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(54) **Lens module and eye fundus camera using the same**

Linsenmodul und Augenhintergrundkamera damit

Module de lentille et caméra de fond d'oeil l'utilisant

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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates to a lens module and an eye fundus camera, particularly to a compact handheld lens module and an eye fundus camera using the same.

2. DESCRIPTION OF THE PRIOR ART

[0002] In an eye fundus observation device, light is guided to the eye fundus of a testee, and then the eye fundus is imaged on the eye of the tester or a photosensor of a camera (such as a film or an image sensor of the camera). The conventional eye fundus observation devices include the direct ophthalmoscope, the indirect ophthalmoscope and the eye fundus camera. Different from the direct ophthalmoscope, the indirect ophthalmoscope forms an intermediary image of the eye fundus in advance and then projects the intermediary image onto the eye of the tester or the photosensor of a camera. The eye fundus camera captures and records the images of the eye fundus of a testee, and the image records are convenient to store and transfer.

[0003] The conventional eye fundus observation devices respectively have their disadvantages. For example, the direct ophthalmoscope has an observation angle of merely about 5 degrees and thus can only observe the optic disc or the fovea centralis. Besides, the user of the direct ophthalmoscope must be very close to the testee. The indirect ophthalmoscope has a wider observation field and can also observe the ocular capillaries in addition to the optic disc and the fovea centralis. However, the user of the indirect ophthalmoscope still has to approach the testee very closely. Further, neither the direct ophthalmoscope nor the indirect ophthalmoscope can record the image of the eye fundus of the testee. The eye fundus camera has a wider observation field and a capability of observing and recording the eye fundus of the testee and exempts the tester from closely approaching the testee. However, the eye fundus camera is bulky, hard to carry about and unlikely to apply to some special testees, such as infants, bedridden patients or handicapped patients. Neither the current handheld ophthalmoscope nor the current handheld eye fundus camera provides a precision light beam to guide the testee to accurately adjust the angle of his eyeball for shooting different regions of the eye fundus. Although the desktop eye fundus camera provides a precision light beam, it occupies considerable space.

[0004] An optical instrument disclosed by US patent No. 5499066 A or an eye inspection apparatus disclosed by US patent No. 4502766 A includes a lens group for illuminating, which is independent from a lens group for imaging, that results the volume and cost of the optical instrument or the eye inspection apparatus is substantially increased.

[0005] A system for reflex-free coaxial illumination is disclosed by US patent No. US 7,174,094 B2, wherein an illumination mask is provided to prevent illumination light from passing through a central area of an objective lens, and a reflex mask is provided to block reflection of at least one light source from the surface of an object.

[0006] Accordingly, the manufacturers are eager to develop an eye fundus observation device not only having the abovementioned advantages but also having reduced volume.

SUMMARY OF THE INVENTION

[0007] The present invention is defined in the appended claims and directed to a lens module and an eye fundus camera, wherein the illumination system and the imaging system share a common set of lens groups for reducing volume, and wherein the set of shared lens groups has biconvex surfaces for decreasing the incidence to the imaging system of the light reflected by the shared lens groups and reducing the ghosting effect.

[0008] In one embodiment, the proposed lens module is used to converge an image light beam reflected from the eye fundus and comprises a first lens group, a second lens group and a third lens group, which are arranged from the eye fundus side to the image side in sequence. The first lens group has a positive effective focal length and includes a first lens having two convex surfaces respectively facing the eye fundus side and the image side. The first lens group is a single piece of lens. The second lens group has a positive or negative effective focal length and includes a plurality of second lenses, wherein the second lens closest to the eye fundus side has a concave surface facing the eye fundus side. The third lens group has a positive effective focal length and includes a plurality of third lenses, wherein at least one third lens is a cemented lens. The lens module further comprising a first light emitting element, which is arranged in the image side of the first lens group and deviated from an optical axis of the lens module, and which is used to generate an illumination light beam, wherein the illumination light beam is converged by the first lens group to a cornea on the eye fundus side.

[0009] In one embodiment, the proposed eye fundus camera comprises an image sensing module and a lens module. The image sensing module senses light and forms an image. The lens module converges an image light beam, which

is reflected from the eye fundus, to the image sensing module. The lens module comprises a first lens group, a second lens group and a third lens group, which are arranged from the eye fundus side to the image side in sequence. The first lens group has a positive effective focal length and includes a first lens having two convex surfaces respectively facing the eye fundus side and the image side. The first lens group is a single piece of lens. The second lens group has a positive or negative effective focal length and includes a plurality of second lenses, wherein the second lens closest to the eye fundus side has a concave surface facing the eye fundus side. The third lens group has a positive effective focal length and includes a plurality of third lenses, wherein at least one third lens is a cemented lens. The eye fundus camera further comprises a first light emitting element, which is arranged in the image side of the first lens group and deviated from an optical axis of the lens module, and which is used to generate an illumination light beam, wherein the illumination light beam is converged by the first lens group to a cornea in the eye fundus side.

[0010] The objective, technologies, features and advantages of the present invention will become apparent from the following description in conjunction with the accompanying drawings wherein certain embodiments of the present invention are set forth by way of illustration and example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The foregoing conceptions and their accompanying advantages of this invention will become more readily appreciated after being better understood by referring to the following detailed description, in conjunction with the accompanying drawings, wherein:

Fig.1 schematically shows a lens module and an eye fundus camera according to a first embodiment of the present invention;

Fig.2a and Fig.2b schematically show that an illumination light beam is reflected by a first lens group of the lens module of the first embodiment of the present invention;

Fig.3 schematically shows a lens module according to a second embodiment of the present invention;

Fig.4 schematically shows a lens module according to a third embodiment of the present invention;

Fig.5 schematically shows a lens module according to a fourth embodiment of the present invention;

Fig.6a schematically shows a lens module according to a fifth embodiment of the present invention; and

Fig.6b schematically shows a lens module according to a sixth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] The detailed explanation of the present invention is described as follows. The described preferred embodiments are presented for purposes of illustrations and description, and they are not intended to limit the scope of the present invention.

[0013] Refer to Fig.1. In one embodiment, the lens module of the present invention is used to converge an image light beam reflected from the fundus of an eyeball 10 of a testee to form an image 12. The lens module of the present invention comprises a first lens group G1, a second lens group G2 and a third lens group G3, which are arranged from the eye fundus side EYE to the image side IMG in sequence. The first lens group G1 has a positive effective focal length and includes a first lens L1 having two convex surfaces S1 and S2 respectively facing the eye fundus side EYE and the image side IMG. The first lens group G1 is a single piece of lens.

[0014] The second lens group G2 has a positive or negative effective focal length and includes a plurality of second lenses L2, wherein the second lens L2 closest to the eye fundus side EYE has a concave surface S3 facing the eye fundus side EYE. The third lens group G3 has a positive effective focal length and includes a plurality of third lenses, wherein at least one third lens is a cemented lens. For example, in the embodiment shown in Fig.1, the third lens group G3 includes three third lenses L3a, L3b and L3c, and the third lens L3b is a cemented lens.

[0015] Refer to Fig.1 again. The lens module of the present invention further comprises a first light emitting element LSa arranged in the image side IMG of the first lens group G1 and deviated from an optical axis A of the lens module. As shown in Fig.1, the first light emitting element LSa generates an illumination light beam IL. The illumination light beam IL is converged by the first lens group G1 to a cornea in the eye fundus side EYE. According to the foregoing structure, the imaging system and the illumination system share the first lens group G1. The image light beam reflected from the eye fundus is converged by the first lens group G1 to form an intermediary image I1; the intermediary image I1 is further

processed by the second lens group G2 and the third lens group G3 to form an image 12. The image 12 is directly observed by an observer or sensed by an image sensing module 20.

[0016] Preferably, the positions of the first light emitting element LSa and the cornea of the eyeball 10 with respect to the first lens group G1 meet the object-image relationship. In other words, the first light emitting element LSa is arranged in the object side of the first lens group G1, and the illumination light beam IL emitted by the first light emitting element LSa is converged at the cornea of the eyeball 10 (i.e. the image side) and incident to the fundus of the eyeball 10. It should be noted that the image side mentioned herein is not the image side IMG of the lens module but the image side of the illumination system. According to optics design, the first light emitting element LSa is arranged at a position separated from the surface S2 of the first lens L1, which faces said image side, by a distance of 40-100mm. According to the foregoing structure, the first light emitting element LSa plus the first lens group G1 is sufficient to make the lens module efficiently utilize the illumination light beam IL emitted by the first light emitting element LSa without a relay lens, i.e. without forming an intermediary image.

[0017] As light is unlikely to pass through a lens completely, a portion of the illumination light beam incident on the first lens group G1 is reflected to the imaging lens, i.e. the second lens group G2, forming the so-called ghost image. Refer to Fig.2a and Fig.2b. In one embodiment, the first lens group G1 of the lens module is a biconvex structure. The surface S1 of the first lens group G1 is a concave surface for the first light emitting element LSa. While the surface S1 reflects the illumination light beam IL, the illumination light beam IL is converged. The convex surface S2 refracts the reflected illumination light beam IL and further converges the reflected illumination light beam IL, whereby the light output angle of the reflected illumination light beam IL is increased furthermore, and whereby the reflected illumination light beam IL incident to the second lens group G2 is greatly decreased, as shown in Fig.2a. The surface S2 of the first lens group G1 is a convex surface for the first light emitting element LSa. While the surface S2 reflects the illumination light beam IL, the illumination light beam IL is divergent. Thus, the reflected illumination light beam IL incident to the second lens group G2 is also greatly decreased, as shown in Fig.2b. From the above description, it is learned: the biconvex design of the first lens group G1 greatly reduces the ghosting effect. Besides, adjusting the position of the first light emitting element LSa, i.e. adjusting the distance between the first light emitting element LSa and the optical axis A, can further reduce the ghosting effect.

[0018] In one embodiment, the first light emitting element LSa may be a visible light LED (Light Emitting Diode) or an infrared LED according to practical requirement. Refer to Fig.3. In one embodiment, the first light emitting element LSa contains a plurality of LEDs, including visible light LEDs LSal and infrared LEDs LSa2. The proportions of visible light LEDs LSal and infrared LEDs LSa2 are designed according to practical requirement. For example, the first light emitting element LSa contains two pieces of visible light LEDs LSal and one piece of infrared LED LSa2. In order to make the positions of the first light emitting element LSa and the cornea of the eyeball 10 meet the object-image relationship, the visible light LED LSal and the infrared LED LSa2 may be arranged one above one, i.e. the visible light LED LSal and the infrared LED LSa2 are respectively separated from the optical axis A by different distances, as shown in Fig.3. Alternatively, the visible light LED LSal and the infrared LED LSa2 are arranged side by side, i.e. the visible light LED LSal and the infrared LED LSa2 are equidistant to the optical axis A. It should be noted that the positions of the visible light LED LSal and the infrared LED LSa2 may be interchanged top and bottom or left and right; the visible light LED LSal and the infrared LED LSa2 may also be arranged in annular symmetry.

[0019] Refer to Fig.4. In one embodiment, the lens module of the present invention further comprises an optical element O1 arranged between the first lens group G1 and the first light emitting element LSa. The optical element O1 diverts the illumination light beam IL to the first lens group G1. For example, the optical element O1 is realized by a polarizer, a prism or a beam splitter. As shown in Fig.4, the illumination light beam IL emitted by the infrared LED LSa2 is diverted by the optical element O1, whereby the virtual position from which the infrared light beam seems to be emitted is identical to the position where the visible light LED LSal is located, and whereby the virtual position of the infrared LED LSa2 and the position of the visible light LED LSal are equidistant to the optical axis A and on the same object plane. Therefore, the illumination field of the infrared LED LSa2 is very close to that of the visible light LED LSal.

[0020] Refer to Fig.5. In one embodiment, the lens module of the present invention further comprises a second light emitting element LSb generating a precision light beam PL. The precision light beam PL is reflected by a beam splitter 02, and the first lens group G1 converges the reflected precision light beam PL to the cornea in the eye fundus side EYE. The precision light beam PL reflected by the beam splitter 02 seems to be emitted from the position of the intermediary image I1 of the lens module. Therefore, the second light emitting element LSb is equivalently located at the position of the intermediary image I1. According to the foregoing structure, the precision light beam PL emitted by the second light emitting element LSb is incident to the fundus of the eyeball 10; the tester ignites the second light emitting element LSb disposed at a special position, and the testee gazes at the ignited second light emitting element LSb, whereby the eyeball 10 of the testee is fixed to a special angle.

[0021] Refer to Fig.6a and Fig.6b. In one embodiment, the lens module further comprises an optical lens 03 arranged between the second light emitting element LSb and the beam splitter 02. The optical lens 03 converges the precision light beam PL generated by the second light emitting element LSb to form an intermediary image, whereby the second

light emitting element LSb is equivalently located at the position of the intermediary image I1 of the lens module. For example, as shown in Fig.6a, the optical lens 03 converges the precision light beam PL to form an intermediary image 13 before the beam splitter 02. The precision light beam PL reflected by the beam splitter 02 is equivalently emitted by a virtual second light emitting element LSb located at the position of the intermediary image I1. Alternatively, as shown in Fig.6b, the precision light beam PL generated by the second light emitting element LSb is converged by the optical lens 03 and reflected by the beam splitter 02 to form an intermediary image located at the position of the intermediary image I1. Via appropriate design, the beam splitter 02 for reflecting the precision light beams PL may be arranged in the eye fundus side EYE or the image side IMG of the intermediary image I1 of the lens module.

[0022] Below, embodiments are used to further demonstrate the lens module of the present invention. Refer to Table.1, which defines the parameters of the lens module shown in Fig.1. The surface numbers are corresponding to the surfaces of the lenses in Fig.1. The surface S7 is a surface of a diaphragm. The thickness is the distance between the current surface and the next surface in the image side IMG along the optical axis A. For example, the value in the field of thickness corresponding to the surface S1 is the distance between the surface S1 and the surface S2 along the optical axis A; the value in the field of thickness corresponding to the surface S11 is the distance between the surface S11 and the image 12 along the optical axis A. An asterisk labeled on a surface number means that the surface is an aspherical surface.

Table.1

Surface Number	Radius of Curvature (mm)	Thickness (mm)	Refractivit y	Dispersion Coefficient
S1*	29.00	15.30	1.545	55.930
S2*	-16.00	49.00		
S3*	-136.50	6.00	1.545	55.930
S4*	-5.26	0.20		
S5*	4.23	2.00	1.585	29.909
S6*	1.93	5.00		
S7 (diaphragm)	∞	0.50		
S8	-1000.00	6.00	1.806	40.926
S9	-6.60	0.80	1.785	26.291
S10	27.45	2.56	1.678	55.341
S11	-17.66	28.87		

[0023] An aspherical surface can be expressed by an equation:

$$z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}} + \alpha_1 r^2 + \alpha_2 r^4 + \alpha_3 r^6 + \alpha_4 r^8 + \alpha_5 r^{10} + \alpha_6 r^{12} + \alpha_7 r^{14} + \alpha_8 r^{16}$$

wherein c is the paraxial curvature, r is the distance between the surface of a lens and the optical axis A, *z* is the distance between Point on the aspherical surface with the distance r and the tangential plane of the vertex of the aspherical surface (a plane vertical to the optical axis A), k is the ellipsoidal coefficient, $\alpha_{1\text{-}8}$ are the coefficients. The coefficients of the aspherical surface are listed in Table.2. The coefficients α_1, α_7 and α_8 are not listed in Table.2, and the values thereof are zero.

Table.2

Surface Number	*K*	α_2	α_3	α_4	α_5	α_6
S1	-	-4.35546E-05	1.17552E-07	-3.28706E-09	2.41621E-11	-5.88136E-14
S2	-0.056640	2.58458E-05	3.72384E-08	-3.72701E-10	2.08903E-12	1.52052E-15
S3	-	-1.16402E-04	-1.54925E-05	-6.10529E-07	6.41977E-08	-1.08872E-09

(continued)

Surface Number	*K*	α_2	α_3	α_4	α_5	α_6
S4	-4.504411	-	-5.79017E-05	4.11551E-06	-1.26210E-07	1.85650E-09
S5	-	-4.13656E-03	1.26750E-05	1.84683E-07	9.22369E-08	-
S6	-1.770931	-	1.39303E-04	-2.19843E-05	6.05103E-06	-

[0024] Refer to Fig.1 again. In one embodiment, the eye fundus camera of the present invention comprises an image sensing module 20 and a lens module. The lens module comprises a first lens group G1, a second lens group G2 and a third lens group G3. The detailed structure of the lens module has been described hereinbefore and will not repeat herein. The image sensing module 20 senses light and forms an image. In Fig.1, a gap is depicted between the image 12 and the image sensing module 20 to signify that they are different objects. In fact, the image 12 should be formed on the sensing surface of the image sensing module 20.

[0025] In one embodiment, the eye fundus camera of the present invention further comprises a display module 30 electrically connected with the image sensing module 20 and presenting the image 12. Thereby, the observer can observe the image of the eye fundus of the testee without approaching the testee closely. In one embodiment, the eye fundus camera of the present invention further comprises a storage module 40 electrically connected with the image sensing module 20 and storing the images 12 captured by the image sensing module 20 as records. Via comparing the records, the physician can determine the extent of recovery.

[0026] In conclusion, the lens module and the eye fundus camera share one of the lens groups with the illumination system, whereby the illumination system is exempted from using any additional lens, and whereby the volume of the system is reduced. Thus, the present invention is easy to carry about and applicable to far-end healthcare. The shared lens group is a biconvex-surface design, which can decrease the incidence of the light reflected by the shared lens group to the imaging system and reduce the ghosting effect. Further, the precision light beam also shares the same lens group and need not use any additional lens. The handheld eye fundus camera can provide a precision light beam to help the testee turn his eyeball to a specified angle, whereby the observer can easily observe the fundus of the eye.

[0027] While the invention is susceptible to various modifications and alternative forms, a specific example thereof has been shown in the drawings and is herein described in detail. It should be understood, however, that the invention is not to be limited to the particular form disclosed, but to the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within the scope of the appended claims.

Claims

1. A lens module, used to converge an image light beam reflected from an eye fundus, the lens module comprising a first lens group (G1), a second lens group (G2) and a third lens group (G3), which are arranged from an eye fundus side (EYE) to an image side (IMG) in sequence, wherein:

   said first lens group (G1) has a positive effective focal length and includes a first lens (L1) having two convex surfaces respectively facing said eye fundus side (EYE) and said image side (IMG), and said first lens group (G1) being a single piece of lens;
   said second lens group (G2) has a positive or negative effective focal length and includes a plurality of second lenses (L2), and wherein said second lens (L2) closest to said eye fundus side (EYE) has a concave surface facing said eye fundus side (EYE); and
   said third lens group (G3) has a positive effective focal length and includes a plurality of third lenses (L3a, L3b, L3c), wherein at least one said third lens is a cemented lens;
   characterized by
   a first light emitting element (LSa), which is arranged in said image side (IMG) of said first lens group (G1) and deviated from an optical axis (A) of said lens module, and which is used to generate an illumination light beam (IL), wherein said illumination light beam (IL) is **directly incident** on a substantial portion of said first lens group (G1) including a central zone around the optical axis (A) **and** converged by said first lens group (G1) to a cornea on said eye fundus side (EYE), **without a relay lens.**

2. The lens module according to claim 1, wherein positions of said first light emitting element (LSa) and said cornea meet an object-image relationship of said first lens group (G1).

3. The lens module according to claim 2, further comprising an optical element (01), which is arranged between said first lens group (G1) and said first light emitting element (LSa) and used to divert said illumination light beam (IL) to said first lens group (G1).

4. The lens module according to claim 1, wherein said first light emitting element (LSa) includes a plurality of light emitting diodes (LEDs), and wherein said plurality of LEDs includes at least one of visible light LEDs and infrared LEDs.

5. The lens module according to claim 1, wherein said first light emitting element (LSa) is arranged at a position separated from a surface of said first lens, which faces said image side (IMG), by a distance of 40-100mm.

6. The lens module according to claim 1, further comprising a second light emitting element (LSb) generating a precision light beam (PL), wherein said precision light beam (PL) is reflected to said first lens group (G1) by a beam splitter (02), and said first lens group (G1) converges said precision light beam (PL) to a cornea in said eye fundus side (EYE), and wherein said precision light beam (PL) is equivalently emitted from a position of a first intermediary image of said lens module.

7. The lens module according to claim 6, further comprising an optical lens (03) arranged between said second light emitting element (LSb) and said beam splitter (02), wherein said optical lens (03) converges said precision light beam (PL), which is emitted by said second light emitting element (LSb), to form a second intermediary image, and wherein positions of said second intermediary image and said first intermediary image of said lens module is equivalent.

8. An eye fundus camera comprising

an image sensing module (20) sensing light to form an image (12); and
a lens module, used to converge an image light beam reflected from an eye fundus to said image sensing module and comprising a first lens group (G1), a second lens group (G2) and a third lens group (G3), which are arranged from an eye fundus side (EYE) to an image side (IMG) in sequence, wherein:

said first lens group (G1) has a positive effective focal length and includes a first lens (L1) having two convex surfaces respectively facing said eye fundus side (EYE) and said image side (IMG), and said first lens group (G1) is a single piece of lens;
said second lens group (G2) has a positive or negative effective focal length and includes a plurality of second lenses (L2), and wherein said second lens (L2) closest to said eye fundus side (EYE) has a concave surface facing said eye fundus side (EYE); and
said third lens group (G3) has a positive effective focal length and includes a plurality of third lenses (L3a, L3b, L3c), wherein at least one said third lens is a cemented lens;
characterized by
a first light emitting element (LSa), which is arranged in said image side (IMG) of said first lens group (G1) and deviated from an optical axis (A) of said lens module, and which is used to generate an illumination light beam (IL), wherein said illumination light beam (IL) is **directly incident** on a substantial portion of said first lens group (G1) including a central zone around the optical axis (A) **and** converged by said first lens group (G1) to a cornea in said eye fundus side (EYE), **without a relay lens.**

9. The eye fundus camera according to claim 8, wherein positions of said first light emitting element (LSa) and said cornea meet an object-image relationship of said first lens group (G1).

10. The eye fundus camera according to claim 9, further comprising an optical element (01), which is arranged between said first lens group (G1) and said first light emitting element (LSa) and used to divert said illumination light beam (IL) to said first lens group (G1).

11. The eye fundus camera according to claim 8, wherein said first light emitting element (LSa) is arranged at a position separated from a surface of said first lens, which faces said image side (IMG), by a distance of 40-100mm.

12. The eye fundus camera according to claim 8, further comprising a second light emitting element (LSb) generating a precision light beam (PL), wherein said precision light beam (PL) is reflected to said first lens group (G1) by a beam splitter (02), and said first lens group (G1) converges said precision light beam (PL) to a cornea in said eye

fundus side (EYE), and wherein said precision light beam (PL) is equivalently emitted from a position of a first intermediary image of said lens module.

13. The eye fundus camera according to claim 12, further comprising an optical lens (03) arranged between said second light emitting element (LSb) and said beam splitter (02), wherein said optical lens (03) converges said precision light beam (PL), which is emitted by said second light emitting element (LSb), to form a second intermediary image, and wherein positions of said second intermediary image and said first intermediary image of said lens module is equivalent.

14. The eye fundus camera according to claim 8, further comprising a display module (30) electrically connected with said image sensing module (20) to present said image (12).

Patentansprüche

1. Linsenmodul, das verwendet wird, um einen Bildlichtstrahl zu konvergieren, der von einem Augenhintergrund reflektiert wird, wobei das Linsenmodul eine erste Linsengruppe (G1), eine zweite Linsengruppe (G2) und eine dritte Linsengruppe (G3) umfasst, die nacheinander von einer Augenhintergrundseite (EYE) zu einer Bildseite (IMG) angeordnet sind, wobei:

die erste Linsengruppe (G1) eine positive effektive Brennweite aufweist und eine erste Linse (L1) mit zwei konvexen Flächen beinhaltet, die jeweils der Augenhintergrundseite (EYE) und der Bildseite (IMG) zugewandt sind, und wobei die erste Linsengruppe (G1) ein einzelnes Linsenstück ist;
die zweite Linsengruppe (G2) eine positive oder negative effektive Brennweite aufweist und eine Vielzahl von zweiten Linsen (L2) aufweist, und wobei die zweite Linse (L2) am nächsten zu der Augenhintergrundseite (EYE) eine konkave Fläche aufweist, die der Augenhintergrundseite (EYE) zugewandt ist; und
die dritte Linsengruppe (G3) eine positive effektive Brennweite aufweist und eine Vielzahl von dritten Linsen (L3a, L3b, L3c) aufweist, wobei mindestens eine der dritten Linsen eine zementierte Linse ist;
gekennzeichnet durch
ein erstes lichtemittierendes Element (LSa), das in der Bildseite (IMG) der ersten Linsengruppe (G1) angeordnet ist und von einer optischen Achse (A) des Linsenmoduls abweicht und das verwendet wird, um einen Beleuchtungslichtstrahl (IL) zu erzeugen, wobei der Beleuchtungslichtstrahl (IL) direkt auf einen wesentlichen Abschnitt der ersten Linsengruppe (G1) auftrifft, welcher Abschnitt eine zentrale Zone um die optische Achse (A) herum umfasst, und von der ersten Linsengruppe (G1) zu einer Hornhaut auf der Augenhintergrundseite (EYE) ohne Relaislinse konvergiert wird.

2. Linsenmodul nach Anspruch 1, wobei Positionen des ersten lichtemittierenden Elements (LSa) und die Hornhaut eine Objekt-Bild-Beziehung der ersten Linsengruppe (G1) erfüllen.

3. Linsenmodul nach Anspruch 2, ferner umfassend ein optisches Element (O1), das zwischen der ersten Linsengruppe (G1) und dem ersten lichtemittierenden Element (LSa) angeordnet ist und verwendet wird, um den Beleuchtungslichtstrahl (IL) zu der ersten Linsengruppe (G1) umzuleiten.

4. Linsenmodul nach Anspruch 1, wobei das erste lichtemittierende Element (LSa) eine Vielzahl von lichtemittierenden Dioden (LEDs) umfasst, und wobei die Vielzahl von LEDs mindestens eine von LEDs mit sichtbarem Licht und Infrarot-LEDs umfasst.

5. Linsenmodul nach Anspruch 1, wobei das erste lichtemittierende Element (LSa) an einer Position angeordnet ist, die von einer Fläche der ersten Linse, die der Bildseite (IMG) zugewandt ist, um einen Abstand von 40-100 mm getrennt ist.

6. Linsenmodul nach Anspruch 1, ferner umfassend ein zweites lichtemittierendes Element (LSb), das einen Präzisionslichtstrahl (PL) erzeugt, wobei der Präzisionslichtstrahl (PL) durch einen Strahlteiler (02) zu der ersten Linsengruppe (G1) reflektiert wird und die erste Linsengruppe (G1) den Präzisionslichtstrahl (PL) zu einer Hornhaut in der Augenhintergrundseite (EYE) konvergiert, und wobei der Präzisionslichtstrahl (PL) von einer Position eines ersten Mittlerbildes des Linsenmoduls äquivalent emittiert wird.

7. Linsenmodul nach Anspruch 6, ferner umfassend eine optische Linse (03), die zwischen dem zweiten lichtemittie-

renden Element (LSb) und dem Strahlteiler (02) angeordnet ist, wobei die optische Linse (03) den Präzisionslichtstrahl (PL) konvergiert, der von dem zweiten lichtemittierenden Element (LSb) emittiert wird, um ein zweites Mittlerbild zu bilden, und wobei Positionen des zweiten Mittlerbildes und des ersten Mittlerbildes des Linsenmoduls äquivalent sind.

8. Augenhintergrundkamera, umfassend

ein Bilderfassungsmodul (20), das Licht erfasst, um ein Bild (I2) zu bilden; und
ein Linsenmodul, das verwendet wird, um einen Bildlichtstrahl zu konvergieren, der von einem Augenhintergrund zu dem Bilderfassungsmodul reflektiert wird, und eine erste Linsengruppe (G1), eine zweite Linsengruppe (G2) und eine dritte Linsengruppe (G3) umfasst, die nacheinander von einer Augenhintergrundseite (EYE) zu einer Bildseite (IMG) angeordnet sind, wobei:

die erste Linsengruppe (G1) eine positive effektive Brennweite aufweist und eine erste Linse (L1) mit zwei konvexen Flächen aufweist, die jeweils der Augenhintergrundseite (EYE) und der Bildseite (IMG) zugewandt sind, und wobei die erste Linsengruppe (G1) ein einzelnes Linsenstück ist;
die zweite Linsengruppe (G2) eine positive oder negative effektive Brennweite aufweist und eine Vielzahl von zweiten Linsen (L2) aufweist, und wobei die zweite Linse (L2) am nächsten zu der Augenhintergrundseite (EYE) eine konkave Fläche aufweist, die der Augenhintergrundseite (EYE) zugewandt ist; und
die dritte Linsengruppe (G3) eine positive effektive Brennweite aufweist und eine Vielzahl von dritten Linsen (L3a, L3b, L3c) aufweist, wobei mindestens eine der dritten Linsen eine zementierte Linse ist;
gekennzeichnet durch
ein erstes lichtemittierendes Element (LSa), das in der Bildseite (IMG) der ersten Linsengruppe (G1) angeordnet ist und von einer optischen Achse (A) des Linsenmoduls abweicht und das verwendet wird, um einen Beleuchtungslichtstrahl (IL) zu erzeugen, wobei der Beleuchtungslichtstrahl (IL) direkt auf einen wesentlichen Abschnitt der ersten Linsengruppe (G1) auftrifft, welcher Abschnitt eine zentrale Zone um die optische Achse (A) herum beinhaltet, und von der ersten Linsengruppe (G1) zu einer Hornhaut auf der Augenhintergrundseite (EYE) ohne Relaislinse konvergiert wird.

9. Augenhintergrundkamera nach Anspruch 8, wobei Positionen des ersten lichtemittierenden Elements (LSa) und der Hornhaut eine Objekt-Bild-Beziehung der ersten Linsengruppe (G1) erfüllen.

10. Augenhintergrundkamera nach Anspruch 9, ferner umfassend ein optisches Element (O1), das zwischen der ersten Linsengruppe (G1) und dem ersten lichtemittierenden Element (LSa) angeordnet ist und verwendet wird, um den Beleuchtungslichtstrahl (IL) zu der ersten Linsengruppe (G1) umzuleiten.

11. Augenhintergrundkamera nach Anspruch 8, wobei das erste lichtemittierende Element (LSa) an einer Position angeordnet ist, die von einer Fläche der ersten Linse, die der Bildseite (IMG) zugewandt ist, um einen Abstand von 40-100 mm getrennt ist.

12. Augenhintergrundkamera nach Anspruch 8, ferner umfassend ein zweites lichtemittierendes Element (LSb), das einen Präzisionslichtstrahl (PL) erzeugt, wobei der Präzisionslichtstrahl (PL) von einem Strahlteiler (02) zu der ersten Linsengruppe (G1) reflektiert wird und die erste Linsengruppe (G1) den Präzisionslichtstrahl (PL) zu einer Hornhaut in der Augenhintergrundseite (EYE) konvergiert, und wobei der Präzisionslichtstrahl (PL) von einer Position eines ersten Mittlerbildes des Linsenmoduls äquivalent emittiert wird.

13. Augenhintergrundkamera nach Anspruch 12, ferner umfassend eine optische Linse (03), die zwischen dem zweiten lichtemittierenden Element (LSb) und dem Strahlteiler (02) angeordnet ist, wobei die optische Linse (03) den Präzisionslichtstrahl (PL) konvergiert, der von dem zweiten lichtemittierenden Element (LSb) emittiert wird, um ein zweites Mittlerbild zu bilden, und wobei Positionen des zweiten Mittlerbildes und des ersten Mittlerbildes des Linsenmoduls äquivalent sind.

14. Augenhintergrundkamera nach Anspruch 8, ferner umfassend ein Anzeigemodul (30), das mit dem Bilderfassungsmodul (20) elektrisch verbunden ist, um das Bild (I2) darzustellen.

Revendications

1. Module de lentille, utilisé pour faire converger un faisceau de lumière d'image réfléchi depuis un fond d'œil, le module de lentille comprenant un premier groupe de lentilles (G1), un deuxième groupe de lentilles (G2) et un troisième groupe de lentilles (G3), qui sont agencés depuis un côté de fond d'œil (EYE) vers un côté d'image (IMG) dans l'ordre, dans lequel :

   ledit premier groupe de lentilles (G1) a une longueur focale efficace positive et inclut une première lentille (L1) ayant deux surfaces convexes tournées respectivement vers ledit côté de fond d'œil (EYE) et ledit côté d'image (IMG), et ledit premier groupe de lentilles (G1) étant un élément unique de lentille ;
   ledit deuxième groupe de lentilles (G2) a une longueur focale efficace positive ou négative et inclut une pluralité de deuxièmes lentilles (L2), et dans lequel ladite deuxième lentille (L2) la plus proche dudit côté de fond d'œil (EYE) a une surface concave tournée vers ledit côté de fond d'œil (EYE) ; et
   ledit troisième groupe de lentilles (G3) a une longueur focale efficace positive et inclut une pluralité de troisièmes lentilles (L3a, L3b, L3c), dans lequel au moins une dite troisième lentille est une lentille collée ;
   caractérisé par
   un premier élément électroluminescent (LSa), qui est agencé dans ledit côté d'image (IMG) dudit premier groupe de lentilles (G1) et écarté d'un axe optique (A) dudit module de lentille, et qui est utilisé pour générer un faisceau de lumière d'illumination (IL), dans lequel ledit faisceau de lumière d'illumination (IL) est directement incident sur une portion substantielle du premier groupe de lentilles (G1) incluant une zone centrale autour de l'axe optique (A) et convergé par ledit premier groupe de lentilles (G1) vers une cornée sur ledit côté de fond d'œil (EYE), sans lentille de relais.

2. Module de lentille selon la revendication 1, dans lequel des positions dudit premier élément électroluminescent (LSa) et de ladite cornée satisfont une relation objet-image dudit premier groupe de lentilles (G1).

3. Module de lentille selon la revendication 2, comprenant en outre un élément optique (O1), qui est agencé entre ledit premier groupe de lentilles (G1) et ledit premier élément électroluminescent (LSa) et utilisé pour détourner ledit faisceau de lumière d'illumination (IL) vers ledit premier groupe de lentilles (G1).

4. Module de lentille selon la revendication 1, dans lequel ledit premier élément électroluminescent (LSa) inclut une pluralité de diodes électroluminescentes (DEL), et dans lequel ladite pluralité de DEL inclut au moins l'une parmi des DEL à lumière visible et des DEL à infrarouge.

5. Module de lentille selon la revendication 1, dans lequel ledit premier élément électroluminescent (LSa) est agencé à une position séparée d'une surface de ladite première lentille, qui est tournée vers ledit côté d'image (IMG), d'une distance de 40 à 100 mm.

6. Module de lentille selon la revendication 1, comprenant en outre un second élément électroluminescent (LSb) générant un faisceau de lumière de précision (PL), dans lequel ledit faisceau de lumière de précision (PL) est réfléchi vers ledit premier groupe de lentilles (G1) par un séparateur de faisceau (02), et ledit premier groupe de lentilles (G1) fait converger ledit faisceau de lumière de précision (PL) vers une cornée dans ledit côté de fond d'œil (EYE), et dans lequel ledit faisceau de lumière de précision (PL) est émis de façon équivalente depuis une position d'une première image intermédiaire dudit module de lentille.

7. Module de lentille selon la revendication 6, comprenant en outre une lentille optique (03) agencée entre ledit second élément électroluminescent (LSb) et ledit séparateur de faisceau (02), dans lequel ladite lentille optique (03) fait converger ledit faisceau de lumière de précision (PL), qui est émis par ledit second élément électroluminescent (LSb), pour former une seconde image intermédiaire, et dans lequel des positions de ladite seconde image intermédiaire et de ladite première image intermédiaire dudit module de lentille sont équivalentes.

8. Caméra pour fond d'œil comprenant

   un module de captage d'image (20) captant de la lumière pour former une image (I2) ; et
   un module de lentille, utilisé pour faire converger un faisceau de lumière d'image réfléchi depuis un fond d'œil vers ledit module de captage d'image et comprenant un premier groupe de lentilles (G1), un deuxième groupe de lentilles (G2) et un troisième groupe de lentilles (G3), qui sont agencés depuis un côté de fond d'œil (EYE) vers un côté d'image (IMG) dans l'ordre, dans laquelle :

ledit premier groupe de lentilles (G1) a une longueur focale efficace positive et inclut une première lentille (L1) ayant deux surfaces convexes tournées respectivement vers ledit côté de fond d'œil (EYE) et ledit côté d'image (IMG), et ledit premier groupe de lentilles (G1) est un élément unique de lentille ;
ledit second groupe de lentilles (G2) a une longueur focale efficace positive ou négative et inclut une pluralité de deuxièmes lentilles (L2), et dans laquelle ladite deuxième lentille (L2) la plus proche dudit côté de fond d'œil (EYE) a une surface concave tournée vers ledit côté de fond d'œil (EYE) ; et
ledit troisième groupe de lentilles (G3) a une longueur focale efficace positive et inclut une pluralité de troisièmes lentilles (L3a, L3b, L3c), dans laquelle au moins une dite troisième lentille est une lentille collée ;
caractérisée par
un premier élément électroluminescent (LSa), qui est agencé dans ledit côté d'image (IMG) dudit premier groupe de lentilles (G1) et écarté d'un axe optique (A) dudit module de lentille, et qui est utilisé pour générer un faisceau de lumière d'illumination (IL), dans laquelle ledit faisceau de lumière d'illumination (IL) est directement incident sur une portion substantielle du premier groupe de lentilles (G1) incluant une zone centrale autour de l'axe optique (A) et convergé par ledit premier groupe de lentilles (G1) vers une cornée dans ledit côté de fond d'œil (EYE), sans lentille de relais.

9. Caméra pour fond d'œil selon la revendication 8, dans laquelle des positions dudit premier élément électroluminescent (LSa) et de ladite cornée satisfont une relation objet-image dudit premier groupe de lentilles (G1).

10. Caméra pour fond d'œil selon la revendication 9, comprenant en outre un élément optique (O1), qui est agencé entre ledit premier groupe de lentilles (G1) et ledit premier élément électroluminescent (LSa) et utilisé pour détourner ledit faisceau de lumière d'illumination (IL) vers ledit premier groupe de lentilles (G1).

11. Caméra pour fond d'œil selon la revendication 8, dans laquelle ledit premier élément électroluminescent (LSa) est agencé à une position séparée d'une surface de ladite première lentille, qui est tournée vers ledit côté d'image (IMG), d'une distance de 40 à 100 mm.

12. Caméra pour fond d'œil selon la revendication 8, comprenant en outre un second élément électroluminescent (LSb) générant un faisceau de lumière de précision (PL), dans laquelle ledit faisceau de lumière de précision (PL) est réfléchi vers ledit premier groupe de lentilles (G1) par un séparateur de faisceau (02), et ledit premier groupe de lentilles (G1) fait converger ledit faisceau de lumière de précision (PL) vers une cornée dans ledit côté de fond d'œil (EYE), et dans laquelle ledit faisceau de lumière de précision (PL) est émis de façon équivalente depuis une position d'une première image intermédiaire dudit module de lentille.

13. Caméra pour fond d'œil selon la revendication 12, comprenant en outre une lentille optique (03) agencée entre ledit second élément électroluminescent (LSb) et ledit séparateur de faisceau (02), dans laquelle ladite lentille optique (03) fait converger ledit faisceau de lumière de précision (PL), qui est émis par ledit second élément électroluminescent (LSb), pour former une seconde image intermédiaire, et dans laquelle des positions de la seconde image intermédiaire et de ladite première image intermédiaire dudit module de lentille sont équivalentes.

14. Caméra pour fond d'œil selon la revendication 8, comprenant en outre un module d'affichage (30) connecté électriquement audit module de captage d'image (20) pour présenter ladite image (I2).

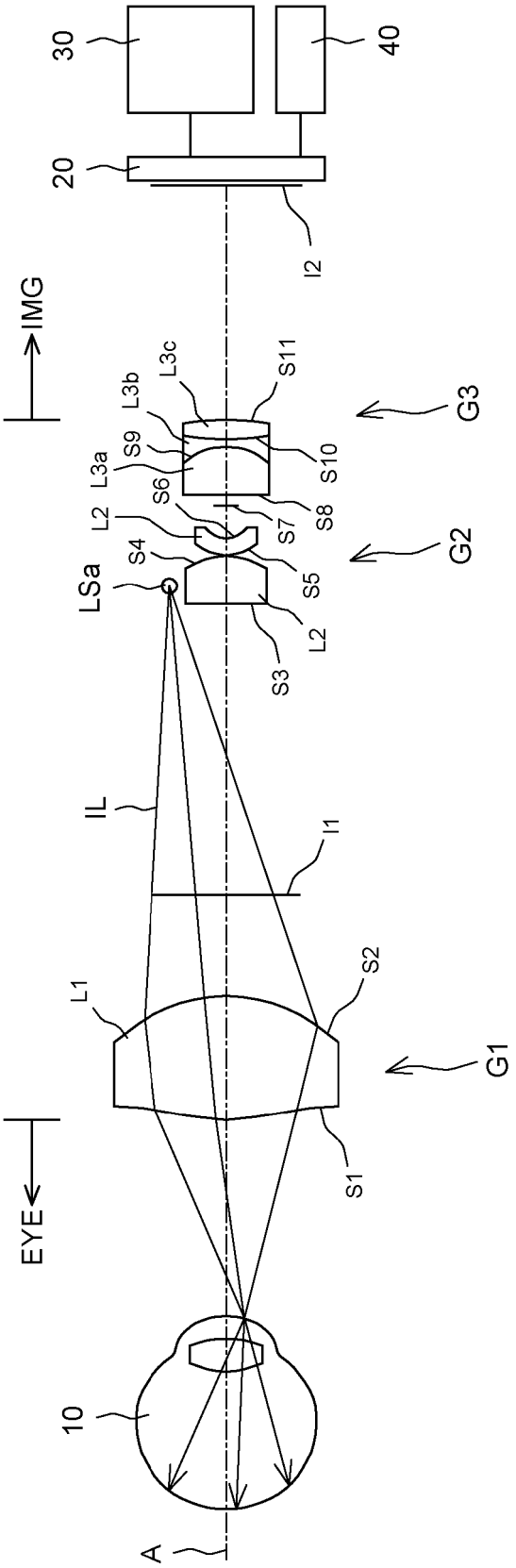
30
40
20
I2
IMG
L3c
L3b
S11
G3
S9
L3a
S10
S6
S8
L2
S7
S4
G2
LSa
S5
L2
S3
IL
I1
L1
S2
G1
EYE
S1
10
A

Fig. 1

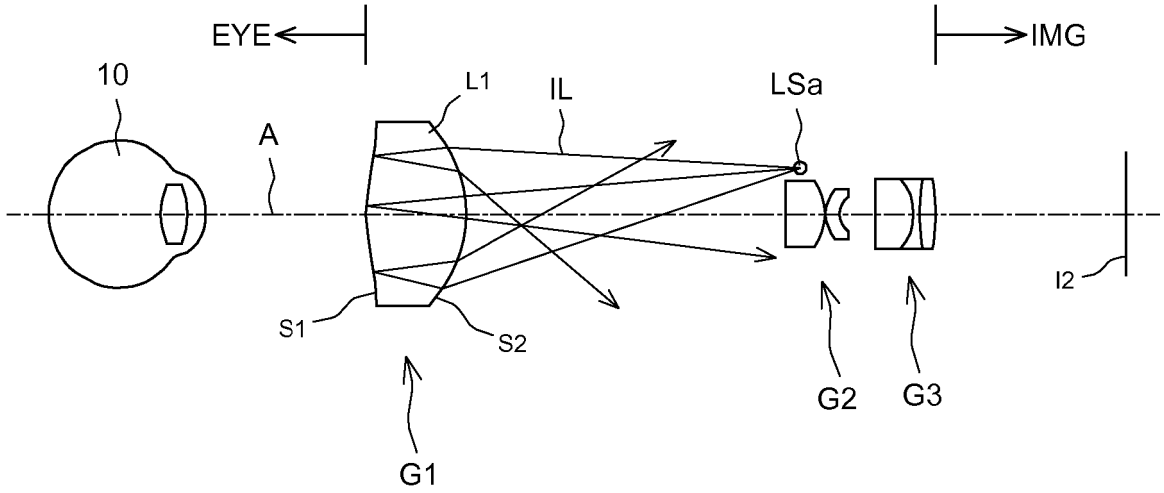
EYE
IMG
10
A
L1
IL
LSa
S1
S2
G1
G2
G3
I2

Fig. 2a

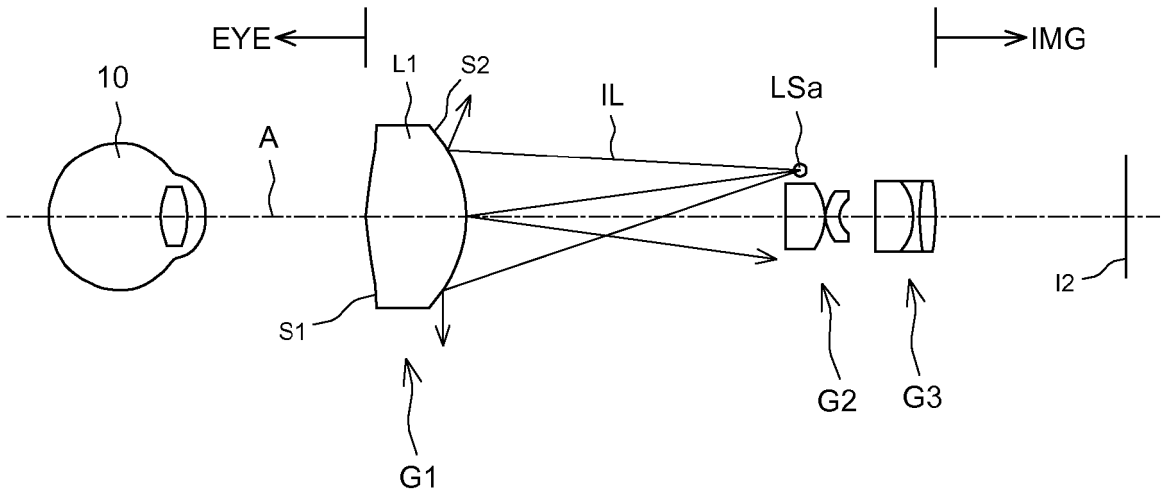
EYE
IMG
10
A
L1
S2
IL
LSa
S1
G1
G2
G3
I2

Fig. 2b

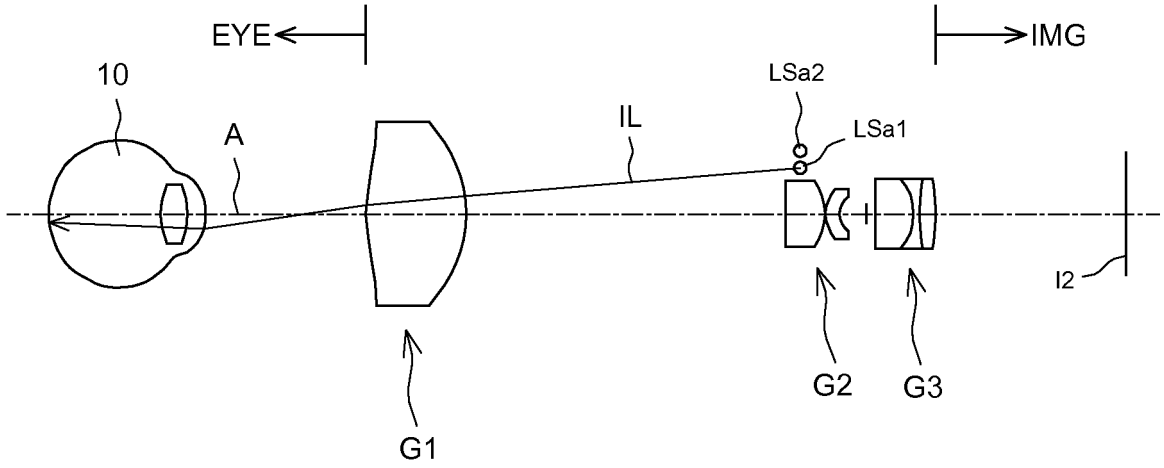
EYE
IMG
10
A
IL
LSa2
LSa1
I2
G1
G2
G3

Fig. 3

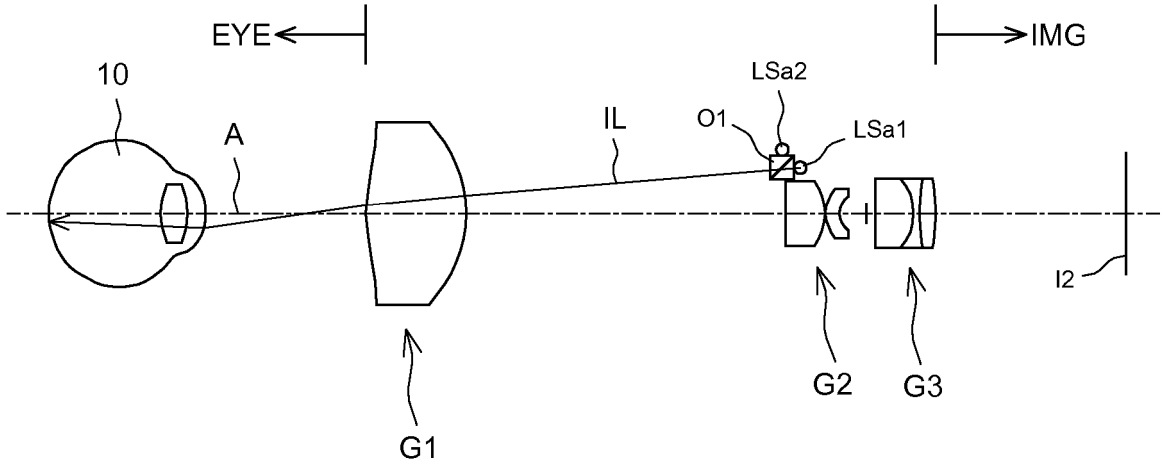
EYE
IMG
10
A
IL
O1
LSa2
LSa1
I2
G1
G2
G3

Fig. 4

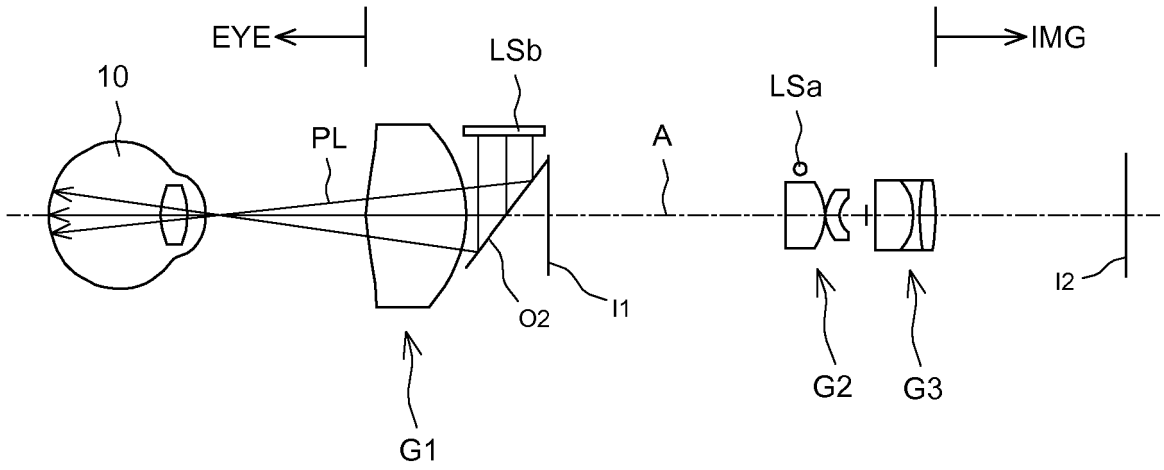

Fig. 5

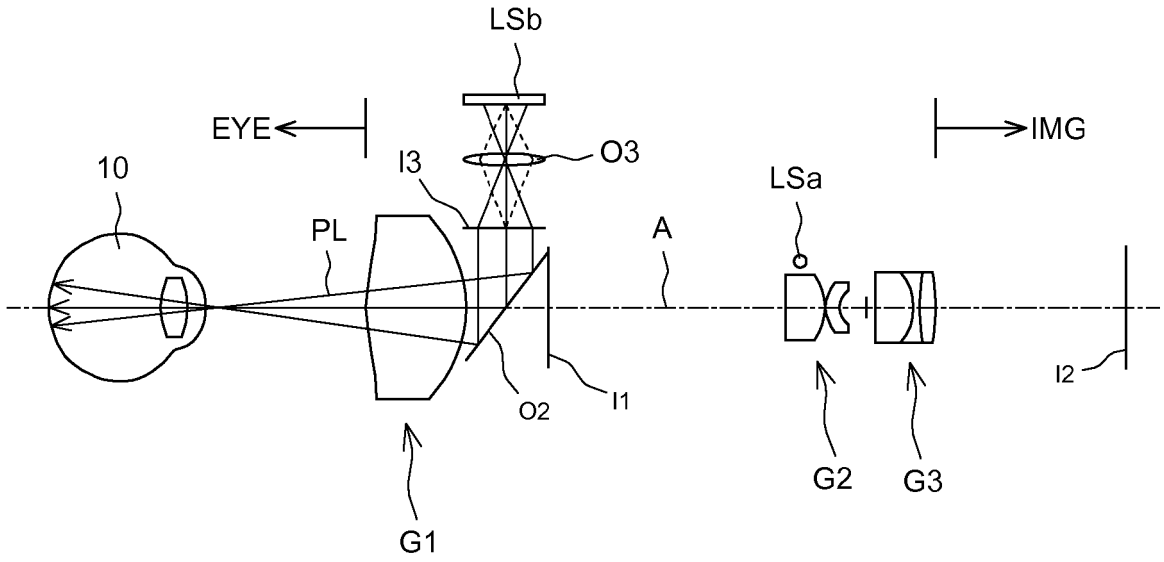
LSb
EYE
IMG
10
I3
O3
LSa
PL
A
I2
O2
I1
G2
G3
G1

Fig. 6a

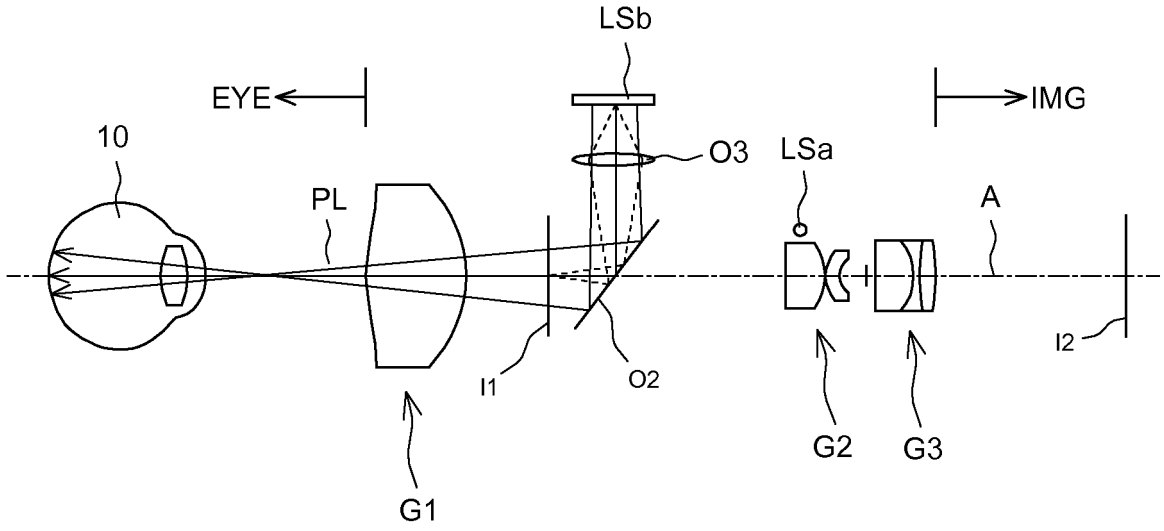
LSb
EYE
IMG
10
O3
LSa
PL
A
I2
I1
O2
G2
G3
G1

Fig. 6b

REFERENCES CITED IN THE DESCRIPTION

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