(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 October 2015 (29.10.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/164881 A1

(51) International Patent Classification:
A61N 5/06 (2006.01)

(21) International Application Number:
PCT/US2015/027846

(22) International Filing Date:
27 April 2015 (27.04.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/984,482 25 April 2014 (25.04.2014) US

(71) Applicant: **MINDSKID LABS, LLC** [US/US]; MindSkid Labs, LLC, 1717 Shipyard Blvd, Suite 140, Wilmington, North Carolina 28403 (US).

(72) Inventor: **BROWN, Alan**; Alan Wesley Brown, 184 Sound View Drive, Wilmington, North Carolina 28409 (US).

(74) Agent: **BRADY, Joshua**; Joshua B. Brady, Williams Mullen, PC, 8300 Greensboro Dr., Suite 1100, Tysons Corner, Virginia 22102 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: ILLUMINATING SPECULUM

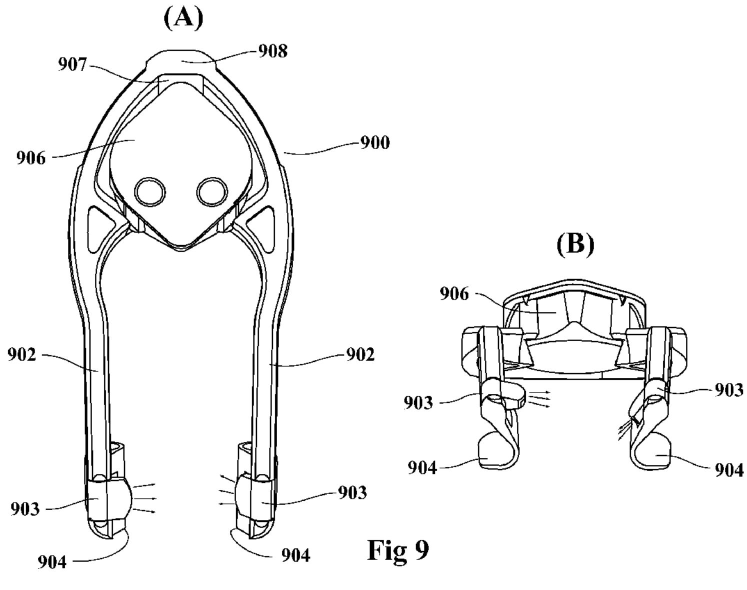


Fig 9

(57) **Abstract**: Disclosed are apparatus for illuminating a central area of an eye by generally lamellar lighting during eye surgery. Basically, a support fixture carrying a light emitter is adapted to be placed adjacent to the surgical field. The support fixture, when in place on an eye, directs light from the light emitter toward the surgical field tangentially to the cornea, at an angle of from about 0 to 90 to the plane of the eye iris. The light entering the eye travels along the lamellae of the cornea in the manner of a light pipe. Very little, if any light reaches the back of the eye, avoiding patient discomfort, or is directed toward the surgical microscope as glare. This generally lamellar lighting combines scleral scatter and retro illumination. In preferred embodiments, the light emitter may be mounted on, or incorporated in, a conventional eyelid speculum or a fixation ring.

WO 2015/164881 A1

ILLUMINATING SPECULUM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/984,482, filed April 25, 2014, the content of which is incorporated by reference in its entirety.

FIELD

[0002] The present disclosure relates generally to an apparatus for illuminating an eye undergoing eye surgery and, more specifically, to an apparatus for illuminating an eye by generally lamellar illumination, combining scleral scatter and retroillumination, during surgery such as astigmatic keratotomy, cataract removal, LASIK, corneal implant surgery, corneal transplant surgeries, glaucoma surgery and the like.

BACKGROUND

[0003] Conventionally, coaxially operating room microscope illumination is used to view the surgical field during eye surgery. Because of observed phototoxic effects of coaxial illumination, various filters or light-dimming techniques have been developed to reduce those effects. Still the operating room microscope places significant light coaxial into the patient's visual axis, which can result in retinal phototoxicity, patient discomfort and corneal drying.

[0004] Illumination approaching perpendicular directly over the pupil enters the eye directly through the pupil and stimulates the most sensitive back surface of the eye. This results in a patient sensation of extreme brightness, associated with discomfort and tearing.

[0005] Axial lighting requires high levels of illumination and the reflected light image must compete with the glare from the projected light. The surgeon can experience difficulties during a procedure with glare that emanates from the axial light source reflecting from the anterior surface of the eye or associated structures and instrumentation.

[0006] The high intensity of axial light is often associated with a drying effect on the anterior structures of the eye secondary to a drying effect on the tear film. This drying can alter the thickness of the cornea and health of the surface tissue of the cornea (corneal epithelium), which in the setting of refractive surgery can result in serious surgical errors and complications. Further, phototoxicity of the posterior structures of the eye (retina) can occur with the use of strong axial microscope lighting and can cause permanent vision loss.

[0007] Thus, there is a continuing need for improved eye illumination apparatus which reduces light intensity, reduces drying effects to the eye decreases the light reaching the back of the eye to reduce patient discomfort and essentially eliminate phototoxicity, reduces glare and light reflected back into the microscope ocular, and provides improved visualization of the surgical field and instrument position.

BRIEF SUMMARY

[0008] The above-noted problems, and others, are overcome in accordance with this disclosure. In some embodiments, an apparatus for illuminating the eye may include one or more supports that a user may place in contact with or close proximity to the eye surface adjacent to, or surrounding, the surgical field, and one or more light emitters on or in close proximity to the support. A light emitter may direct light toward the surgical field. In some embodiments, a light emitter emits light at an angle of from about 0 to about 90 degrees towards select portions of the cornea. In some embodiments, a light emitter may be configured for emitting light at a desired angle, and/or on a desired location of or near the eye. Generally, select portions may include locations where light will not be reflected from the cornea surface back along the eye axis, and generally will not directly pass to the back of the eye. In some embodiments, light rays may be directed at the eye along paths in a slit-like or generally rectangular shape

[0009] In some embodiments, the light may be directed in a ring-like or generally tubular volume, varying from a conical ring when the angle to the iris plane approaches 0 to a tubular volume when the angle approaches 90 degrees of this ring. Such embodiments may provide illumination within which light is not conically focused through the pupil on to the central vision area, the fovea, in the back of the eye.

[0010] When light is presented to the anterior surface of the eye (cornea) or at an acute angle, the cornea acts in the manner of a "light pipe," so that light entering at one edge of the cornea is internally reflected and passes in between and parallel to the anterior and posterior cornea surfaces, to exit 180 degrees away from the entrance illumination. Light may be diffused through the lamellae of the cornea for a distance from the light entrance. Light that projects onto the corneal scleral junction at an acute angel will thus be directed within the corneal lamellae which act as the light diffuser or light pipe.

[0011] When light is presented to the anterior surface of the eye (cornea or sclera) in less acute angles or perpendicular to the iris plane, the light entering the eye is reflected off the iris or other eye structures and so retro-illuminates the cornea and internal structures. Retro illumination provides a quality of light that enhances visibility of certain fine details and thus facilitates surgery.

[0012] Light directed perpendicular to the plane of the iris is by definition parallel to the pupillary/visual axis. However, light so directed will not enter the pupillary axis if the parallel illumination is offset from the pupillary axis. The offset allows for the advantage of retro illumination of the cornea without the disadvantages of focused light coaxial to the pupillary axis. The offset is sufficient to prevent refraction of the offset light by the cornea into the pupillary axis.

[0013] Because the light is not directed perpendicularly through the central area of the pupil, very little light actually enters the eye to cause patient discomfort. Almost no light can enter the eye in a focused manner to reach the central posterior structure and cause photo toxicity to central vision. Similarly, there will be very little reflected light entering the microscope ocular. Instead, light refracted from the cornea projects to the microscope. Consequently, there is essentially no glare in the visualized structures and those visualized can be seen more clearly at lower light levels. This is particularly true when the surgery involves the cornea and involves altering the shape of the cornea through optical (laser) means or when corneal lamellar structures are incised in a procedure such as radial or astigmatic keratotomy or lamellar corneal surgery. In addition, since lower light levels can be used and light enters outside the visual axis or towards the edges of the cornea the drying effect on the anterior surface of the eye is reduced.

[0014] Any of several different embodiments of apparatus for introducing light in this manner at selected eye surface locations may be used, depending on the particular circumstances, such as, for example, the procedure(s) to be performed and the need for illumination of specific tissue.

[0015] In some embodiments, one or more light emitters may be secured to one or both retractor arms of an eyelid speculum assembly. For the purposes of this application, an eyelid speculum assembly, also referred to as a speculum, may refer to both an integral two-arm speculum and a two-cooperating single arm speculum. In some embodiments, the light emitters may be oriented to direct the light into the eye at an angle between about 0 degrees and about 90 degrees. As described above, light may direct pass to the back of the eye or directly reflect back along the eye axis. The light emitters may include, for example, fiber optics and/or light pipes. Some embodiments of a light emitter may include additional optics and filters, such as to direct and focus light, and/or remove undesired wavelengths. A light emitter may conduct light from a remote source to emitting ends, which in some embodiments may be at or near the end of a speculum arm. The fiber optics or other optical system may be supported in any desired manner, such as by running through an opening in a handle or along the exterior of a handle. A number of light sources may be used to provide illumination. For example, incandescent bulbs, light emitting diodes, organic light emitting diodes, laser emitting diodes, including white laser LED, electroluminescent emission, light reflected from a microscope lamp, and other known illuminating devices, may be used to direct light into a light emitter. If desired, the light source and/or light shaping optics may be included in housings attached to speculum arms to more directly provide the required light. The housings may also contain batteries to power the light emitter. In general, for optimum results the light should be directed along a narrow beam or through a narrow linear slit. Focusing optics at the light emitting member can provide the desired beam profile.

[0016] In some embodiments, an apparatus may include one or more light emitters in different locations. For example, some embodiments include one or more light emitting segments positioned in the space between the retracting members of the speculum. In some embodiments, a retractor may act as a fixation point and/or an electrical power supply point for a light emitting segment. For example, in some embodiments a first light emitting segment spans from the superior to inferior nasal edge of the lid retractors, and a second light emitting segment spans the temporal aspect of the lid retractors. These segments may contain, for example, a single LED or multiple LEDs, a focusing optical element, and may electrically connect to the lid retractors. Electrical connections may be through, for example, magnetic contacts or traditional contacts. The speculum may contain a battery and circuitry, and be configured to supply the positive electrical contact to a first retractor, and the negative electrical contact to a second retractor.

[0017] In some embodiments, a ring or partial ring of illumination may be attached to one or more retractors. An illumination ring may provide the fixation point(s) and the electrical power to run the illumination ring or ring segments.

[0018] Some embodiments may include one or more detachable light emitters that insert into the speculum body distal to light source, such as in a channel along the retractor arm. Several different light pipe configurations allow a user to customize the bending of the light and the illuminated area, in a manner that would be advantageous for the particular procedure being performed. For example, in some embodiments, the light pipe may be configured to bend light at about 90 degrees from the axis of the retractor arm, to shine along the axis of the lid retractor. Some light emitters may include a tab used to rotate the light emitter from 0 degrees to 90 degrees relative to the iris plane. Some embodiments of a light emitter may carry the light beyond the retractor and effective bend the light back at up to about 180 degrees, thereby illuminating the nasal aspect of the eye. In some embodiments, a light emitter may inset into a socket in the speculum housing. In some embodiments, the proximal end of the light pipe may be in close proximity to or touch the light source, or a light source coupler. Yet another variation would eliminate the retractors on the speculum housing, and instead would use a retractor light pipe that would insert into the proximal housing near a light source. This retractor light pipe configuration would not only allow the flexibility of changing light shaping optics, but would also allow the surgeon to change the size, shape and configuration of the lid retractor to best match the intended surgery.

[0019] Embodiments of an illuminating speculum may include a speculum handle and a pair of retractor arms extending from the speculum handle. A retractor arm may include a retractor at a distal end or distal from the handle, and a light emitter. In some embodiments, the light emitter illuminates the interior of an eye by lamellar visible light during eye surgery. Light may be made available from a light source, and in some embodiments the light source is housed within a light channel in the retractor arm. A light source may be any light source, such as an LED light source and a fiber optic light source.

[0020] In some embodiments, a housing may be connected to the speculum handle. A retractor arm may have a series of steps, and the housing may have a detent member configured for sequentially engaging each step upon sequential depression of the housing. In these embodiments, each sequentially engaged step causes a distance between the retractors to increase by a predetermined amount. In some embodiments, the housing may be a battery housing. Some embodiments of the battery housing may be detachable from the speculum.

[0021] In some embodiments, a retractor arm may have a side wing, such that a user may apply a force against the side wing, for example, when mounting the speculum to a patient.

[0022] Embodiments of the illuminating speculum may include a light emitter that pivots about an axis to adjust an area of illumination. In some embodiments, the speculum may also feature one or more goose neck light sources. A goose neck light source may protrude from, for example, the speculum handle or a retractor arm.

[0023] In some embodiments of the illuminating speculum, a retractor arm comprises a distally located light channel, and a light pipe may be inserted into the light channel and provide light from a light source. A light pipe may be configured to pivot in the light channel to adjust an area of illumination. Some embodiments of a light pipe have a movable distal end. The movable end may pivot separate from the light pipe, and if the light pipe includes a bend, the movable end may provide an additional axis of rotation for a user to adjust the area of illumination. For example, a light pipe may have a bend and be configured to pivot about a first axis, and the movable end is located distally from the bend and is configured to pivot about a second axis.

[0024] Some embodiments may also feature a light emitting segment that illuminates a region between the retractor arms. A light emitting segment may be removably coupled to the speculum, and may attach to the speculum in various ways as described below. For example, the light emitting segment may be coupled to the speculum by flexible wires, allowing for easy adjustment of the region illuminated by the light emitting segment. Some embodiments may also feature an illumination ring. An illumination ring may removably attach to the speculum, and may illuminate a region between the retractor arms.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The present disclosure is illustrated and described herein with reference to the various drawings, in which like reference numbers denote like method steps and/or system components, respectively, and in which:

[0026] FIG. 1 is a schematic axial section view though an eye illuminated in accordance with the prior art;

[0027] FIG. 2 is a schematic axial section view though an eye illuminated by generally lamellar lighting resulting in scleral scatter;

[0028] FIG. 3 is a schematic axial section view though an eye illuminated by low angle generally lamellar lighting resulting in retro illumination;

[0029] FIG. 3a is a schematic axial section view though an eye illuminated by light entering at approximately 90° to the eye plane along a ring-like path having a diameter such that light does not pass to the back of the eye;

[0030] FIG. 4 is a perspective view of an embodiment of a laminar light emitting means mounted on a speculum;

[0031] FIG. 5 is a plan view, partially cut away, of the apparatus of an illuminating speculum;

[0032] FIG. 6 is a plan view, partially cut away, of an embodiment of a laminar light emitting means mounted on an eyelid speculum;

[0033] FIG. 7 is a plan view, partially cut away, of an embodiment of a laminar light emitters mounted on an eyelid speculum;

[0034] FIG. 7a is a plan view of a variation of the embodiment shown in FIG. 7;

[0035] FIG. 7b is a section view taken on line 7b--7b in FIG. 7a;

[0036] FIG. 8 is a left elevation view of the embodiment shown in FIG. 7;

[0037] FIG. 9 shows various views of an embodiment of an illuminating speculum;

[0038] FIG. 10 shows various view of an embodiment of an illuminating speculum;

[0039] FIG. 11 shows an embodiment of a battery contact switch configuration;

[0040] FIG. 12 shows an embodiment with a replaceable battery;

[0041] FIG. 13 is a view of an embodiment of an illuminating speculum locking mechanism;

[0042] FIG. 15 shows a view of an embodiment with goose neck illumination;

[0043] FIG. 16 shows an embodiment of an illuminating speculum having retraction blade light emitters;

[0044] FIG. 17 illustrates an embodiment of a rotating light emitter;

[0045] FIG. 18 shows an embodiment of an illuminating speculum having a light emitter with a movable end;

[0046] FIG. 19 is a drawing of an embodiment of an illuminating speculum having a light emitting segment; and

[0047] FIG. 20 shows an embodiment of an illuminating speculum having a light emitting ring with adjustable metal contacts.

DETAILED DESCRIPTION

[0048] The present approach may be understood more readily by reference to the following detailed description of various embodiments, taken in connection with the accompanying drawings, which form a part of this disclosure. It is to be understood that this disclosure is not limited to the specific embodiments, apparatus, devices, methods, or parameters described and/or shown herein, and that the terminology used herein is for the purpose of describing particular embodiments by way of example only, and is not intended to be limiting of the claims. Any and all patents and other publications identified in this specification are incorporated by reference as though fully set forth herein.

[0049] Also, as used in the specification including the appended claims, the singular forms “a,” “an,” and “the” include the plural, and reference to a particular numerical value includes at least that particular value, unless the context clearly dictates otherwise. Ranges may be expressed herein as from “about” or “approximately” one particular value and/or to “about” or “approximately” another particular value. When such a range is expressed, another embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent “about,” it will be understood that the particular value forms another embodiment.

[0050] FIG. 1 is an axial section through an eye 10, schematically illustrating the light path of axial lighting 12 from a conventional microscope lighting system (not shown). As shown, a portion 14 of the light passes directly through cornea 15 to the back of the eye, causing discomfort to the patient. Another portion 16 of the incident light reflects from the front surface of the eye, causing glare. Only a small part 18 of the light is reflected from incisions and the like within the iris. Thus, a surgeon must use rather intense light to receive sufficient feedback light from the areas of surgical interest.

[0051] FIG. 2 shows the path of light 20 which enters eye 10 at a low angle nearly parallel with the plane of the iris and cornea 15. This lighting, termed "generally lamellar lighting", which is primarily sclerotic scatter, directs the light into the lamellae of cornea 15 where it follows the path shown in the manner of a light pipe until a disruption such as incision 22 is encountered to scatter light 23, making the incision particularly visible to the surgeon viewing the incision through a surgical microscope. As seen in FIG. 3, some light 24 entering as retro illumination at a higher angle may pass through the cornea and be reflected at the eye interior. Light reflects off the surface of the eye at an angle that prevents direct entrance into the axis of the operating microscope and thus prevents glare. Light 26 reflected from internal structures such as iris 21 is attenuated and provides a back lit (retro illumination) of the cornea. Such illumination significantly enhances visualization of fine corneal detail. Light scattered by any object, such as an embedded foreign body, or incision in the eye or any corneal discontinuities (not shown) will scatter light in the manner shown in FIG. 2 and become visible through the microscope. Because of the acute entrance angle, only a very small portion of the entering light will reach the back of the eye, avoiding patient discomfort.

[0052] Offset lamellar lighting is illustrated in FIG. 3a, with the lighted directed parallel to the eye axis (90 provides both retro illumination and sclerotic scatter with the benefits described above. The offset nature of the narrowly focused beam prevents direct or refracted light from entering the pupillary axis.

[0053] Because generally lamellar lighting causes any corneal discontinuity to scatter light in the absence of associated glare, and with a relatively dark background, these discontinuities glow brightly allowing excellent visualization. For example, in incisional refractive surgery, the incisions glow and the diamond knife intercepts the light and pipes it toward the diamond tip, making the exact location of the diamond tip easily visualized. These advantages are not possible with conventional microscope lighting.

[0054] Thus generally lamellar lighting, which is a combination of scleral scatter and retro illumination, avoids significant light impact on the back of the eye and associated patient discomfort and phototoxicity. Generally lamellar lighting also avoids glare which makes viewing a surgical field through a microscope difficult. Light may enter the eye at an angle of from about 0 degrees to about 90 degrees using embodiments of the apparatus hereinafter described. In particular circumstances, a particular angle within that range may be preferred. The iris is the contractile circular diaphragm forming the colored portion of the eye. The plane of eye iris 21 for the purposes of this application is considered to be the plane in which the outer edge of the iris substantially lies.

[0055] In some embodiments of an illuminating speculum, as seen in the embodiments shown in FIGS. 4-6, a housing 28 containing a light source 30 is mounted on, or formed as part of, a conventional eyelid speculum 32. Speculum 32 includes two arcuate members 34, also referred to as lid retractors or retractors, mounted on arms 36 and shaped to engage and spread apart a patient's eyelids 38 to keep a central surgical field clear. The embodiment shown in Fig. 4 includes a fiber optic light source 30, in which the fiber optic bundle 40 splits into two fibers along the retractor arms 36. The embodiment shown in Fig. 5 includes an LED as the light source 30. Fig. 6 shows an embodiment in which retractor arms 46 include a plurality of fiber optics 54, splitting from fiber optic bundle 50. One of ordinary skill should appreciate that numerous light sources and light source configurations may be used in an embodiment, without departing from the principles described herein.

[0056] Each housing 28 may include an elongated opening 42 oriented to direct light into the eye as shown in FIG. 2. Opening 42 may have any suitable dimensions. In general, a relatively thin slit may be used, oriented at a predetermined angle to the eye plane within a range of from about 0° to 90°. The interior of housing 28 is preferably highly reflective. Any suitable light source 30 may be used. While a light emitting diode as shown is preferred in this embodiment, a combination LED and laser source may be utilized in unison. Alternatively, a changing color source may also be included to allow different views. Additionally, the light source 30 on each arm 36 may contain a plurality of LEDs or laser sources.

[0057] The speculum 32 may contain an LED that produces white light illumination and an LED that can emit light in the UV range, including, for example, at wavelengths above 250 nm. In this embodiment, the light source 30 of the speculum 32 changes from a regular white light illumination to UV light. A speculum 32 with white LEDs and UV laser LEDs may be utilized to accelerate a corneal crosslinking procedure and so reduce operating room time. In some embodiments, the light source 30 and/or a light emitter may include a rotatable portion, such that the light emitted from the device may be directed as desired by the user.

[0058] FIG. 6 shows an alternate arrangement in which an eyelid speculum 44 includes two hollow retractor arms 46, each of which has a pair of "U" or "J" shaped retractors 48 sized to retract eyelids from the surgical field. Fiber optic bundles 50 extend down handle 52 and along each arm 46, terminating in emitting ends 54 spaced along arms 46. The fiber optic bundles may extend within handle 52 as shown or may be supported along the handle exterior. Ends 54 are preferably in a plane radially oriented toward the center of the pupil, parallel to the iris plane when the speculum is in place. As before, the light from light emitting ends 54 enters the eye at a predetermined angle or range of angles to the plane of the iris of from about 0° to 90°. Any suitable source of light may be used to introduce light into the receiving ends of fiber bundles 50 in handle 52 or beyond. Typical light sources include incandescent bulbs, light emitting diodes, light reflected from the normal microscope illumination system, laser, electro luminescent panels, etc.

[0059] A further embodiment of a speculum-mounted generally lamellar light source is shown in FIGS. 7 and 8. Here, speculum 58 includes retractor arms 60, handle 62 and retractor members 64 for restraining the eyelids. A light pipe 65, formed from conventional light pipe materials includes rods 66 extending from handle portion 68 and generally trapezoidal light emitting ends 70. As is usual, the light pipe 65 is internally reflecting except for a line 74 along the surface facing cornea 72.

[0060] The partial slit of light produced by light pipe can enter the eye at any predetermined angle between about 0° to 90° to the eye plane by selecting the distance between line 74 on opposite sides of the eye and the orientation of the line toward the eye. The facing surface may be planar or curved, generally conforming to the cornea edge, and may include focusing optics to accomplish a desired beam profile, as desired. Any suitable source of light may be used to introduce light into the light receiving end (not shown) of light pipe 65 in handle 68 or beyond. In an additional alternative, the entire speculum could be fabricated from light pipe material having sufficient flexibility so that the arms can be compressed together and released to retract the eyelids.

[0061] In an additional alternative, using the general structure of FIGS. 7 and 8, a line of electro luminescent material could be employed along line 74, with ends 70 being simple supports and power wires running along rods 66 in place of the light pipe materials. While in many cases the light pipes are preferred for higher possible illumination levels, the electro luminescent panels may provide sufficient light for certain forms of eye surgery. Alternatively, a line of micro LEDs may be employed along line 74 in a similar fashion.

[0062] FIGS. 7a and 7b show another embodiment. In this embodiment, the speculum is mounted on arms 60 extending from handle portion 68, with ends 70 being hollow tubes on which retractor members 64 are mounted. Ends 70 house and frictionally engage ends of a light pipe 65, although a light pipe may be supported differently in other embodiments. An elongated slot 71 is formed along a portion of each end 70, extending radially around a portion of the end 70.

[0063] A focusing lens 73 may be an integral part of the light pipe or may be secured to the light pipe end within slot 71 by adhesive bonding or the like. Typically, lens 73 will condense light emitted by light pipe 65 on the surface of the eye or at some other desired distance from the light pipe. By moving tab 75, the focused beam's angle of incidence could be changed to any desired angle between 0° and 90°.

[0064] If desired, lens 73 may be omitted and the surface of light pipe 65 could be coated with an opaque material, leaving an uncoated, light transmitting line corresponding to the base of lens 73. That light emitting line could be moved transverse to the length of slot 71 by manually moving tab 75. With this version, slot 71 could be replaced with a plurality of spaced, parallel slots, so that the light pipe could be rotated to align the light emitting line with any individual slot, so that light would be emitted at a precise selected angle.

[0065] A tab 75 is fastened to light pipe 65 adjacent to end 70 so that the light pipe can be rotated to move focusing lens 73 along slot 71 so that the light can be concentrated at an angle to the iris plane of from about 0° to 90°. Of course, any of the other illumination means described herein, such as LED's and the like could be used in this embodiment in a manner similar to the other speculum embodiments. Additionally, one of ordinary skill should appreciate that a light emitter may be located in various locations in a speculum, such as, for example, a retractor.

[0066] Figure 9 illustrates speculum 900 consisting of arms 902 which terminate with lid retractors 904. The lid retractors 904 contain LED housings 903 which are capable of rotational adjustment generally along the axis of arms 902 and retractors 903. The speculum arms 902 are connected at speculum handle 908 from which a flexible member 907 extends that connects battery housing 906 to arms 902.

[0067] Figure 10 illustrates an exploded view of the speculum embodiment shown in Figure 9. Speculum 1000 consists of an upper cover 1005 and a lower base 1015. Sandwiched between the cover 1005 and base 1015 is a lighting module 1011. Lighting module 1011 includes an integrated power source 1001 that provides power and microprocessor logic to wire leads 1010. Wire leads 1010 power LEDs or other light sources 1008. The LEDs 1008 may be sealed in an LED housing 1003. The LED housings 1003 in this embodiment include an upper LED cover 1013, the LEDs 1008, an optional light filter 1009, a light shaping optic 1023 and a lower base 1033. The proximal and distal sides of upper LED cover 1013 in this embodiment include pivot protrusions 1007 that secure the LED housing 1003 to the lower speculum base 1015 and retractors 1004 by means of a pivot receptacle 1014. Lighting module 1011 with completed LED housing 1003 may be placed into battery housing 1026 with wire leads 1010 placed in wire recess 1017 and LED housings 1003 secured into pivot receptacle 1014. In embodiments with a light source other than an LED, the retractor arms may include a light emitter 1003.

[0068] Upper speculum cover 1005 may then seal any exposed wire leads 1010 and integrated power source 1001. Once all parts are secured, the LED housings 1003 can pivot from 0 degrees to 90 degrees. This is demonstrated in Figure 9, where LED housings 903 are shown in different angles of inclination relative to lid retractors 904.

[0069] The speculum embodiments illustrated in Figures 9-20 may contain an integrated power source, such as the integrated power source shown in Figure 11. In Figure 11, the integrated power source 1101 may contain a single battery or multiple batteries 1102, to power one or more light sources. Some embodiments may include a microprocessor 1103 that may be combined with the integrated power source 1101 for controlling and regulating the power flow from the batteries 1102 to operate one or more light sources 1008. An integrated power source 1101 with or without a microprocessor 1103 may be utilized for the goose neck light source described above, as well as with other embodiments described herein. The battery housing 1013 may be completely sealed, so as to prevent contamination of the integrated power source 1006. In some embodiments, the battery housing 1013 may be opened sufficiently to replace the power source. In some embodiments, the battery may be removable for disposal, such as disposal separate from a speculum. In some embodiments, the battery housing 1013 itself may be detachable from the speculum for disposal.

[0070] Embodiments may include an activation switch that, when depressed, may activate a light source. In some embodiments, activation of a light source may be through an algorithm included on a microprocessor. For example, an algorithm may provide successive increases in illumination power upon subsequent depressions, until reaching a cutoff count. In the embodiment shown in Fig. 11, an activation switch 1104 is engaged to the center of battery housing upper lid 1016 for activating the light source. The activation switch 1104 may be, for example, a sealed push switch or other mechanical switch, and in some embodiments may include a plunger that may be depressed to open or close the switch. Some embodiments may incorporate a magnetic reed switch, such as a magnetic reed switch that contains at least a pair of magnetized, flexible, metal reeds with end portions separated by a gap when the switch is open. In some embodiments, a removable element, such as a thin film or opaque tab, may be placed in the speculum circuit path, such that, when the opaque tab is removed, the sensor is activated to cause the microprocessor to turn on the light source(s) of the speculum. In some embodiments, a light sensing element may be included in the speculum circuit path, such that uncovering a light sensor window (e.g., by removing an opaque tab), activates the light sensing element and activates the light source. Subsequent covering and uncovering the light sensor window may disable the light source. For example, covering the window may provide a digital instruction signal to allow the microprocessor to sequence through a variety of lighting options. In some embodiments, capacitance sensing switches 1105 may be used to cycle a microprocessor through one or more lighting options and/or configurations.

[0071] The speculum 1001 may contain a battery housing 1013 for housing one or more batteries. The battery housing 1013 may contain a rotatable or removable lid 1012 for accessing a cavity contained within the battery housing 1013 for housing a battery or batteries 1014 or batteries 1102 shown in Fig. 11. The battery housing 1013 may be completely sealed for preventing battery source contamination or selectively secured by a retention means (screw or spring clasp) or friction fit. Some embodiments may include an LED may be positioned on the battery housing for providing a light source from the temporal direction. Alternatively, a plurality of electrical sockets could be provided anywhere in the speculum to allow additional attachable light sources or of the flexible or rigid variety.

[0072] Embodiments may include a housing for an integrated power supply, such as a battery. In some embodiments, a battery housing may be detachable, and thereby easily replaced, such as during an operating procedure. The embodiment of Figure 12 illustrates speculum 1200 with a detachable battery housing, 1216. The detachable battery 1216 housing may attach to a speculum in one or more manners. For example, embodiments may use protrusion-and-groove mating configurations, magnetic attachment, or combinations thereof, to connect a battery housing to a speculum. Electrical contacts 1218 and 1220 allow the electrical connection between the detachable battery housing

1216 and the speculum battery receptacle 1226. In this manner, a battery housing may be reused for multiple speculums that, according to standard and accepted medical practices, should be disposed of after use. In some embodiments, the power supply for a speculum may be replaced or re-charged to prolong use of the speculum. For example, some embodiments may include a charging connection to receive a power supply from an external power source. In another embodiment a speculum battery receptacle connection could be configured in the same form as the replaceable battery housing using similar placement of electrical contacts and so allow an external power connection into battery receptacle 1226. Some embodiments may include replaceable batteries.

[0073] The speculum and any components of the speculum may be composed of various materials, such as plastic. Some embodiments may be designed for a single use and disposable. Alternatively, embodiments of the speculum and any components of the speculum may be composed of metal or plastic, and may be designed for multiple. For example, some embodiments may be configured for easy sanitized.

[0074] As illustrated in Figs. 13 A and B, the speculum 1300 may include a detent mechanism 1312 and corresponding series of steps 1314. The detent mechanism 1312 may be disposed on the external side of the battery housing 1306 or other central structure of the speculum handle, and the series of steps 1314 may disposed externally of a surface of the housing, such as, for example, of an outcrop on the retractor arm 1302 and facing towards the battery housing 1306. It should be appreciated that the relative locations of detent mechanism 1312 and corresponding steps 1314 may be reversed in some embodiments. The retractor arms 1302 extend from the speculum handle and are biased with a spring tension to the normal desired opening dimension of the speculum. In the embodiment in Figs. 13 A and B when the battery housing 1306 is depressed, the interaction between a detent mechanism 1312 and a corresponding series of steps 1314 counteracts the spring tension to expand the distance between retractor arms 1302 from “X” to “Z”. In some embodiments, the series of steps 1314 may be configured to provide controllable degrees of retractor arm opening. In some embodiments, the battery housing 1306 may be depressed to counteract the spring tension when the patient attempts to squeeze their eyelids in an attempt to shut them during a procedure. It should be noted that a speculum 1300 including detent mechanism 1312 and corresponding steps 1314 may be positioned apart from the battery housing 1306. Additionally, in some embodiments a speculum 1200 may include detent mechanism 1312 and corresponding steps 1314, without a light source or integrated power supply.

[0075] In the embodiment shown in Figs. 13, when the battery housing is depressed, the detent mechanism 1312 engages the first step in the series of steps 1314. In response, retractor arms 1216 extending from the speculum handle are pushed outwards. As the battery housing 1306 is further depressed, the detent mechanism 1312 engages to the next step 1314, causing the retractor arms 1216 to push further outwards. One of ordinary skill should appreciate that although these embodiments show battery housing 1306 as the structure for engaging the detent mechanism 1312 and corresponding steps 1314, some embodiments may use another portion of the speculum 1200, such as an additional push button or lever, to do so.

[0076] Fig. 14 shows an embodiment in which a side wing 1418 is included on speculum 1400. In this embodiment, retractor arms 1402 extending from the speculum handle include a side wing 1418. When pressure is applied to side wing 1418 in order to compress the retractor arms 1402 into a closed position, the speculum arms 1402 and retractors 1404 rotate vertically to the midline along a rotation point, such that the edges of the retractors 1404 contact each other and provide a very narrow profile in order to get in between the eyelids. When releasing the compression of the side wings 1418, the retractor arms 1402, and the retractors 1404 will rotate along a rotation point back to the non-compressed configuration and in doing so will gently lift and open the eyelids into the desired position needed for good visualization of the eye.

[0077] Embodiments may include one or more “goose neck” light sources to provide additional illumination, and illuminate from different directions. In the embodiment shown in Fig. 15, speculum 1500 includes a pair of a “goose neck” light source 1530. It should be understood that some embodiments may feature one goose neck light source 1530, whereas other embodiments may feature multiple goose neck light sources 1530. A goose neck light source 1530 generally includes an elongate, flexible portion 1531 that can be rotated in the x, y, and z axis or just the x, y axis. In some embodiments, the goose neck light source 1531 includes a flexible material with enough rigidity to stay in place once positioned by the user, and may be reconfigured as desired. The goose neck light source may be powered by battery 1504. In some embodiments, goose neck light source 1530 may be powered by its own individual battery or batteries or a shared battery or batteries for two or more goose neck light sources. Goose neck light sources 1530 may also originate from any location between the battery 1504 and terminal retractors including proximal and distal battery housing or speculum arms locations. For example, a goose neck light source 1530 may protrude from a speculum handle or housing 1504, or from a retractor arm, as shown in Fig. 15. The goose neck light source 1530 may be inserted into a socket disposed on the speculum 1500 that provides power to an electrical connector 1506 that may mate with goose neck light source connector 1508.

[0078] Some embodiments may include light pipes that fit into a retractor arm. In some embodiments, a light pipe may be removable for, as examples, convenient replacement and/or adjustment. In the embodiment shown in Fig. 16, speculum 1600 includes a battery and circuitry housing 1601, and retractor arms extending therefrom. A retractor arm includes a light source 1602, such as an LED, and an open channel for receiving light pipe 1605. In some embodiments, a retractor arm may also include an optic and/or light filter device 1603. A filter 1603 may be placed adjacent the light source 1602 that passes light of a specific polarization and blocks waves of other polarizations. One of ordinary skill should appreciate that optical filters, such as a polarizer, may also be located elsewhere, such as at the location where light exits. The optical filter 1603 can convert a beam of light of undefined or mixed polarization into a beam with well-defined polarization, polarized light that when viewed with a polarizing analyzer in a microscope, and allows the user to see stress lines in the cornea. The optical filter 1603 may be a polarizing optical filter, cross-polarizing filter, or the like. In other embodiments, a diffuser, such as diffuser 1009 shown in Fig. 10, may be placed adjacent the light source 1008 for diffusing the light emanating from the light source

1008 into a uniform slit beam. Similarly, an optical filter could be placed in front of an illumination source and/or an optic located in the blades or retractors of the speculum, the battery housing, or a separated LED attachment arm.

[0079] A retractor arm may also include a securing device 1604, such as an o-ring or gasket, to secure light pipe 1605. The securing device may induce a friction fit, such that light pipe 1605 may be re-positioned both depth-wise in the channel and/or rotationally, with the application of sufficient force. Light pipe 1605 may include a hollow channel for light 1606 to travel for emission through a light pipe end, as seen with emitted light 1607. In some embodiments, the emitting end of a light pipe 1605 may include an optic and/or light filter device, such as focus lens 1608. In the embodiment shown in Fig. 16, focus lens 1608 focuses light 1606 to illuminate a smaller target 1609. It should be appreciated that numerous optics and filters may be used to produce desired effects.

[0080] As referenced above, a light pipe may be configured to rotate about an axis. Rotating a light pipe (or other light emitter) about an axis from a first position to a second position may change the illuminated region. Although several embodiments are described that include light pipes, it should be understood that other light emitters, such as illuminating wires, LED structures, and the like, may be used. In the embodiment shown in Fig. 17, speculum 1701 includes retractor arm 1702. Retractor arm 1702 includes a hollow channel, in which light source 1703, such as an LED, is located, and an opening 1708 through which a light pipe 1706 may be inserted. Some embodiments may include a securing device, such as o-ring 1704, to secure the light pipe 1706 in the desired position in the hollow channel. Some embodiments of light pipe 1706 may include a tab 1705, which may be used to change the position of the light pipe 1706 relative to the retractor arm 1702. For example, tab 1705 may be pushed toward or away from retractor 1707 to rotate light pipe 1706, thereby changing the illuminated area. In some embodiments, the retractor arm 1702 may include a contact surface beyond the opening 1708 to provide support for the light pipe 1706. The contact surface may also limit the rotational movement of light pipe 1706. For example, tab 1705 may be positioned on the light pipe 1706 such that the tab 1705 will contact a portion of the retractor arm 1702 at a fully rotated position. In some embodiments, retractor arm 1702 may include a stopping structure to limit rotation of the light pipe 1706, such as to reduce wear and tear.

[0081] Some embodiments may include a light pipe having a movable end. The movable end may be adjusted to change the illuminated region. For example, Fig. 18 shows an embodiment of a speculum 1800 in which light pipes 1806 include a rotating end 1807. In this embodiment, speculum 1800 includes a battery and circuitry housing 1801 with corresponding steps 1802, such as described above. Retractor arms 1803 extend away from the battery and circuitry housing 1801, and may include a light source 1804 such as an LED. The light source 1804 may be within a hollow channel in retractor arm 1803. Some embodiments may include a transparent and/or translucent material through which light from the light source 1804 may travel. Light from the light source 1804 may pass through light pipe 1806, and ultimately through movable end 1807. As described above, light pipe 1806 may fit into a channel in the retractor arm 1803. A securing device such as o-ring 1808 may be used to secure the light pipe 1806 in a desired position. For example, o-ring 1808 may apply sufficient force against light pipe 1806, such that a sufficient force must be applied to re-position the light pipe 1806. In the embodiment shown in Fig. 18, light pipe 1806 includes movable end 1807. Movable end 1807 may rotate or swivel about an axis to change the illuminated area. 1812, by redirecting light path 1810 as shown in Fig. 18. Thus, a user may manipulate the movable end 1807 with a tab 1813 to direct the illumination to the desired location. Embodiments may include tab 1809 on the movable end 1807, to provide a surface for a user to apply force and rotate the movable end 1807.

[0082] In some embodiments, light pipe 1806 may include one or more bends. For example, the light pipes 1806 shown in Fig. 18 include a single bend of approximately 90 degrees, as the light pipe 1806 exits the retractor arm 1803. The light pipe 1806 may include internal reflective surfaces to direct light from light source 1804 through the bend. Advantageously, the non-linear shape of the light pipe 1806 may be used in connection with the retractor arm 1803 to allow the light pipe 1806 to rotate completely about an axis. Whereas the light pipe in the embodiment shown in Fig. 17 is limited in terms of its ability to rotate about different axes due to the structure at the end of the retractor arm 1702, the light pipe in Fig. 18 may completely rotate about a common axis with the retractor arm 1803. As a result, a user may rotate the light pipe 1806 and adjust the movable end 1807, to have more precise control over the illuminated area.

[0083] Some embodiments may provide for additional illumination, and/or illumination from a repositionable light emitting segment. For example, some embodiments may include one or more light emitting segments positioned in the space between the retracting members of the speculum. Fig. 19 shows an embodiment of a speculum (not shown) in which light emitting segment 1912 is attached to the distal end of retractor arms 1901 and 1902. A light emitting segment may be attached to a speculum in several ways, such as hardwired to a speculum light and/or power supply, magnetic attachment, clip-on or snap-on attachment, as examples. The embodiment in Fig. 19 includes light emitting segment 1912 attached to metal contacts 1905 and 1906, to provide power from a speculum power supply to the light emitting segment 1912. In this embodiment, the light emitting segment may include magnetic contacts 1910 for attachment to the speculum. It should be appreciated that other methods may be used to connect a light emitting segment to a speculum.

[0084] The light emitting segment 1912 may connect to a speculum through various structures, such as rigid extensions, flexible extensions, and the like. Fig. 19 shows light emitting segment connected through flexible wires 1908 and 1909, which a user may manipulate to adjust the emitted light 1913. In some embodiments, a retractor may act as a fixation point and/or an electrical power supply point for a light emitting segment. For example, in some embodiments a first light emitting segment spans from the superior to inferior nasal edge of the lid retractors, and a second light emitting segment spans the temporal aspect of the lid retractors. These segments may contain, for example, a single LED or multiple LEDs, a focusing optical element, and may electrically connect to the lid retractors. Electrical connections may be through, for example, magnetic contacts or traditional contacts. The speculum may contain a battery and circuitry, and be configured to supply the positive electrical contact 1905 to a first retractor, and the negative electrical contact 1906 to a second retractor. It should be appreciated that other methods for supplying power to a light emitting segment may be used without departing from the principles described herein.

[0085] In some embodiments, a ring or partial ring of illumination may be attached to a speculum to provide additional illumination. An illumination ring may provide the fixation point(s) and the electrical power to run the illumination ring or ring segments. Fig. 20 shows an embodiment in which retractor arms 2001 and 2002 connect to an illumination ring 2005 through flexible metallic ribbon guides 2003 and 2004. The embodiment shown in Fig. 20 has ribbon guides that extend from a medial portion of retractor arms 2001 and 2002, to a connection point on the illumination ring 2005 at about the midpoint of the retractor blades. It should be appreciated that the length and relative start and end points of the ribbon guides, or other attaching structures, may vary in different embodiments. For example, attaching structure may protrude from top or side surfaces of a retractor arm in some embodiments, and may connect to an illumination ring 2005 at locations other than as shown in the drawing. It should also be appreciated that other methods of attaching an illumination ring to a retractor arm may be used, such as flexible wires and semi-rigid polymers. In some embodiments, the speculum may provide light and/or power to illumination ring 2005. In some embodiments, the position of illumination ring 2005 may be adjusted by manipulating the flexible metallic ribbon guides 2003 and 2004. In some embodiments, illumination ring 2005 may include magnetic contacts. Magnetic contacts may be positioned at or along, for example, an outer edge of the ring 2005, to allow for attachment to electrically-powered retractors or other power-providing contacts provided on the speculum. One of ordinary skill should understand that other methods for connecting an illumination ring 2005 to a speculum may be used, such as, for example, rigid extensions, flexible extensions, and the like. Although the illumination ring 2005 in Fig. 20 is shown as being a complete ring, other embodiments may employ a partial ring, such that only an arc length is present. A partial illumination ring may allow access for various medical devices that may be unattainable with a complete illumination ring. In some embodiments, illumination ring 2005 may be configured to hold various surgical lenses. In some embodiments, illumination ring 2005 may be configured to hold multiple light sources, such as LEDs, placed at various inclinations. For example, LEDs may be placed at inclinations from 0 degrees to 90 degrees relative to the plane of the iris. Some embodiments may include a microprocessor configured to operate lights sources according to various algorithms, such as to provide various illumination conditions. It should be apparent that numerous illumination conditions may be provided, as desired. In some embodiments, the illumination ring 2005 may include a light source mounted on a flexible housing. In such embodiments, a user may alter the shape of the illumination ring 2005 to suit particular purposes.

[0086] Although the present approach has been illustrated and described herein with reference to preferred embodiments and specific examples thereof, it will be readily apparent to those of ordinary skill in the art that other embodiments and examples may perform similar functions and/or achieve like results. All such equivalent embodiments and examples are within the spirit and scope of the present approach and are intended to be covered by the following claims.

CLAIMS

What is claimed is:

1. An speculum apparatus for illuminating an eye, the apparatus comprising:

a speculum handle;

a pair of retractor arms extending from the speculum handle, each retractor arm comprising

a retractor located distally from the speculum handle, and

a light emitter.

2. The apparatus of claim 1, wherein the light emitter is configured to illuminate the interior of an eye by lamellar visible light and UV light above 250 nm during eye surgery.

3. The apparatus of claim 1, wherein a retractor arm further comprises a light source.

4. The apparatus of claim 3, wherein a retractor arm further comprises a light channel, and the light source is housed within the light channel.

5. The apparatus of claim 3, wherein the light source is one of an LED light source, fiber optic light source, white laser LED light source, electroluminescent emission light source, and light reflected from a microscope lamp.

6. The apparatus of claim 1, further comprising a housing connected to the speculum handle, wherein a retractor arm comprises a series of steps and the housing comprises a detent member configured for sequentially engaging each step upon sequential depression of the housing, each sequentially engaged step causing a distance between the retractors to increase by a predetermined amount.

7. The apparatus of claim 1, further comprising a battery housing connected to the speculum handle and configured to provide power to a light emitter.

8. The apparatus of claim 7, wherein a retractor arm comprises a series of steps and the housing comprises a detent member configured for sequentially engaging

each step upon sequential depression of the housing, each sequentially engaged step causing a distance between the retractors to increase by a predetermined amount.

9. The apparatus of claim 1, wherein a retractor arm further comprises a side wing.

10. The apparatus of claim 1, wherein the light emitter is configured to pivot about an axis to adjust an area of illumination.

11. The apparatus of claim 1, further comprising a goose neck light source.

12. The apparatus of claim 11, wherein the goose neck light source protrudes from one of a speculum handle and a retractor arm.

13. The apparatus of claim 1, wherein each retractor arm comprises a distally located light channel, and a light emitter comprises a light pipe configured for insertion into the light channel.

14. The apparatus of claim 13, wherein the light pipe is configured to pivot in the light channel to adjust an area of illumination.

15. The apparatus of claim 14, further comprising a light source housed within the light channel.

16. The apparatus of claim 14, wherein the light pipe extends distally beyond a most distal end of a retractor arm.

17. The apparatus of claim 13, wherein the light pipe comprises a movable end at a distal end of the light pipe, the movable end configured to pivot.

18. The apparatus of claim 17, wherein the light pipe comprises a bend and is configured to pivot about a first axis, and the movable end is located distally from the bend and is configured to pivot about a second axis.

19. The apparatus of claim 1, further comprising a light emitting segment configured to illuminate a region between the retractor arms.

20. The apparatus of claim 19, wherein the light emitting segment is removably coupled to the speculum.

21. The apparatus of claim 19, wherein the light emitting segment is coupled to the speculum by flexible wires configured for adjusting a region illuminated by the light emitting segment.

22. The apparatus of claim 1, further comprising an illumination ring configured to illuminate a region between the retractor arms.

23. The apparatus of claim 22, wherein the illumination ring is removably coupled to the speculum.

24. An speculum apparatus for illuminating an eye, the apparatus comprising:

a speculum handle;

a pair of retractor arms extending from the speculum handle, each retractor arm comprising

a retractor located distally from the speculum handle,

a light channel,

a light source contained in the light channel, and

a light pipe configured to pivot in the light channel to adjust an area of illumination.

25. An speculum apparatus for illuminating an eye, the apparatus comprising:

a speculum handle;

a pair of retractor arms extending from the speculum handle, each retractor arm comprising

a retractor located distally from the speculum handle, and

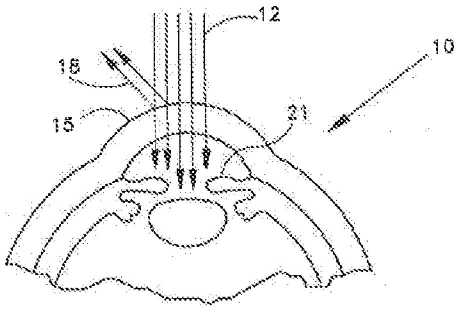
a light emitter,

a housing connected to the speculum handle,

wherein each retractor arm comprises a series of steps and the housing comprises a detent member configured for sequentially engaging each step upon sequential depression of the housing, each sequentially engaged step causing a distance between the retractors to increase by a predetermined amount.

26. The apparatus of claim 25, wherein the housing comprises a battery housing.

27. The apparatus of claim 26, wherein the battery housing is removably attached to the speculum handle.



PRIOR ART

FIG 1

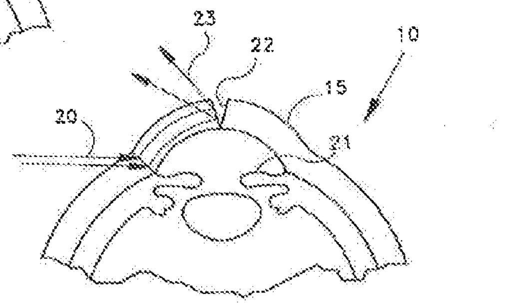


FIG 2

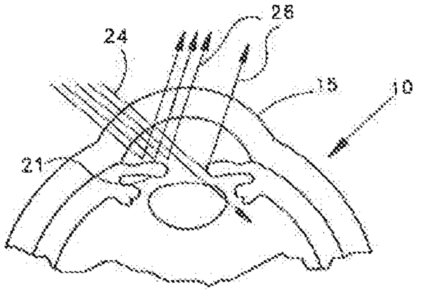


FIG 3

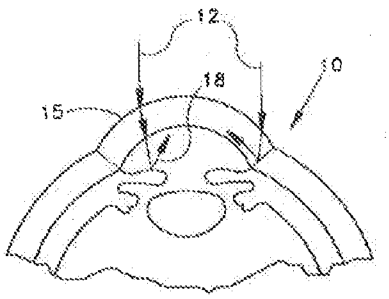


FIG 3a

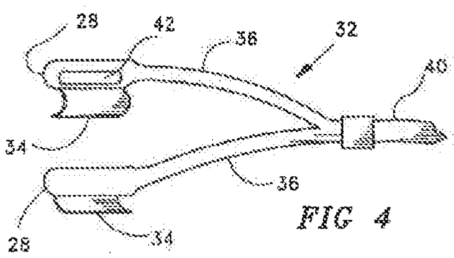


FIG 4

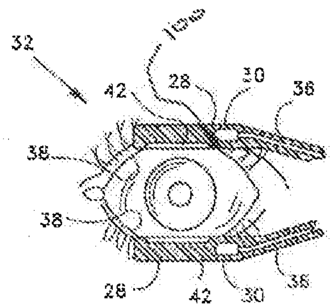


FIG 5

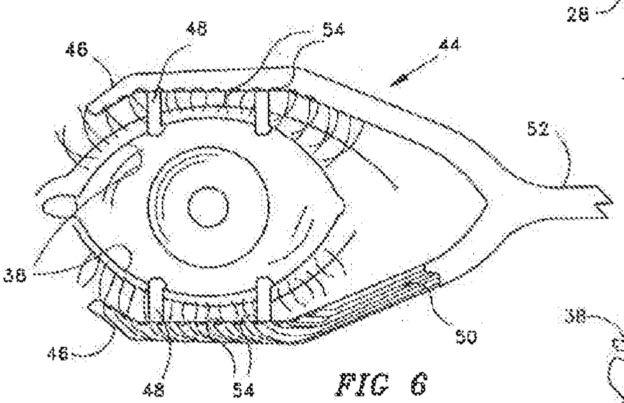


FIG 6

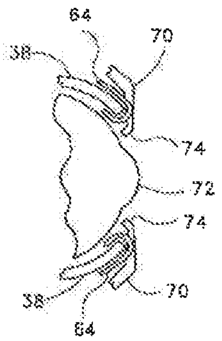


FIG 8

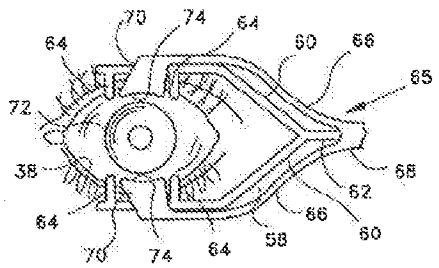


FIG 7

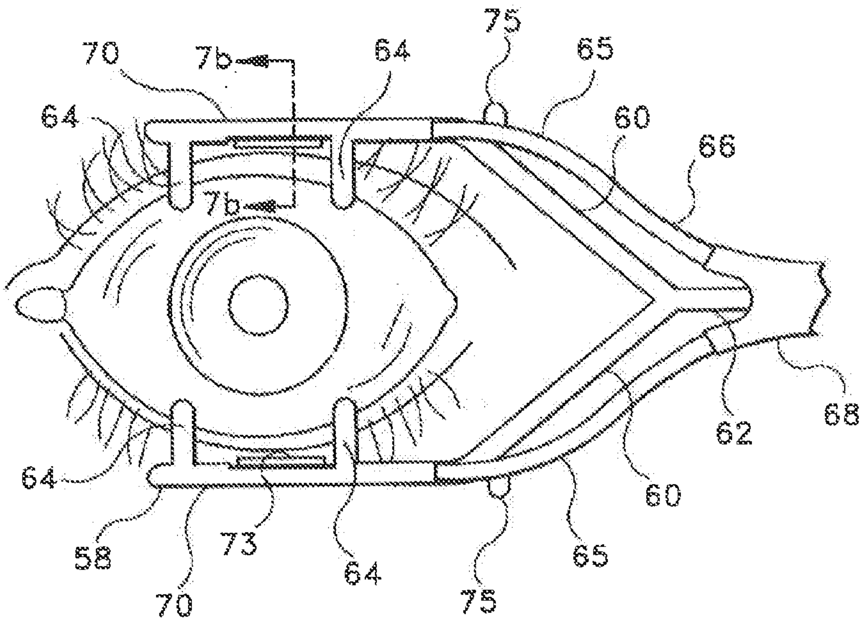


FIG 7a

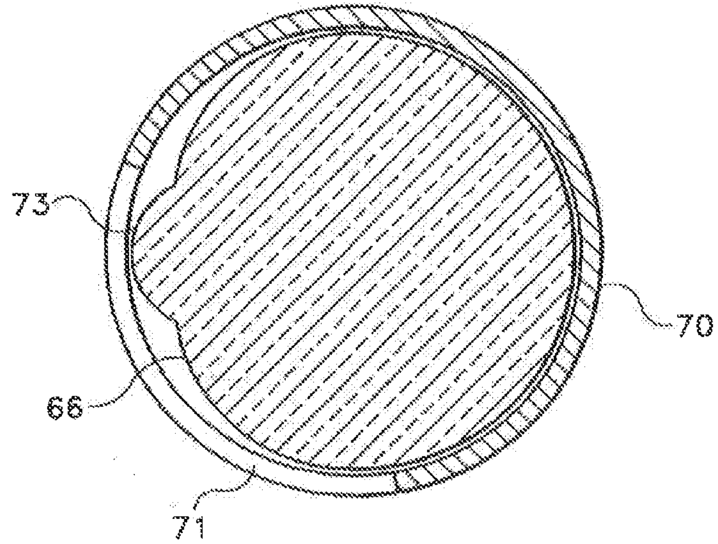


FIG 7b

(A)

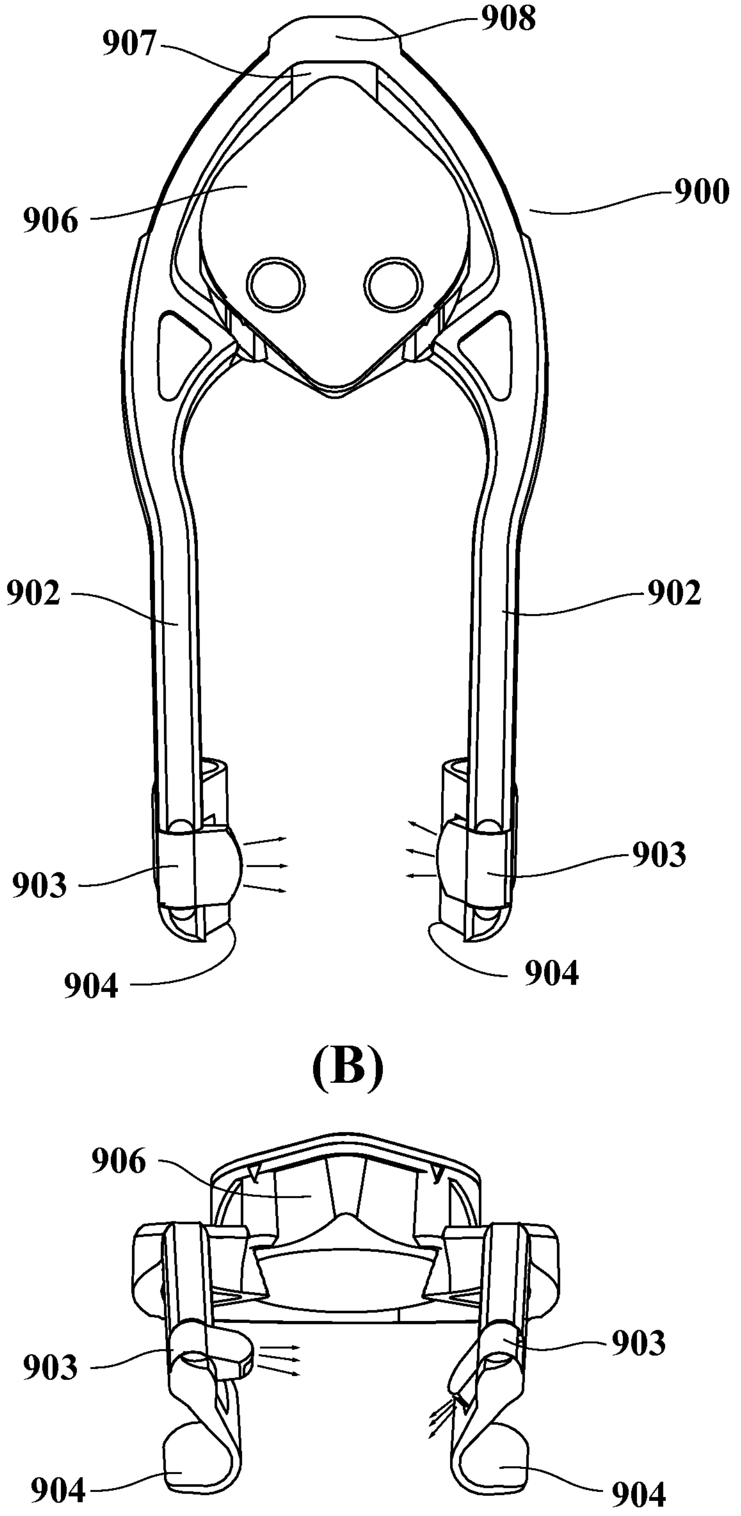


Fig 9

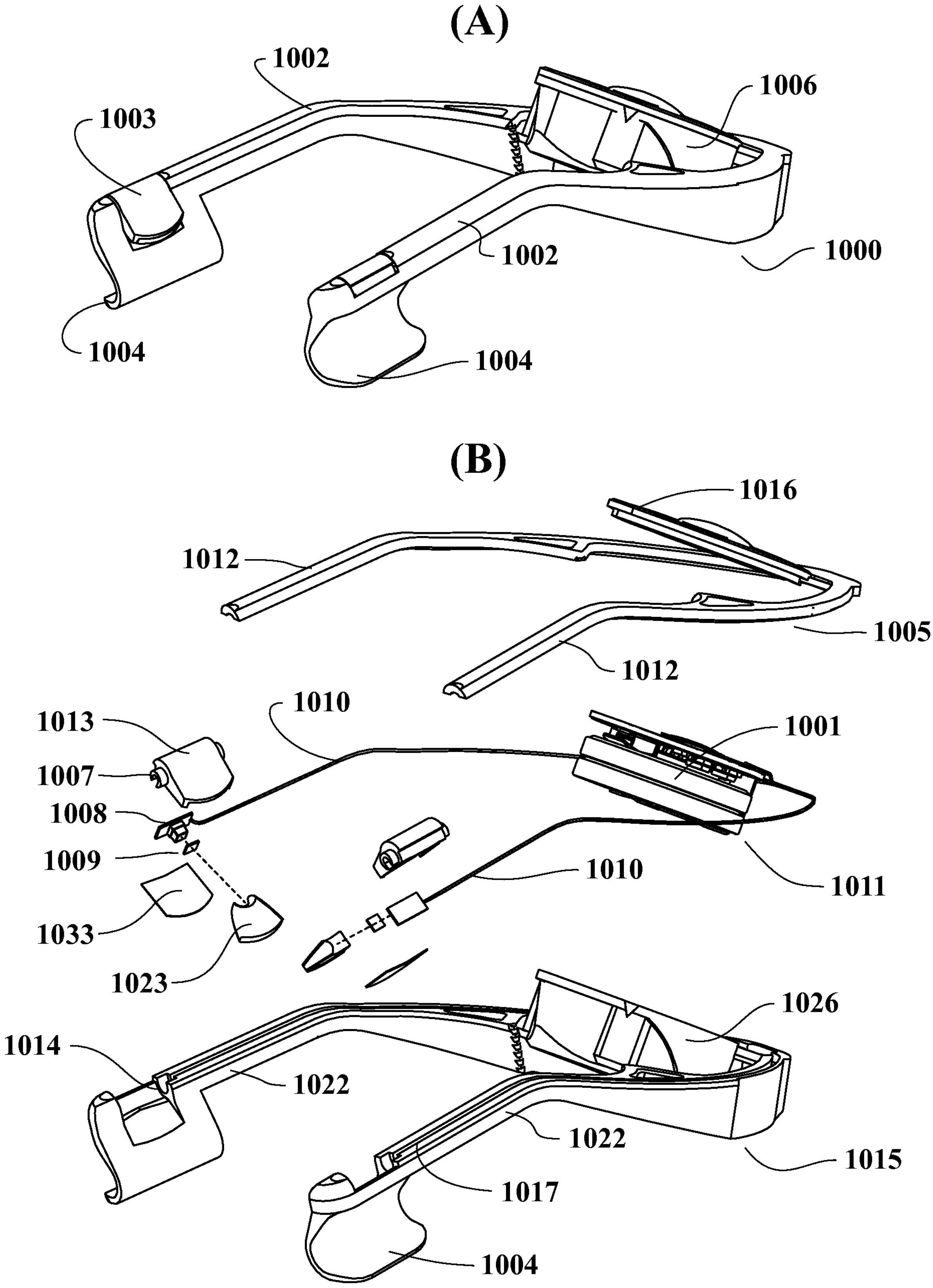

(A)
1002
1006
1003
1002
1000
1004
1004
(B)
1016
1012
1005
1012
1010
1001
1013
1007
1008
1009
1010
1011
1033
1023
1026
1014
1022
1022
1015
1017
1004

Fig 10

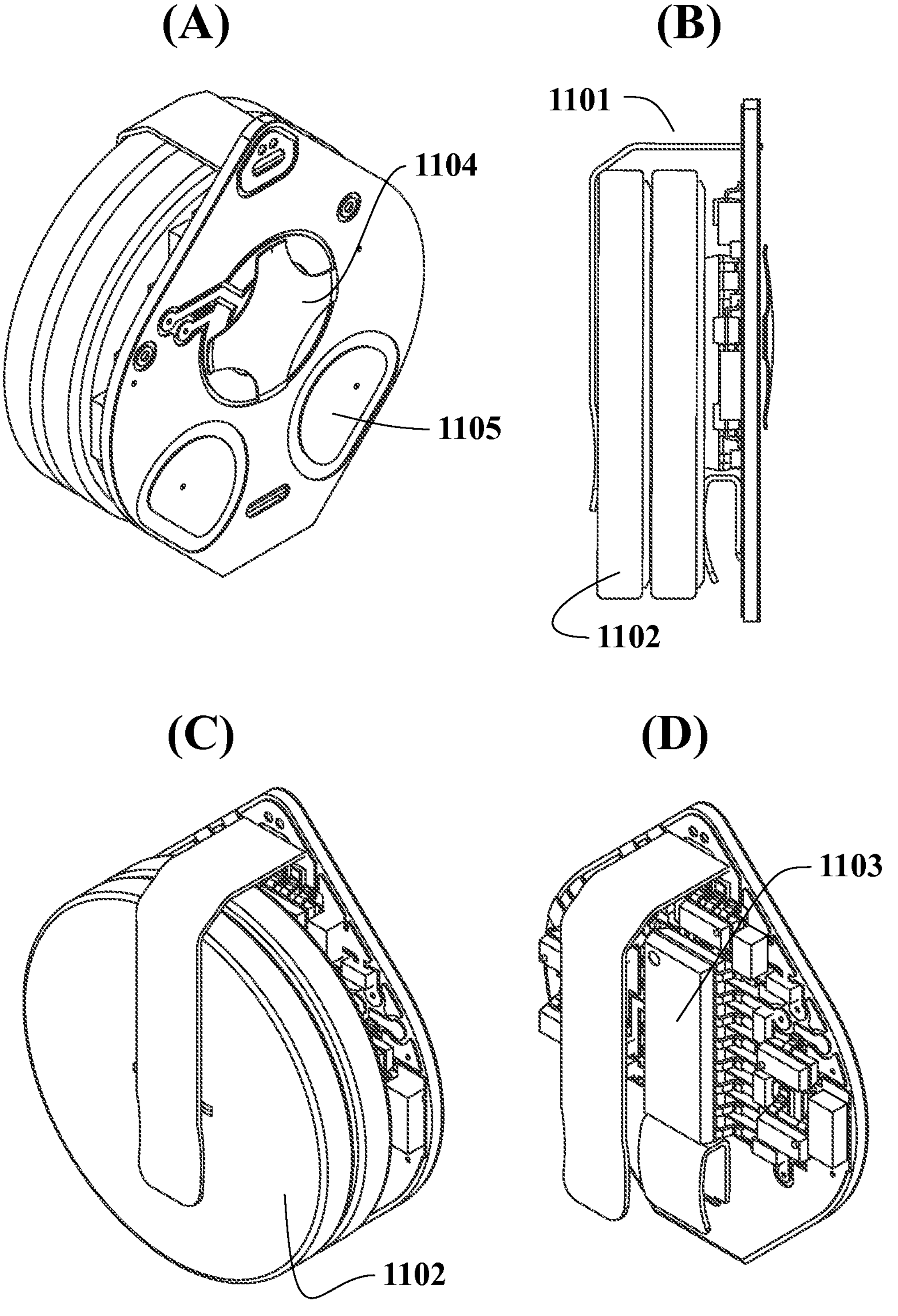


Fig 11

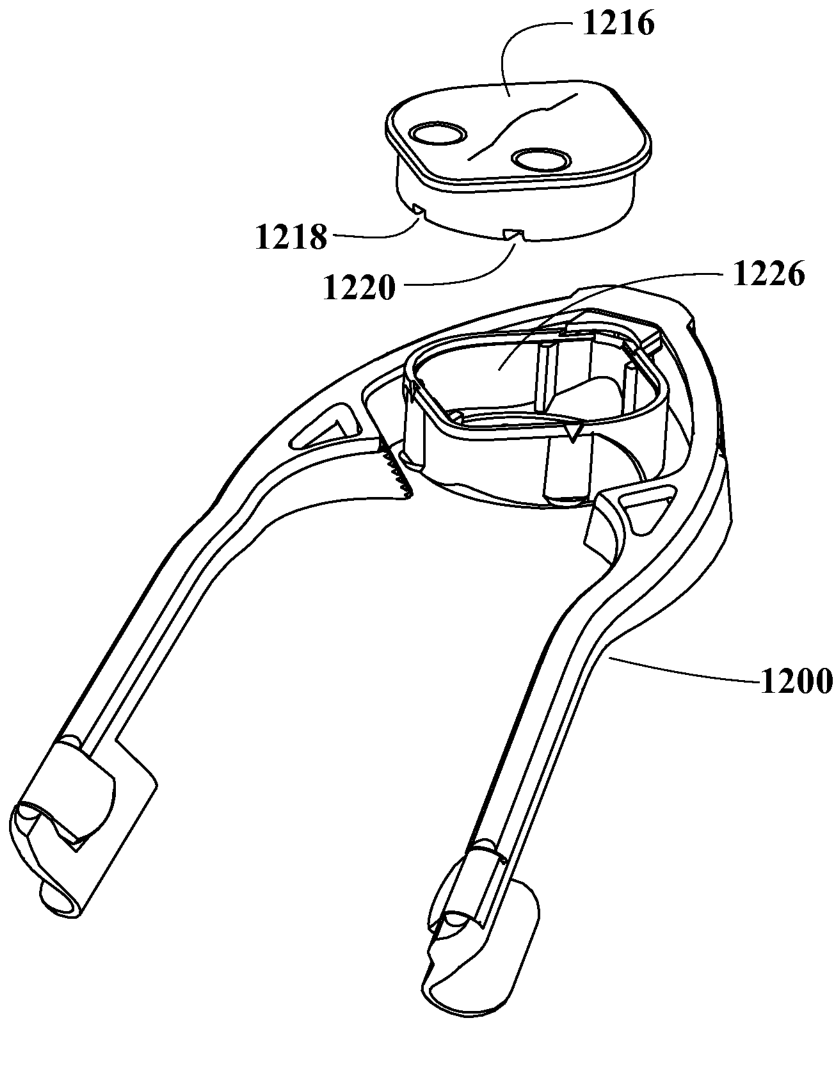
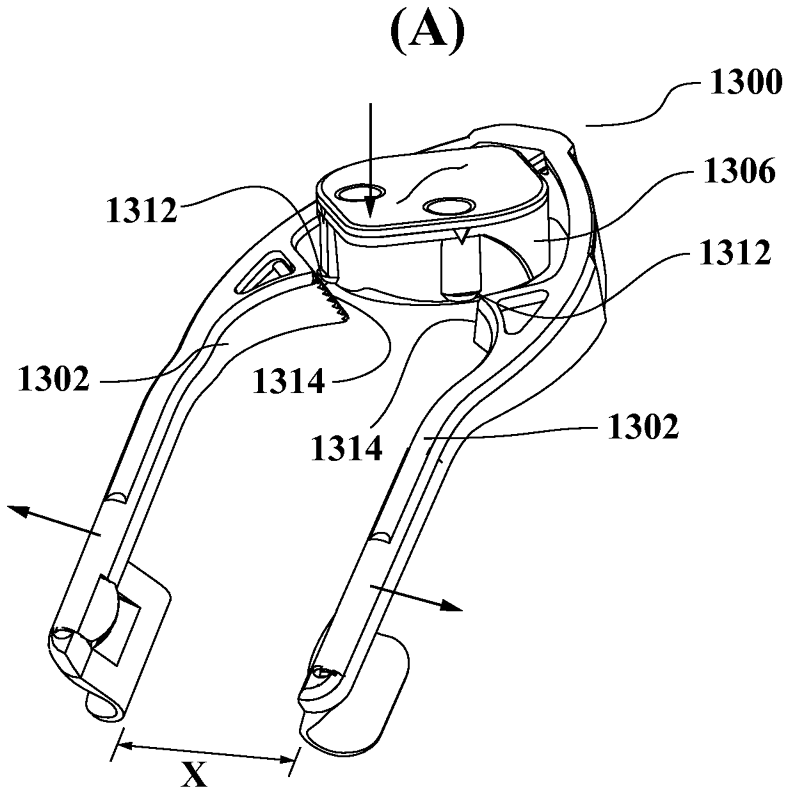


Fig 12


(A)
1300
1306
1312
1312
1302
1314
1314
1302
X

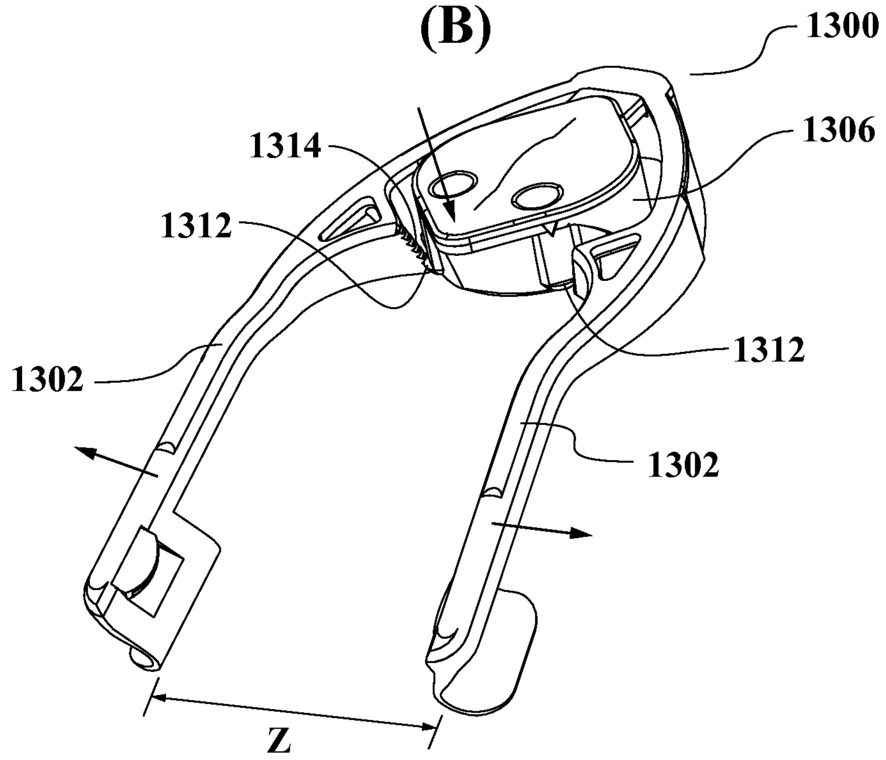

(B)
1300
1306
1314
1312
1302
1312
1302
Z

Fig 13

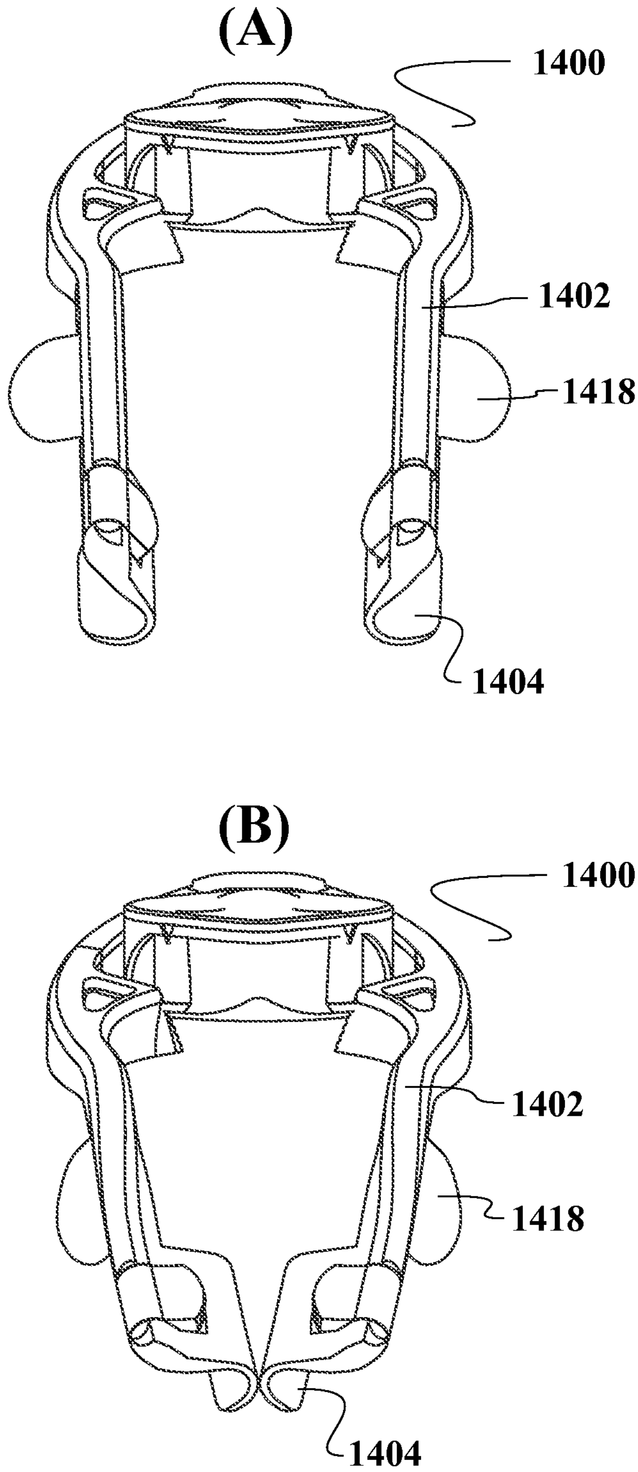


Fig 14

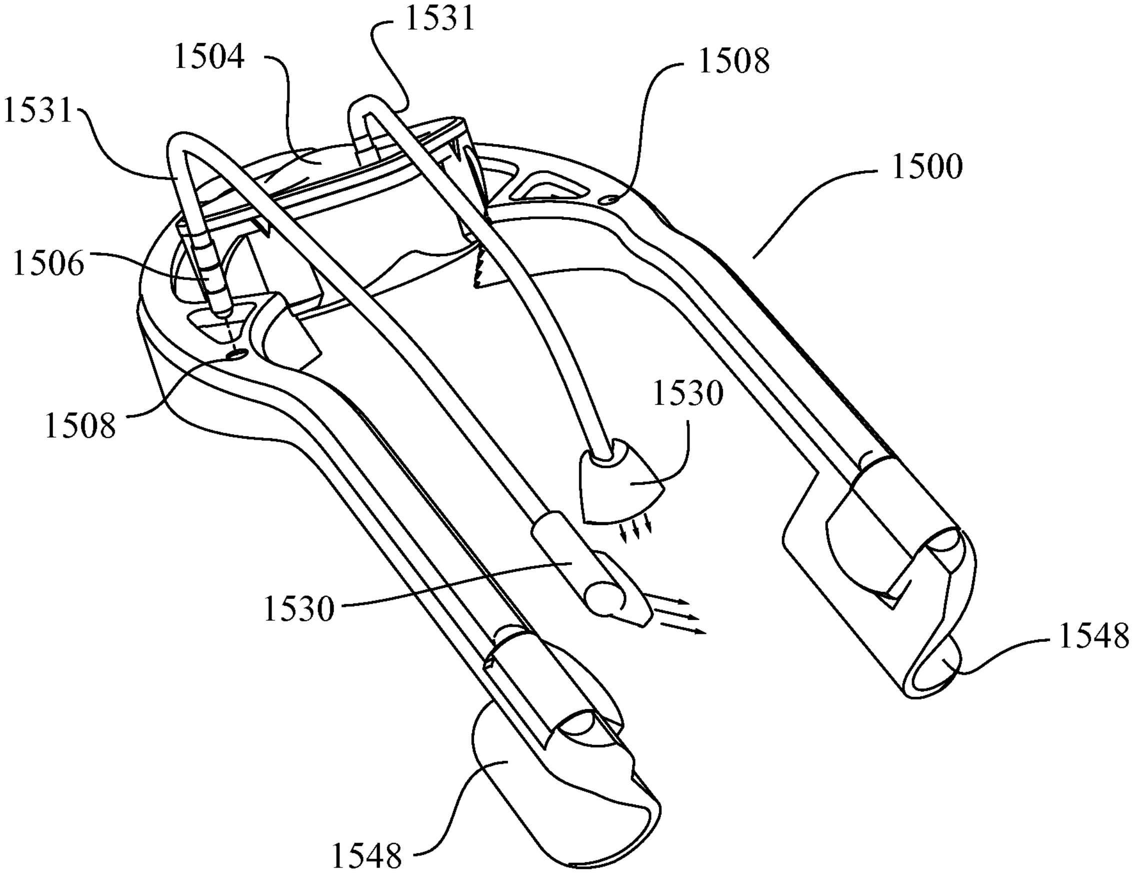


FIG 15

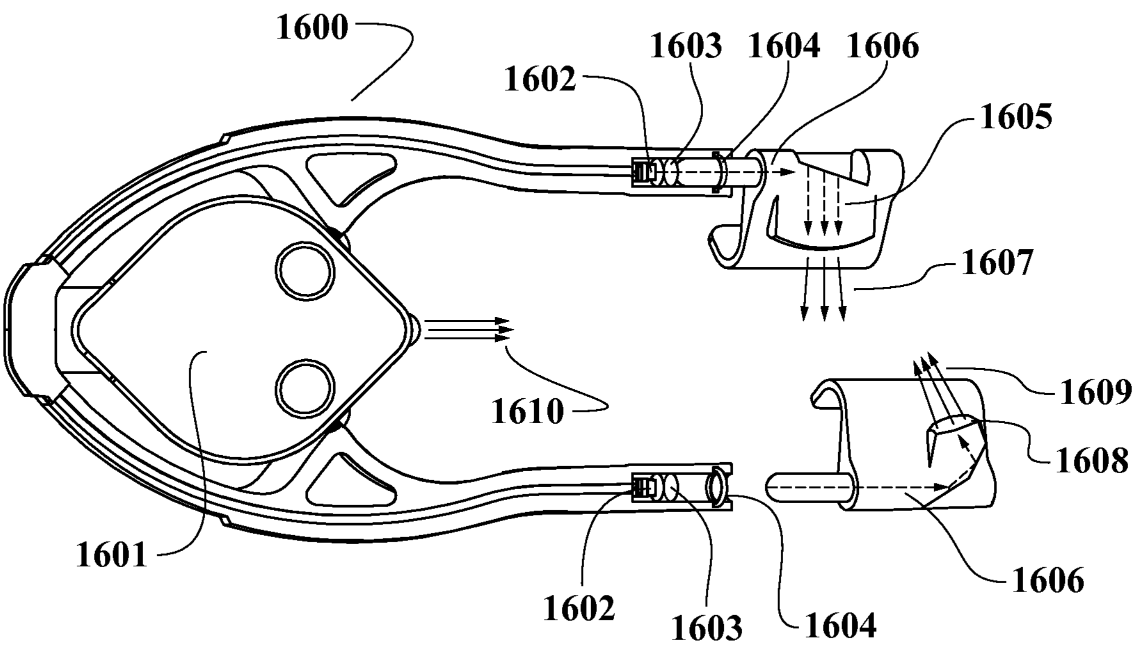

1600
1602
1603
1604
1606
1605
1607
1610
1609
1608
1601
1606
1602
1603
1604

Fig 16

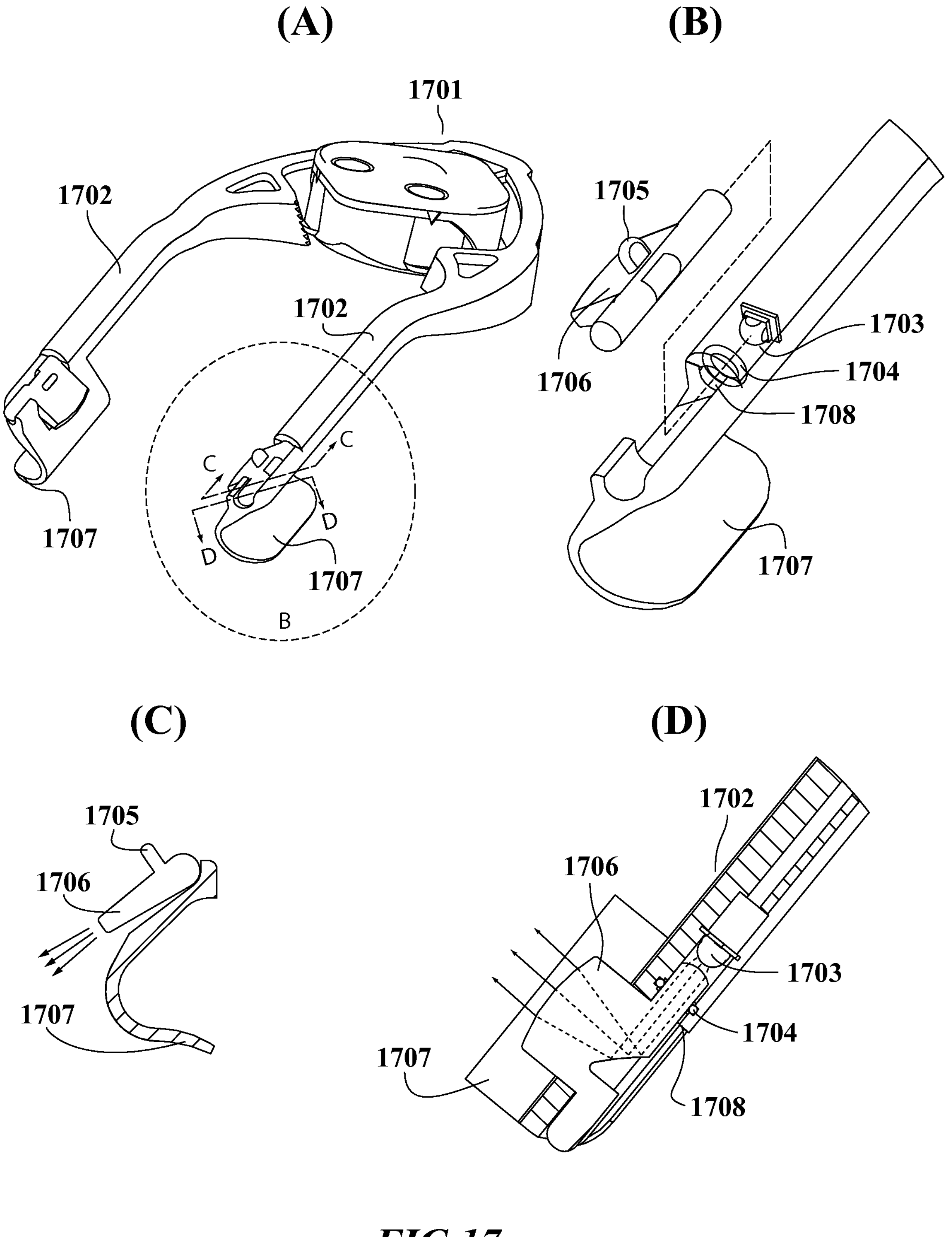
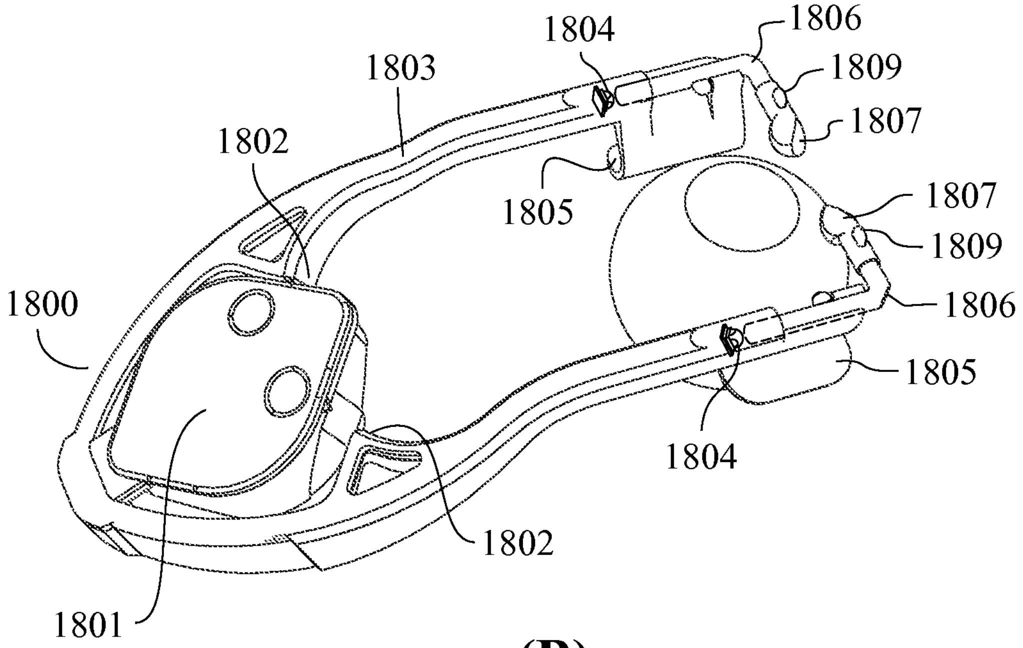

(A)
(B)
1701
1702
1702
1707
1707
C
C
D
D
B
1705
1706
1703
1704
1708
1707
(C)
(D)
1705
1706
1707
1702
1706
1703
1704
1707
1708

FIG 17

(A)


1804
1806
1803
1809
1807
1802
1805
1807
1809
1800
1806
1805
1804
1802
1801

(B)

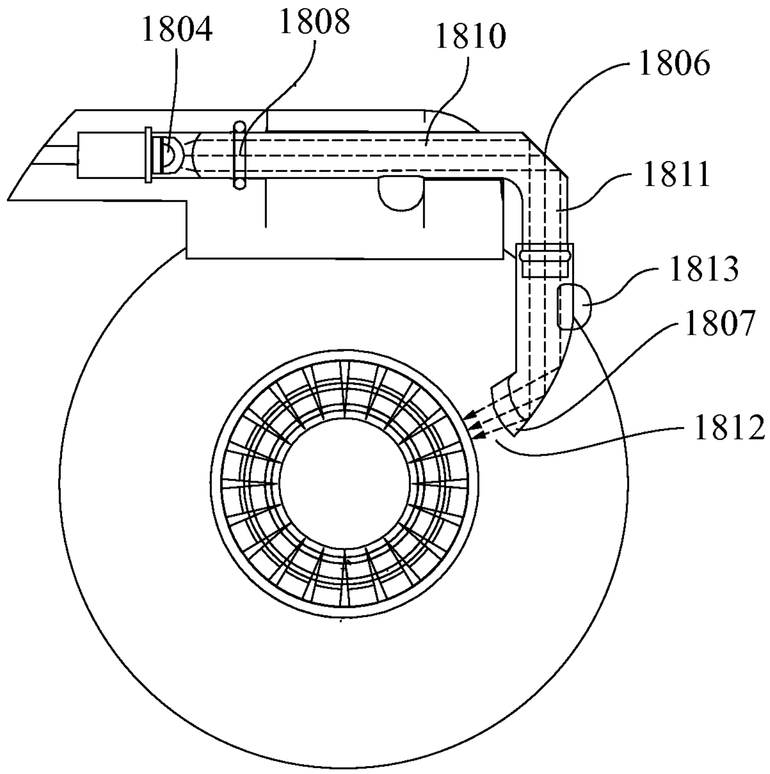

1804
1808
1810
1806
1811
1813
1807
1812

FIG 18

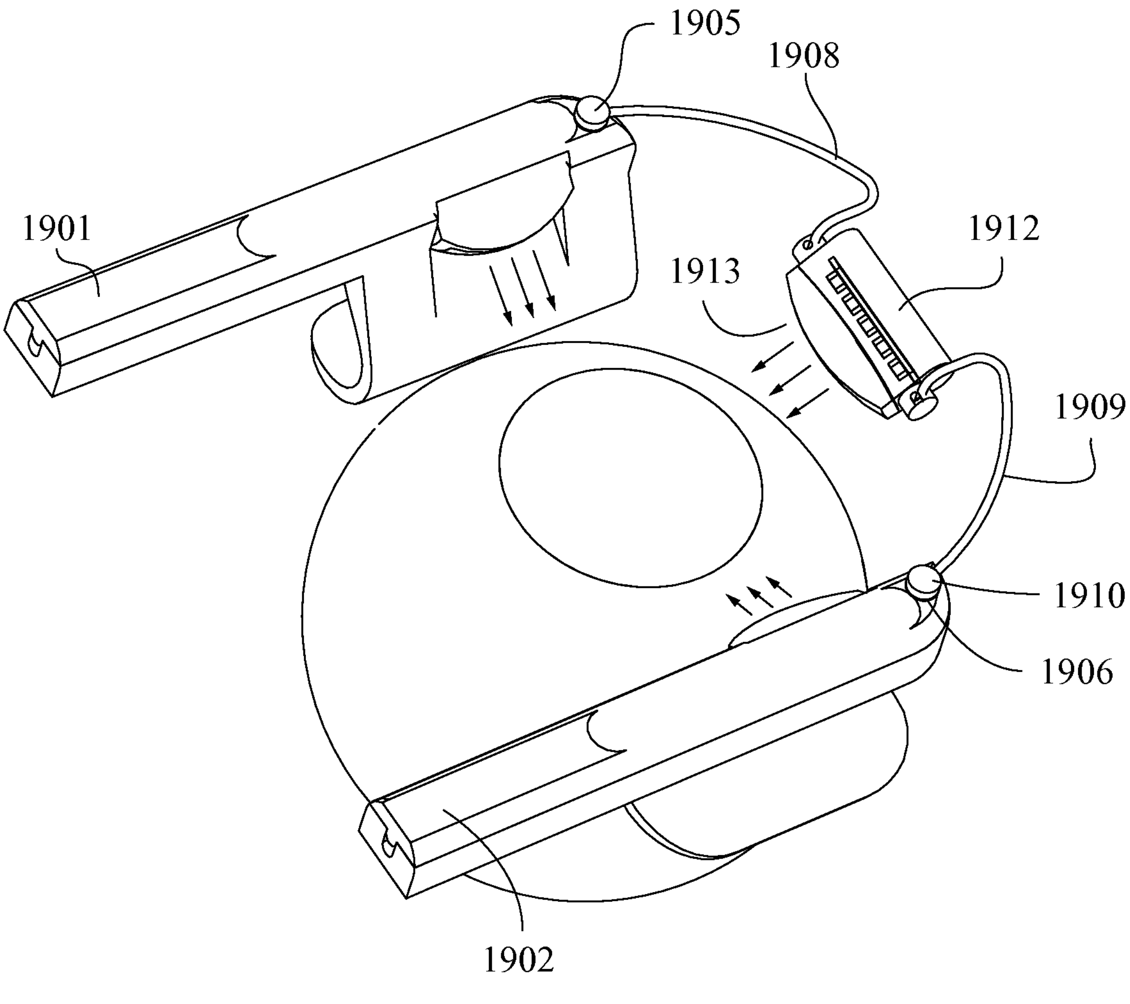


Fig. 19

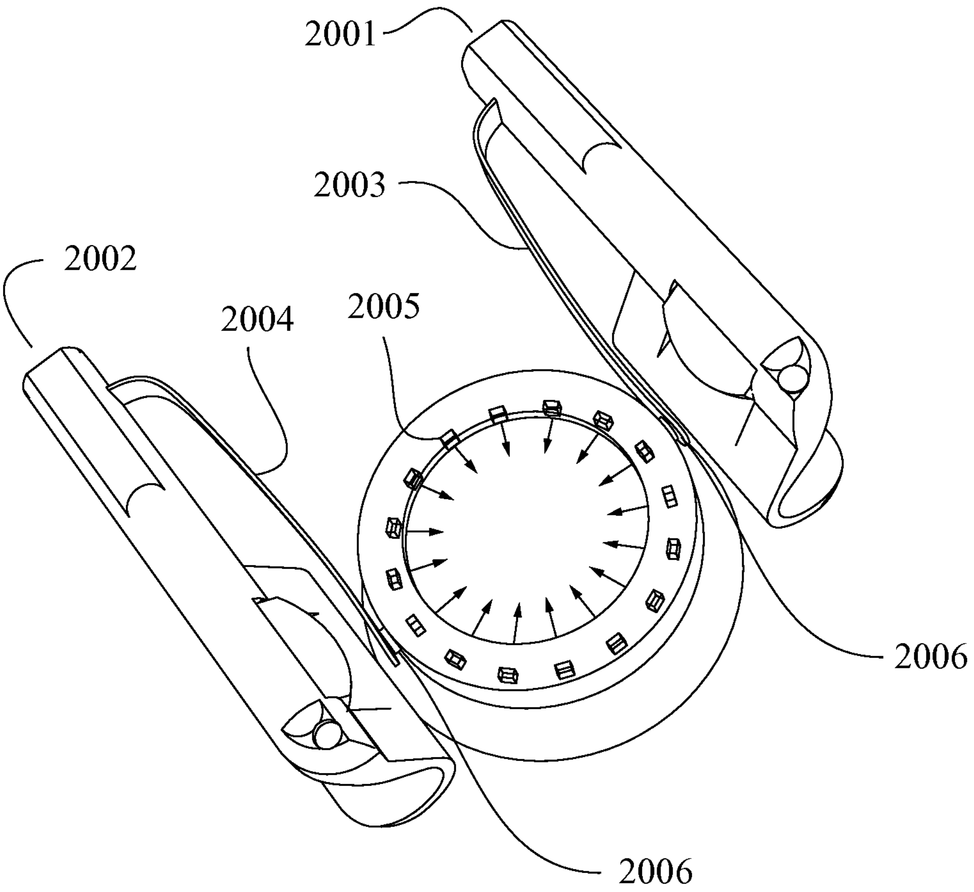


FIG 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/27846

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61N 5/06 (2015.01)
CPC - A61B 3/0008, 17/0231, A61N 5/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): A61N 5/06 (2015.01)
CPC: A61B 3/0008, 17/0231, A61N 5/06

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)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data), Google Patents, EBSCO, ProQuest, Google Scholar.
Search terms: eye, illumination, light, retractor, specula, speculum, ultraviolet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5695492 A (BROWN, AW) 9 December 1977; abstract; figures 4, 5, 7, 7a, 7b, 8, 14, 15; column 5, lines 30-57; column 6, lines 21-59; column 7, lines 1-15; column 8, lines 1-13; claim 1	1, 3-5, 9, 10, 13-15, 17, 18, 22-24 -------------- 2, 6-8, 11, 12, 16, 19-21, 25-27
Y	US 2009/0192437 A1 (SOLTZ, R et al.) 30 July 2009; paragraphs [0034], [0093]	2
Y	US 6322500 B1 (SIKORA, G et al.) 27 November 2001; figures 2b, 3a; column 4, lines 1-12, 33-34; column 5, lines 1-3	6, 8, 16, 25-27
Y	US 2013/0197313 A1 (WAN, SP) 1 August 2013; figure 7, paragraph [0032]	7, 8, 27
Y	US 4605990 A (WILDER, JR et al.) 12 August 1986; column 5, lines 1-7; column 6, lines 14-15	11, 12, 19-21
A	US 1706500 A (SMITH, HJ) 26 March 1929; entire document	1-27
A	US 5556417 A (SHER, NA) 17 September 1996; entire document	1-27
A	US 3680546 A (ASRICAN, M) 1 August 1972; entire document	1-27

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 July 2015 (17.07.2015)	04 AUG 2015

Name and mailing address of the ISA/	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774