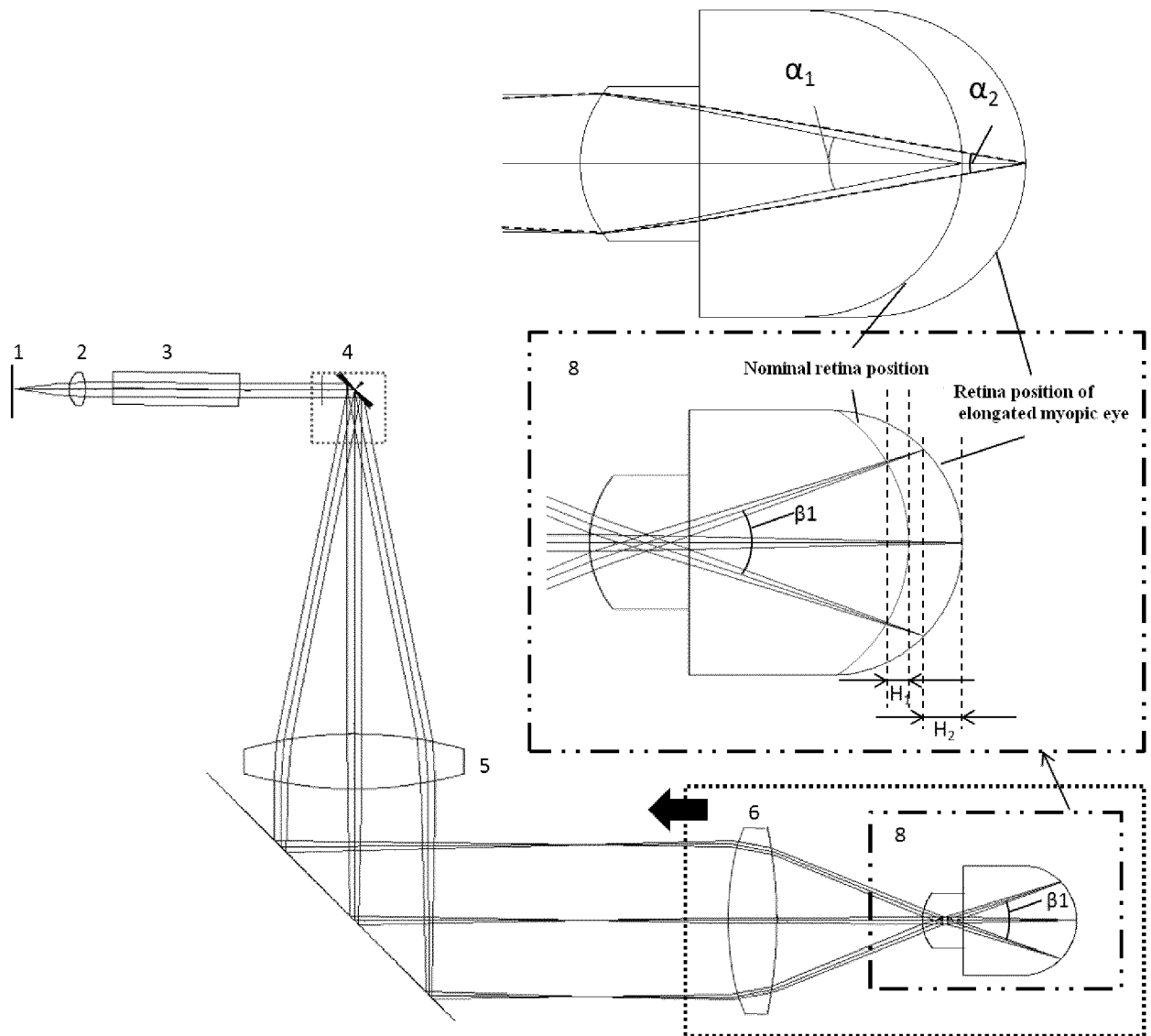


Fig. 5

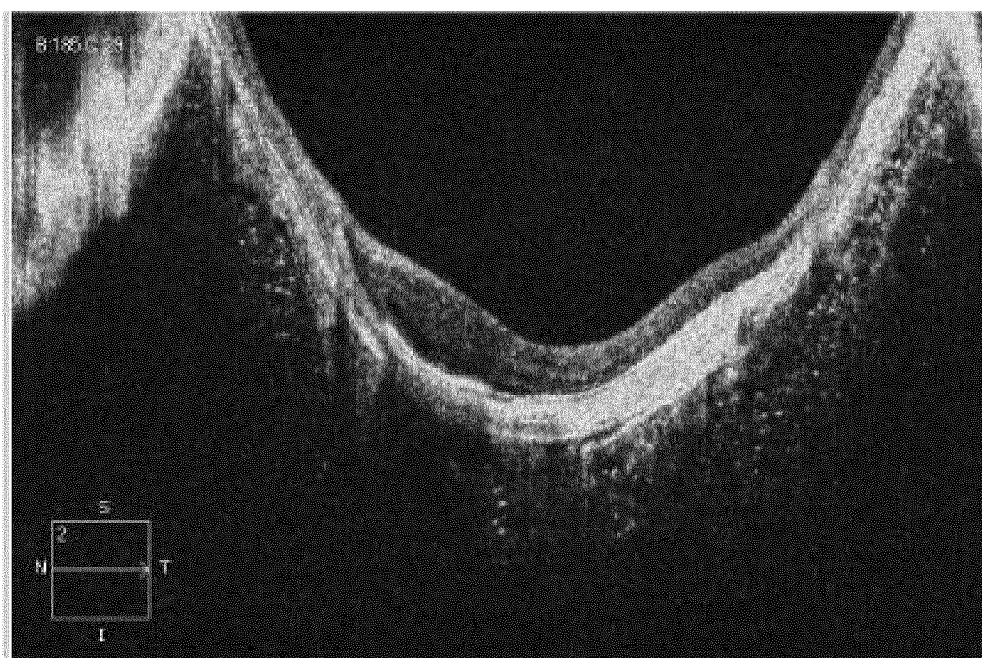


Fig. 6

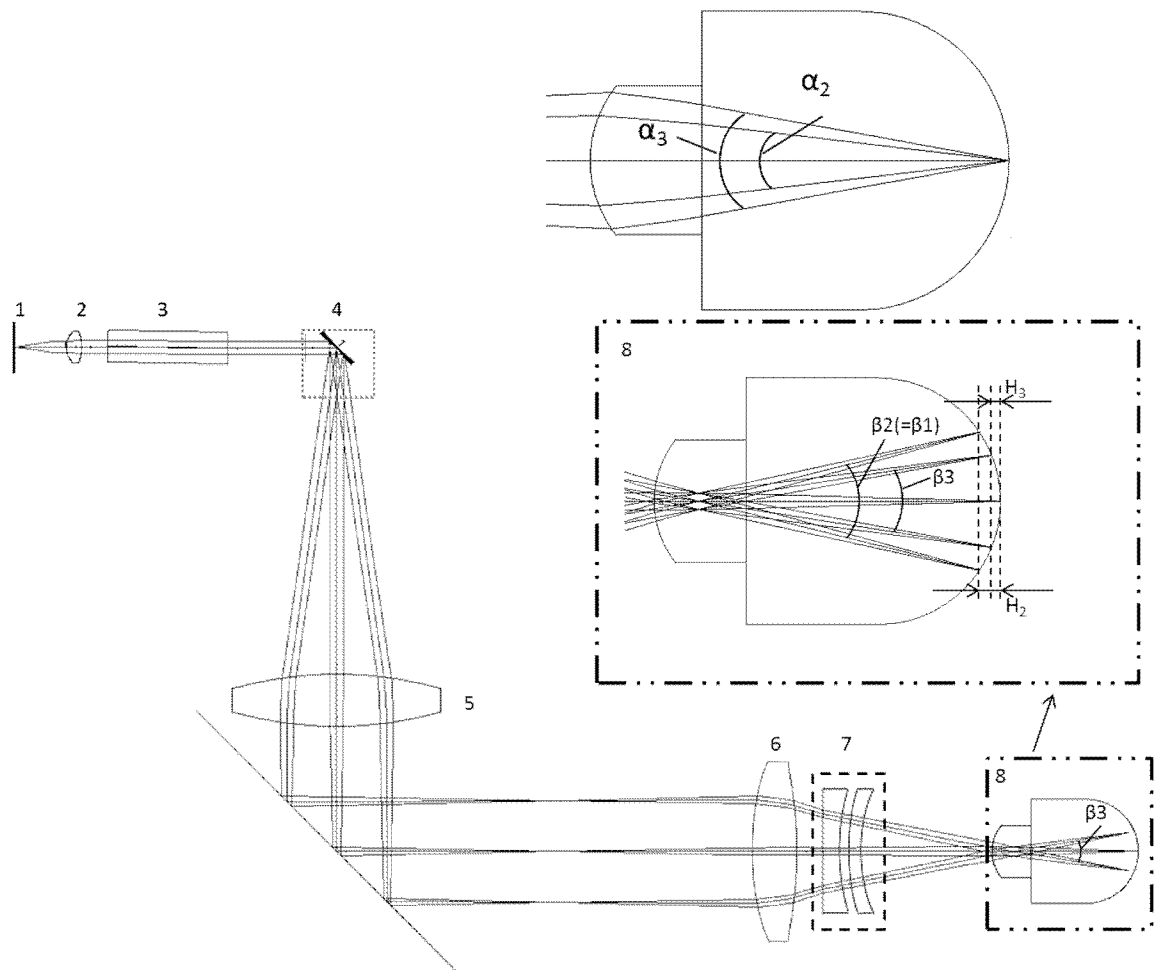


Fig. 7

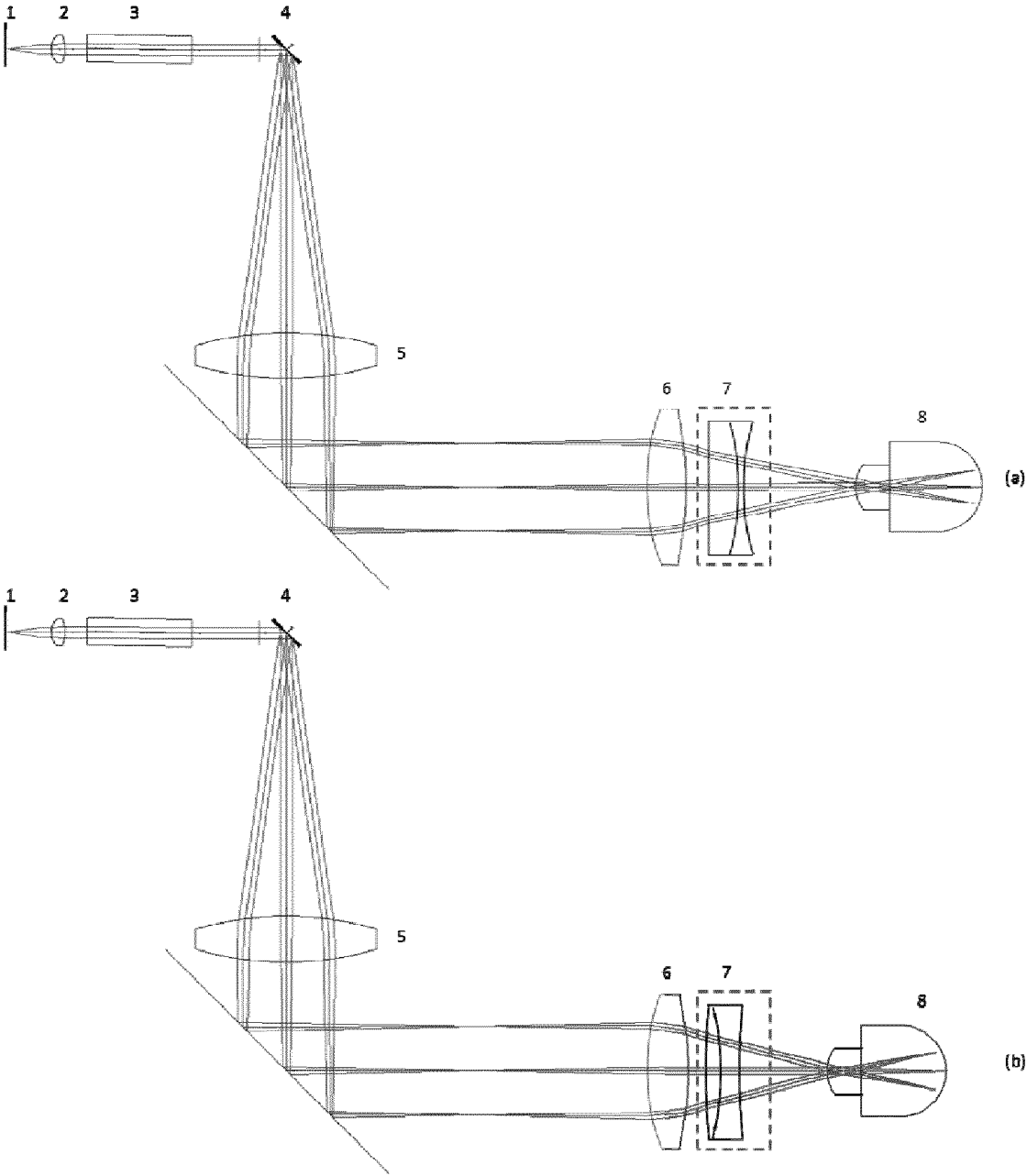


Fig.8

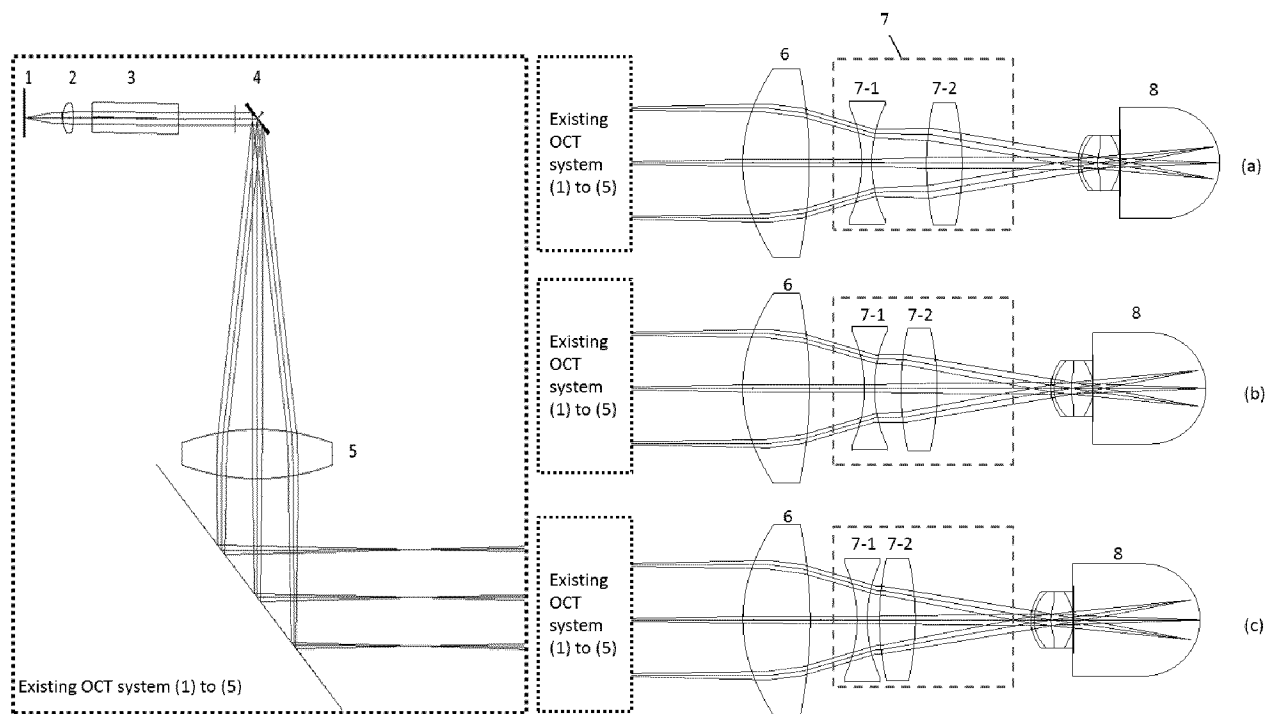


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/055055

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B3/10 A61B3/12 G01B9/02
ADD.

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)
A61B G01B

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2015/042951 A1 (STANGA PAULO E [GB] ET AL) 12 February 2015 (2015-02-12)	1-6, 12-17
Y	paragraph [0044] - paragraph [0045] paragraph [0043] -----	7-9, 18-20
Y	US 2013/141695 A1 (BUCKLAND ERIC L [US] ET AL) 6 June 2013 (2013-06-06) paragraph [0081] paragraph [0082] - paragraph [0083] ----- -/-	7-9, 18-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

10 May 2016

Date of mailing of the international search report

30/05/2016

Name and mailing address of the ISA/

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Authorized officer

Apostol, Simona

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/055055

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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