



(51) International Patent Classification:

A61F 2/14 (2006.01)

(21) International Application Number:

PCT/EP2022/075851

(22) International Filing Date:

16 September 2022 (16.09.2022)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/245,384 17 September 2021 (17.09.2021) US

63/351,480 13 June 2022 (13.06.2022) US

(72) Inventor; and

(71) Applicant: BUSIN, Massimo [IT/IT]; Via Sisa 33, 47122 Forlì (IT).

(72) Inventors: ELIACHAR, Eliahu; 25 Yefe Nof St., 3437113 Haifa (IL). YU, Angeli Christy; 26 Paseo John, Maria Luisa Estate Park, Baniad, Cebu City, 6000 (PH). LILACH, Nir; 3658200 Kfar Yehoshua (IL). LAVAN, Ron Michael; 16 Hatamar Street, 3432520 Haifa (IL).

(74) Agent: BOULT WADE TENNANT LLP; Salisbury Square House, 8 Salisbury Square, London, Greater London EC4Y 8AP (GB).

(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, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, 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,

(54) Title: INTRACORNEAL OPTICAL IMPLANT

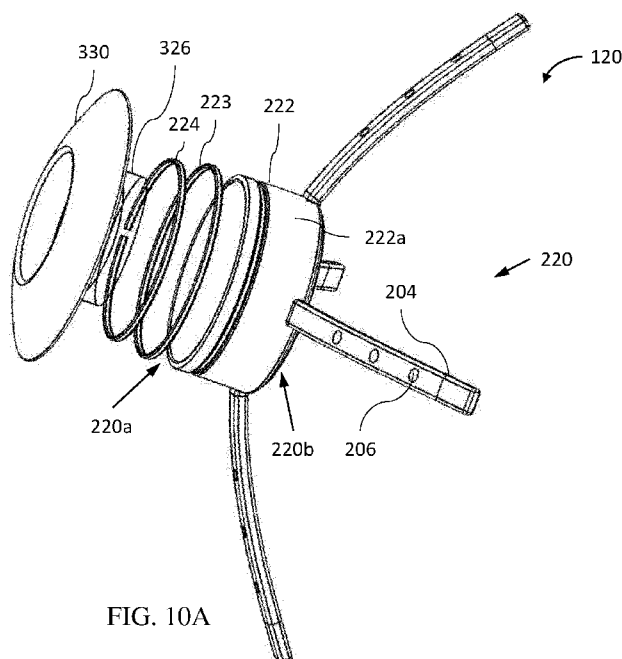


FIG. 10A

(57) Abstract: A device (120) comprising a corneal implant for implantation within the cornea, the implant defining a planar body comprising: (i) an inner platform portion (222) located about an axis of circular symmetry of the implant, (ii) a peripheral portion comprising one or more angularly-spaced arms (204) that extend laterally from a peripheral edge of the inner platform, and (iii) a peripheral skirt portion which defines an outer circular perimeter of the implant, wherein the one or more angularly-spaced arms connect between the inner platform and the peripheral skirt portion; a wireless communication circuit configured for receiving an image data signal from an extraocular unit; an image projection controller configured to process the received image data signal to generate an image; and an image generator mounted to the inner platform portion, configured to project an image projection light beam, based on the generated image, in a posterior direction onto the retina of the eye.

RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,
TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
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).

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

INTRACORNEAL OPTICAL IMPLANT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority from U.S. Provisional Patent Application No. 63/245,384, filed September 17, 2021, entitled, “INTRACORNEAL IMPLANT FOR PROJECTING IMAGES ONTO THE RETINA,” and from U.S. Provisional Patent Application No. 63/351,480, filed June 13, 2022, entitled “INTRACORNEAL OPTICAL IMPLANT,” the contents of both of which are hereby incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

[0002] The invention relates to the field of ocular devices and methods.

BACKGROUND

[0003] The cornea is the transparent anterior portion of the eyeball that covers the iris, pupil, and anterior chamber. A healthy cornea acts as a transparent window that allows entry of light, which passes through the crystalline lens, and allows formation of images onto the retina.

[0004] Opacities of the cornea can lead to irreversible loss of its transparency, which may result in severe visual impairment. Corneal opacities can occur due to scarring from various causes such as mechanical trauma, chemical injuries, infections, and several other diseases of the cornea and the ocular surface.

[0005] Importantly, corneal opacities may cause blindness in an otherwise healthy eye. Despite the presence of complete corneal opacification, eyes with corneal blindness can retain an intact intraocular visual pathway through a functional retina and optic nerve. Even with severe visual impairment secondary to corneal disease, patients may still have significant potential visual acuity.

[0006] Corneal transplantation is traditionally performed to replace an irreversibly opaque cornea with a corneal allograft. However, a considerable number of cases are

deemed ineligible for corneal transplantation due to the presence of high-risk features for allograft rejection and graft failure. While alternative surgical treatments such as artificial corneal implants or keratoprosthesis have been developed to obviate the risk of allograft rejection, such procedures can be associated with several complications including device extrusion, retroprosthetic membrane formation, retinal detachment and endophthalmitis. In patients with substantial corneal damage secondary to ocular trauma or burns, ocular infections, cicatricial keratoconjunctivitis, multiple failed corneal grafts or immunologic and ocular surface diseases, there is still no safe and effective surgical treatment for long-term visual rehabilitation.

[0007] The foregoing examples of the related art and limitations related therewith are intended to be illustrative and not exclusive. Other limitations of the related art will become apparent to those of skill in the art upon a reading of the specification and a study of the figures.

SUMMARY

[0008] The following embodiments and aspects thereof are described and illustrated in conjunction with systems, tools and methods which are meant to be exemplary and illustrative, not limiting in scope.

[0009] There is provided, in an embodiment, a device comprising: an intracorneal implant dimensioned and adapted for implantation within the cornea of an eye, the intracorneal implant defining a planar body having a convexity which substantially conforms to the convexity of the cornea, the intracorneal implant comprising: (i) a central optical part comprising an optical stem having an anterior end and extending axially through the cornea to a posterior end, and (ii) a peripheral haptic part comprising two or more angularly-spaced haptics that extend laterally from the central optical part, wherein, when the intracorneal implant is implanted within the cornea, the anterior end is located substantially at the anterior surface of the eye, and the posterior end abuts or is substantially in contact engagement with a thin layer of corneal tissue located posteriorly to the posterior end.

[0010] There is also provided, in an embodiment, a method comprising: providing an intracorneal implant dimensioned and adapted for implantation within the cornea of an eye,

the intracorneal implant defining a planar body having a convexity which substantially conforms to the convexity of the cornea, the intracorneal implant comprising: (i) a central optical part comprising an optical stem having an anterior end and extending axially through the cornea to a posterior end, and (ii) a peripheral haptic part comprising two or more angularly-spaced haptics that extend laterally from the central optical part; and implanting the intracorneal implant within the cornea, such that the anterior end is located substantially at the anterior surface of the eye, and the posterior end is in contact engagement with a thin layer of corneal tissue located posteriorly to the posterior end.

[0011] In some embodiments, the optical stem is configured to project an image in a posterior direction, through the thin layer of corneal tissue, and onto the retina of the eye.

[0012] In some embodiments, the anterior end is a light-receiving end, wherein the optical stem defines a light-transparent pathway oriented for transmitting light received at the anterior end from an extraocular light source through the optical stem and through the thin layer of corneal tissue, onto the retina of the eye.

[0013] In some embodiments, the optical stem includes an image generator configured to receive an image data signal from an extraocular source, and to project an image in a posterior direction, through the thin layer of corneal tissue, onto the retina of the eye.

[0014] In some embodiments, the optical stem comprises at least one optical lens.

[0015] In some embodiments, the thin layer of corneal tissue is substantially transparent.

[0016] In some embodiments, the thin layer of corneal tissue has a thickness of approximately 10-50 μ m.

[0017] In some embodiments, the thin layer of corneal tissue comprises, in at least a central portion thereof, the pre-Descemet layer and the Descemet membrane of the cornea.

[0018] In some embodiments, the thin layer of corneal tissue further comprises, in at least the central portion thereof, the Descemet membrane of the cornea.

[0019] In some embodiments, the thin layer of corneal tissue further comprises, in at least the central portion thereof, the endothelial layer of the cornea.

[0020] In some embodiments, the thin layer of corneal tissue is part of a corneal tissue scaffold configured for surgical implantation in the eye within a through-recess formed by a full-thickness corneal trephination in the eye.

[0021] In some embodiments, the thin layer of corneal tissue forms a central, substantially transparent, region of the corneal tissue scaffold.

[0022] In some embodiments, the corneal tissue scaffold is preprocessed using at least one of the following techniques: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, and sterilization.

[0023] In some embodiments, each of the haptics comprises at least one opening configured to facilitate fixation and adaptation of the device with the corneal tissue through the at least one opening, when the device is implanted within the cornea.

[0024] In some embodiments, when the intracorneal implant is implanted within the cornea, at least a portion of the anterior end is exposed through the anterior surface of the eye.

[0025] In some embodiments, the anterior end is configured for mounting at least one external optical element.

[0026] In some embodiments, the at least one external optical element is removably mounted to the anterior end.

[0027] There is further provided, in an embodiment, an implantable corneal tissue scaffold device, comprising: a central portion defining a recess having a posterior end comprising a thin layer of corneal tissue, wherein the thin layer of corneal tissue comprises at least the pre-Descemet layer and the Descemet membrane, or at least the pre-Descemet layer; and a peripheral portion of corneal tissue which surrounds the recess, comprising one or more of: posterior layers of the stroma of the cornea, the pre-Descemet layer, the Descemet membrane, and the endothelial layer, wherein the implantable corneal tissue scaffold is prepared by: (i) performing, in a cornea, a deep lamellar dissection which separates between the deep posterior stroma of the cornea and the pre-Descemet layer or between the pre-Descemet layer and the Descemet membrane; (ii) performing, in the cornea, a partial trephination and removal of anterior layers of the stroma of the cornea; (iii)

removing a central portion of deep posterior stroma of the cornea to create the recess, and (iv) performing a full-thickness trephination to remove the entire implantable corneal tissue scaffold device comprising the central portion and the peripheral portion, from the cornea.

[0028] There is further provided, in an embodiment, a method comprising: preparing an implantable corneal tissue scaffold comprising a central portion defining a recess having a posterior end comprising a thin layer of corneal tissue, wherein the thin layer of corneal tissue comprises at least the pre-Descemet layer and the Descemet membrane, or at least the pre-Descemet layer, and a peripheral portion of corneal tissue which surrounds the recess, comprising one or more of: posterior layers of the stroma of the cornea, the pre-Descemet layer, the Descemet membrane, and the endothelial layer, by: (i) performing, in a cornea, a deep lamellar dissection which separates between the deep posterior stroma of the cornea and the pre-Descemet layer or between the pre-Descemet layer and the Descemet membrane; (ii) performing, in the cornea, a partial trephination and removal of anterior layers of the stroma of the cornea; (iii) removing a central portion of deep posterior stroma of the cornea to create the recess, and (iv) performing a full-thickness trephination to remove the entire implantable corneal tissue scaffold device comprising the central portion and the peripheral portion, from the cornea.

[0029] In some embodiments, the corneal tissue scaffold device has a diameter of 5-11mm.

[0030] In some embodiments, the thin layer of corneal tissue has a thickness of between 10-50 μ m, wherein the peripheral portion has a thickness of between 100-500 μ m.

[0031] In some embodiments, the thin layer of corneal tissue is substantially transparent.

[0032] In some embodiments, the cornea is a donor cornea.

[0033] In some embodiments, the recess has a diameter of between 3-7mm.

[0034] In some embodiments, the deep lamellar dissection is performed using one or more of: pneumatic dissection, hydro-assisted dissection, viscoelastic-assisted dissection, and manual dissection.

[0035] In some embodiments, the removed anterior layers of the stroma of the cornea have a thickness of between 100-400 μ m.

[0036] In some embodiments, the corneal tissue scaffold device is configured for implanting in an eye within a through-recess formed in the eye by a full-thickness trephination.

[0037] In some embodiments, the corneal tissue scaffold device is preprocessed using at least one of the following techniques: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, decontamination, and sterilization.

[0038] There is further provided, in an embodiment, a system comprising: an implantable corneal tissue scaffold comprising a central portion defining a recess having a posterior end comprising a thin layer of corneal tissue, wherein the thin layer of corneal tissue comprises at least the pre-Descemet layer and the Descemet membrane, or at least the pre-Descemet layer, and a peripheral portion of corneal tissue which surrounds the recess, comprising one or more of: posterior layers of the stroma of the cornea, the pre-Descemet layer, the Descemet membrane, and the endothelial layer; and an intracorneal implant defining a planar body having a convexity which substantially conforms to the convexity of the cornea, the intracorneal implant comprising: (i) a central optical part comprising an optical stem having an anterior end and extending axially through the cornea to a posterior end, and (ii) a peripheral haptic part comprising two or more angularly-spaced haptics that extend laterally from the central optical part, wherein the intracorneal implant is mounted to the implantable corneal tissue scaffold device such that the posterior end abuts or is in contact engagement with the thin layer of corneal tissue.

[0039] In some embodiments, the system further comprises an anterior corneal lamella layer sutured in place over the intracorneal implant.

[0040] In some embodiments, the system is intended for surgical implantation within a through-recess formed by a full-thickness corneal trephination in an eye.

[0041] There is further provided, in an embodiment, a device comprising: a corneal implant dimensioned and adapted for implantation within the cornea of an eye, the implant defining a planar body comprising: (i) an inner platform portion located about an axis of circular symmetry of the implant, and (ii) a peripheral portion comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of the inner platform; a

wireless communication circuit configured for receiving an image data signal from an extraocular unit; an image projection controller configured to process the received image data signal to generate an image; and an image generator mounted to the inner platform portion, configured to project an image projection light beam, based on the generated image, in a posterior direction onto the retina of the eye.

[0042] There is further provided, in an embodiment, a method comprising: providing a device comprising a corneal implant dimensioned and adapted for implantation within the cornea of an eye, the implant defining a planar body comprising: (i) an inner platform portion located about an axis of circular symmetry of the implant, and (ii) a peripheral portion comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of the inner platform; a wireless communication circuit configured for receiving an image data signal from an extraocular unit; an image projection controller configured to process the received image data signal to generate an image; and an image generator mounted to the inner platform portion, configured to project an image projection light beam, based on the generated image, in a posterior direction onto the retina of the eye; implanting the device in the cornea of an eye, such that transparent corneal tissue or no corneal tissue is present posterior to the image generator of the device; receiving, by the wireless communication circuit, the image data signal; processing, by the image projection controller, the received image data signal, to generate the image; and projecting, by the image generator, the image in a posterior direction onto the retina of the eye.

[0043] In some embodiments, the device further comprises a peripheral skirt portion which defines an outer circular perimeter of the implant, wherein the one or more angularly-spaced arms connect between the inner platform and the peripheral skirt portion;

[0044] In some embodiments, the wireless communication circuit comprises a reception inductive coil.

[0045] In some embodiments, the reception inductive coil is further configured for receiving power inductively from the extraocular unit.

[0046] In some embodiments, the wireless communication circuit comprises a photovoltaic cell configured to receive a light beam encoding the image data signal.

[0047] In some embodiments, the photovoltaic cell is further configured for receiving power from the light beam.

[0048] In some embodiments, the device further comprises a memory storage for storing the received image data signal.

[0049] In some embodiments, the image generator comprises a liquid crystal display device having an illuminator element optically coupled thereto.

[0050] In some embodiments, the image generator comprises a liquid crystal display device configured for being illuminated by an extraocular illumination source.

[0051] In some embodiments, the peripheral skirt portion, inner platform portion, and at least one arm, define at least one opening in the planar body, wherein the at least one opening is configured to facilitate fixation and adaptation of the device with the corneal tissue through the at least one opening, when the device is implanted within the cornea.

[0052] In some embodiments, the device further comprises an optical assembly mounted posteriorly of the image generator and optically coupled therewith, configured to focus the projected image onto the retina.

[0053] In some embodiments, the device further comprises at least one haptic that extends outwardly from the outer circular perimeter of the implant, wherein the at least one haptic comprises a proximal end which is connected to the outer circular perimeter, and a projecting segment culminating in a distal end.

[0054] There is further provided, in an embodiment, a system comprising: a device comprising a corneal implant dimensioned and adapted for implantation within the cornea of an eye, the implant defining a planar body comprising: (i) an inner platform portion located about an axis of circular symmetry of the implant, and (ii) a peripheral portion comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of the inner platform, a wireless communication circuit configured for receiving an image data signal from an extraocular unit, an image projection controller configured to process the received image data signal to generate an image, and an image generator mounted to the inner platform portion, configured to project an image projection light beam, based on the generated image, in a posterior direction onto the retina of the eye; and an extraocular unit

comprising: at least one imaging device for capturing visual images, an image processing module for processing and storing the captured visual images as digital image data, and a wireless communication module for transmitting the digital image data to the device through the wireless communication circuit.

[0055] There is further provided, in an embodiment, a method comprising: providing a system comprising a device comprising a corneal implant dimensioned and adapted for implantation within the cornea of an eye, the implant defining a planar body comprising: (i) an inner platform portion located about an axis of circular symmetry of the implant, and (ii) a peripheral portion comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of the inner platform, a wireless communication circuit configured for receiving an image data signal from an extraocular unit; an image projection controller configured to process the received image data signal to generate an image; and an image generator mounted to the inner platform portion, configured to project an image projection light beam, based on the generated image, in a posterior direction onto the retina of the eye, and an extraocular unit comprising: at least one imaging device for capturing visual images, an image processing module for processing the captured visual images to generate digital image data, and a wireless communication module for transmitting the digital image data to the device through the wireless communication circuit; implanting the device in the cornea of an eye, such that transparent corneal tissue or no corneal tissue is present posterior to the image generator of the device; capturing, by the at least one imaging device of the extraocular unit, at least one visual image; processing, by the image processing module, the at least one captured visual image, to generate the digital image data, transmitting, by the wireless communication module, the image data signal, receiving, by the wireless communication circuit, the image data signal; processing, by the image projection controller, the received image data signal, to generate the image; and projecting, by the image generator, the image in a posterior direction onto the retina of the eye.

[0056] In some embodiments, the device further comprises a peripheral skirt portion which defines an outer circular perimeter of the implant, wherein the one or more angularly-spaced arms connect between the inner platform and the peripheral skirt portion;

[0057] In some embodiments, the wireless communication circuit comprises a reception inductive coil, wherein the wireless communication module comprises a transmission inductive coil.

[0058] In some embodiments, the reception inductive coil is further configured for receiving power inductively from the transmission inductive coil.

[0059] In some embodiments, the wireless communication module comprises a light beam source.

[0060] In some embodiments, the wireless communication circuit comprises a photovoltaic cell configured to receive a light beam encoding the image data signal, wherein the light beam is emitted from the light beam source.

[0061] In some embodiments, the photovoltaic cell is further configured for receiving power from the light beam.

[0062] In some embodiments, the device comprises a memory storage for storing the received image data signal.

[0063] In some embodiments, the image generator comprises a liquid crystal display device having an illuminator element optically coupled thereto.

[0064] In some embodiments, the image generator comprises a liquid crystal display device, wherein the extraocular unit comprises an illumination source configured to provide illumination to the liquid crystal display device.

[0065] In some embodiments, the illumination source is configured to emit sufficient illumination so as to traverse impaired or opaque layers and to reach the device, when it is implanted within the cornea.

[0066] In some embodiments, the peripheral skirt portion, inner platform portion, and at least one arm, define at least one opening in the planar body, wherein the at least one opening is configured to facilitate fixation and adaptation of the device with the corneal tissue through the at least one opening, when the device is implanted within the cornea.

[0067] In some embodiments, the device comprises an optical assembly mounted posteriorly of the image generator and optically coupled therewith, configured to focus the projected image onto the retina.

[0068] In some embodiments, the device comprises at least one haptic that extends outwardly from the outer circular perimeter of the implant, wherein the at least one haptic comprises a proximal end which is connected to the outer circular perimeter, and a projecting segment culminating in a distal end

[0069] In some embodiments, the components of the extraocular unit are mounted to one of: a spectacle frame, headwear, a helmet, and a headband.

[0070] In addition to the exemplary aspects and embodiments described above, further aspects and embodiments will become apparent by reference to the figures and by study of the following detailed description.

BRIEF DESCRIPTION OF THE FIGURES

[0071] Exemplary embodiments are illustrated in referenced figures. Dimensions of components and features shown in the figures are generally chosen for convenience and clarity of presentation and are not necessarily shown to scale. The figures are listed below.

[0072] Figs. 1A-1C are schematic illustrations, in perspective (Fig. 1A), perspective cross-section (Fig. 1B), a side cross-section (Fig 1C) views, of an exemplary device of the present disclosure which provides a pathway for transmitting external light through the eye and onto the retina, to replace impaired or opaque layers of the cornea that is otherwise fully or partially impermeable to visible light, according to some embodiments of the present disclosure;

[0073] Figs. 1D-1E illustrate a device of the present disclosure as implanted within an eye, according to some embodiments of the present disclosure;

[0074] Figs. 2A-2E show an exemplary intracorneal implant of the device of the present disclosure in top perspective (Fig. 2A), bottom perspective (Fig. 2B), side (Fig. 2C), top (Fig. 2D), and bottom (Fig. 2E) views, according to some embodiments of the present disclosure;

[0075] Figs. 3A-3C are illustrations, in cross-sectional (Fig. 3A), exploded perspective (Fig. 3B) and exploded side (Fig. 3C) views, of an exemplary optical stem of the device of the present disclosure, configured to be implanted within the cornea of the eye, and to transmit light from an ambient environment and/or an extraocular light source, through the eye, along an optical path and onto the retina, according to some embodiments of the present disclosure;

[0076] Figs. 4A-4B show, in perspective (Fig. 4A) and side (Fig. 4B) views, an exemplary inner optical lens of the present disclosure, such as may be used in conjunction with the device of the present disclosure, according to some embodiments of the present disclosure;

[0077] Figs. 5A-5D show, in front perspective (Fig. 5A), back perspective (Fig. 5B), side (Fig. 5C), and top (Fig. 5D) views an exemplary optical stem of the present disclosure, such as may be used in conjunction with the device of the present disclosure, according to some embodiments of the present disclosure;

[0078] Fig. 6 is an exploded perspective view of an exemplary device of the present disclosure, which further comprises optional external optical elements, according to some embodiments of the present disclosure;

[0079] Figs. 7A-7D show front perspective (Fig. 7A), back perspective (Fig. 7B), side (Fig. 7C), and top (Fig. 7E) views of an exemplary optional external optical elements (e.g. external anterior end plate and/or external optical lens) which may be further comprised in the device of the present disclosure, according to some embodiments of the present disclosure;

[0080] Figs. 8A-8B show an external optical lens of the present disclosure, according to some embodiments of the present disclosure;

[0081] Figs. 9A-9D show exploded perspective (Fig. 9A), exploded side (Fig. 9B) and cross-sectional (Figs. 9C and 9D) views of an exemplary embodiment of a device of the present disclosure, according to some embodiments of the present disclosure;

[0082] Figs. 10A-10C show exploded perspective (Fig. 10A), exploded side (Fig. 10B) and cross-sectional (Fig. 10C) views of another exemplary embodiment of a device of the present disclosure, according to some embodiments of the present disclosure;

[0083] Figs. 11A-11D show exploded perspective (Fig. 11A), exploded side (Fig. 11B) and cross-sectional (Figs. 11C and 11D) views of another exemplary embodiment of a device of the present disclosure, according to some embodiments of the present disclosure;

[0084] Figs. 11E-11G show exemplary variations of an optical stem comprising a magnetic coupling system configured for magnetically removably attaching an optional external end plate to the anterior end of the device of the present disclosure, according to some embodiments of the present disclosure;

[0085] Figs. 12A-12C show exploded perspective (Fig. 12A), exploded side (Fig. 12B) and cross-sectional (Fig. 12C) views of another exemplary embodiment of a device of the present disclosure, according to some embodiments of the present disclosure;

[0086] Figs. 13A-13F illustrate the functional steps in a process for the preparation of an exemplary pre-processed corneal tissue scaffold derived from a donor cornea, according to some embodiments of the present disclosure;

[0087] Figs. 14A-14D illustrate an exemplary process for producing a pre-assembled intracorneal system including the corneal tissue scaffold and the device of the present disclosure, according to some embodiments of the present disclosure;

[0088] Figs. 15A-15F show the functional steps in an exemplary process for surgical implantation of a preassembled intracorneal system including the corneal tissue scaffold and the device of the present disclosure, according to some embodiments of the present disclosure;

[0089] Figs. 16A-16G show the functional steps in an exemplary process for surgical implantation of a pre-processed corneal tissue scaffold separately, followed by an implantation of an intracorneal implant of the present disclosure, according to some embodiments of the present disclosure;

[0090] Figs. 17A-17J show the functional steps in an exemplary process for surgical implantation of an intracorneal implant of the present disclosure, according to some embodiments of the present disclosure;

[0091] Figs. 18A-18C are schematic illustrations of exemplary system for intracorneal projecting of images onto a retina, according to some embodiments of the present disclosure;

[0092] Fig. 18D illustrates an exemplary extraocular unit, according to some embodiments of the present disclosure;

[0093] Fig. 18E shows an exemplary illumination source, according to some embodiments of the present disclosure;

[0094] Figs. 19A-19D show front perspective, posterior, anterior, and side views of an exemplary intracorneal implant, according to some embodiments of the present disclosure;

[0095] Fig. 20 is a schematic illustration of an exemplary intracorneal implant comprising a plurality of haptics, according to some embodiments of the present disclosure;

[0096] Figs. 21A-21D illustrate steps in the process for surgical implantation of an intracorneal implant o the present disclosure within the cornea, according to some embodiments of the present disclosure;

[0097] Fig. 21E shows an optional optical assembly, according to some embodiments of the present disclosure; and

[0098] Fig. 22 shows a cross-sectional view of an eye having an intracorneal implant implanted within the cornea, according to some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0099] Disclosed herein are systems, devices and methods which provide for intracorneal implants configured for implantation within the eye, and having a light-projecting posterior port configured to project images onto the retina of the eye.

[00100] As used herein, the term 'intracorneal implant' may be used to refer to any device configured to be implanted or deployed inside the cornea of the eye.

[00101] In some embodiments, the intracorneal implants of the present disclosure are configured to be implanted within the eye such that only corneal tissue that is substantially transparent is present posteriorly to the light-projecting posterior port of the device, wherein

the light-projecting posterior port of the device is configured to project an image projection light beam which traverses the substantially transparent corneal tissue present posteriorly to the light-projecting posterior port, to reach the retina of the eye.

[00102] In other embodiments, the intracorneal implants of the present disclosure are configured to be implanted within the eye such that a layer of corneal tissue that is partially transparent, partially semi-transparent, and/or partially opaque, is present posteriorly to the light-projecting posterior port of the device, wherein the light-projecting posterior port of the device is configured to project an image projection light beam which traverses the corneal tissue present posteriorly to the light-projecting posterior port, to reach the retina of the eye.

[00103] In accordance with some aspects of the present invention, a device of the present disclosure provides an optical pathway for transmitting external light through the eye and onto the retina, wherein the pathway traverses or completely replaces impaired or opaque layers of the cornea that are otherwise fully or partially impermeable to visible light.

[00104] In one aspect of the present disclosure, the device is provided comprising an intracorneal implant configured for surgical implantation within the eye. In some embodiments, the device of the present disclosure may be dimensioned and configured for surgical implantation within the eye, traversing or completely replacing any opaque tissue layers of the cornea, and wherein only substantially transparent corneal tissue is present posterior to the device. In some embodiments, the device of the present disclosure may be configured for surgical implantation within the eye, such that a light-projecting posterior port of the device abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50 μ m) that is substantially transparent to light, located posteriorly to the light-projecting posterior port of the device. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium. In some embodiments, the very thin layer of corneal tissue acts as a barrier such that the device does not extend into

the anterior chamber, thereby avoiding potential complications including device luxation, hypotony, glaucoma, retroprosthetic membrane formation, or intraocular infection.

[00105] In some embodiments, the device of the present disclosure comprises an intracorneal implant configured for surgical implantation within the cornea of the eye, wherein the intracorneal implant comprises an optical stem configured to transmit light from an ambient environment and/or an extraocular light source, through the eye, along an optical path and through the image projection posterior port, onto the retina. In some embodiments, the intracorneal implant of the present disclosure may be configured for surgical implantation within the cornea of the eye, such that a light-projecting posterior port of the device abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50 μ m) that is substantially transparent to light, located posteriorly to the light-projecting posterior port of the device. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium.

[00106] In some embodiments, the device of the present disclosure comprises an intracorneal implant configured for surgical implantation within the cornea of the eye, wherein the intracorneal implant comprises an optical stem configured to transmit light from an ambient environment and/or an external light source, through the eye, along an optical path, through the image projection port, and onto the retina. In some embodiments, the optical stem defines a light-transparent pathway for transmitting light from the ambient environment and/or an extraocular light source through the eye along an optical path, wherein the pathway defined by the optical stem may comprise at least one optical element, such as an optical lens.

[00107] In some embodiments, the optical stem of the present disclosure comprises an optical device that projects an image beyond its light-projecting posterior port (e.g., when the device of the present disclosure is implanted in the eye, the image is projected on the retina), based on light entering the anterior end of the optical stem. In some embodiments, the optical stem has a light-receiving anterior port at an anterior end of the optical stem,

located close to the eye's anterior surface. The optical stem extends through the cornea to a light-projecting posterior port of the optical stem, closer to the posterior surface of the cornea. In some embodiments, the anterior end of the optical stem lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface. In some embodiments, the anterior end of the optical stem sits proximately to the eye's surface, fully or partially covered by a thin conjunctival flap layer. In some embodiments, at least a portion of the anterior end of the optical stem is exposed through the eye's anterior surface and forms a means for accepting external optical elements of the device of the present disclosure, as shall be further described below. In some embodiments, the anterior end of the optical stem may comprise an anterior surface which acts as an external optical lens or other optical element. In some embodiments, the anterior end of the optical stem may be configured to receive one or more external optical elements. In some embodiments, the anterior end of the optical stem may comprise a facility configured for removably and/or adjustably mounting one or more optional external elements. In some embodiments, the external elements may be colored or feature a design configured for cosmesis and/or to impart a natural appearance to the eye (e.g. the external optical elements may be colored to resemble/mimic the natural color of the iris).

[00108] In some embodiments, the optical stem is a transparent optical path that allows external light or imaging components to pass through the optical stem and to project through the light-projecting posterior port, to form an image on the retina. In some embodiments, the optical stem includes inner optical and/or imaging components along the optical path, such as lenses, which assist in providing a focused image on the retina.

[00109] In other embodiments, the optical stem includes an image generator incorporating any suitable image display and/or projection technology, such as liquid crystal display (LCD) element that has an illuminator element optically coupled thereto, a LED projector, a laser diode projector, a LED array, and the like. In some embodiments, the image generator is configured to receive an image data signal from an extraocular source (such as an extraocular imaging device), and to generate an optical image signal that is projected in a posterior direction through the light-projecting posterior port, onto the retina of the eye.

[00110] In some embodiments, the device of the present disclosure comprises: (i) an intracorneal implant configured for surgical implantation within the cornea of the eye, and (ii) an optical stem configured to transmit light from an ambient environment and/or an extraocular light source, through the eye, along an optical path, and through the light-projecting posterior port, onto the retina.

[00111] In some embodiments, an intracorneal implant of the present disclosure generally defines a convex body having a convexity which substantially conforms to the convexity of the cornea. In some embodiments, the implant comprises a central optical part, configured to receive and retain the optical stem of the present device, and a peripheral haptic part. In some embodiments, the central optical part comprises a circumferentially-continuous annular rim, which defines a central aperture configured to receive and retain the optical stem of the present device therein. In some embodiments, the peripheral haptic part of the implant comprises two or more angularly-spaced haptics that extend laterally from a peripheral edge of the annular body member.

[00112] In another aspect of the present disclosure, a method is disclosed which provides a pathway for transmitting external light through the eye and onto the retina, traversing or completely replacing any opaque layers of the cornea that are otherwise fully or partially impermeable to visible light. In some embodiments, the method comprises providing a device comprising an intracorneal implant, and surgically implanting the intracorneal implant within the cornea of the eye, at a position where only substantially transparent corneal tissue is present posterior to a light-projecting posterior port of the device. In some embodiments, the intracorneal implant of the present disclosure may be configured for surgical implantation within the cornea of the eye, such that a light-projecting posterior port of the device abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50 μ m) that is substantially transparent to light, located posteriorly to the light-projecting posterior port of the device. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium.

[00113] In some embodiments, the device of the present disclosure comprises an intracorneal implant configured for surgical implantation within the cornea of the eye, wherein the intracorneal implant comprises an optical stem configured to transmit light from an ambient environment and/or an extraocular light source, through the eye, along an optical path and onto the retina. In some embodiments, the intracorneal implant of the present disclosure may be configured for surgical implantation within the cornea of the eye, such that a light-projecting posterior port of the device abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50 μ m) that is substantially transparent to light, located posteriorly to the light-projecting posterior port of the device. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium. In some embodiments, the very thin layer of corneal tissue may comprise a part of the optical path.

[00114] In some embodiments, the optical stem defines a light-transparent pathway for transmitting light from the ambient environment and/or an extraocular light source through the eye along an optical path, wherein the pathway defined by the optical stem may comprise one or more optional optical elements, such as optical lenses. In some embodiments, the optical stem of the present disclosure comprises an optical device that projects an image beyond its light-projecting posterior port (e.g., when the device of the present disclosure is implanted in the eye, the image is projected on the retina) based on light entering a light-receiving anterior port located at an anterior end of the optical stem. In some embodiments, the optical stem has a light-receiving anterior port located at an anterior end of the optical stem, close to the eye's anterior surface. In some embodiments, the optical stem extends through the cornea to a light-projecting posterior port of the optical stem, located closer to the posterior surface of the cornea. In some embodiments, the anterior end of the optical stem lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface. In some embodiments, the anterior end of the optical stem sits proximately to the eye's surface, fully or partially underneath a thin conjunctival flap layer. In some embodiments, the anterior end of the optical stem may comprise a curved anterior

surface which acts as an anterior-end focusing optical element. In some embodiments, the anterior end of the optical stem may be configured to receive one or more external optical elements. In some embodiments, the optical stem includes inner optical and/or imaging components, such as lenses, which assist in providing a focused image on the retina. In other embodiments, the optical stem is simply a transparent path that allows external light or imaging components to form the image on the retina. In some embodiments, the external optical elements may be removable, replaceable, adjustable, and/or may be colored or feature a design configured for cosmesis and/or to impart a natural appearance to the eye (e.g. the external optical elements may be colored to resemble/mimic the natural color of the iris).

[00115] In other embodiments, the optical stem includes an image generator incorporating any suitable image display and/or projection technology, such as liquid crystal display (LCD) element that has an illuminator element optically coupled thereto, a LED projector, a laser diode projector, a LED array, and the like. In some embodiments, the image generator is configured to receive an image data signal from an extraocular source (such as an extraocular imaging device), and to generate an optical image signal that is projected in a posterior direction through the light-projecting posterior port, onto the retina of the eye.

[00116] In some embodiments, the intracorneal implant of the present disclosure generally defines a convex body having a convexity which substantially conforms to the convexity of the cornea. In some embodiments, the implant comprises a central optical part, configured to receive and retain an optical stem of the present device therein, and a peripheral haptic part. In some embodiments, the central optical part comprises a circumferentially-continuous annular body member configured to receive and retain an optical stem of the present device therein. In some embodiments, the peripheral haptic part of the implant comprises two or more angularly-spaced haptics that extend laterally from a peripheral edge of the annular body member.

[00117] In some embodiments, the method comprises surgically implanting a device of the present disclosure in a recipient, by first performing deep lamellar dissection (e.g. pneumatic, hydro-assisted, viscoelastic-assisted and/or manual dissection) in the recipient cornea which separates between the deep posterior stroma and the pre-Descemet layer

(alternatively, between the pre-Descemet layer and the Descemet membrane). A partial thickness trephination and anterior keratectomy is performed to remove the anterior corneal lamella of the recipient cornea. The deep posterior stroma (e.g. the bubble roof) is removed to create a recess, leaving the layers posterior thereto, i.e., pre-Descemet layer, the Descemet membrane, and/or the endothelium, intact. The device of the present disclosure is placed and sutured within the created recess. The previously-removed recipient anterior corneal lamella, or a donor anterior corneal lamella, is sutured. A conjunctival flap may be placed to temporarily cover the cornea. The conjunctival flap can then be partially removed, to create a central aperture corresponding to the anterior end of the device, which may be configured to receive one or more external optical elements. As used herein, 'recess' may refer to any opening, dissection, separation, niche or any other opening within the cornea in any shape that can host the intracorneal implant.

[00118] In yet another aspect of the present disclosure, there is provided a pre-processed corneal tissue scaffold derived from a donor cornea and comprising at least some of stromal layers, pre-Descemet layer, the Descemet membrane, and/or the endothelium.

[00119] In some embodiments, a corneal tissue scaffold of the present disclosure may comprise various compositions of corneal layers at different regions thereof. For example, the corneal tissue scaffold may comprise, at a central, substantially transparent, region thereof, the pre-Descemet layer, the Descemet membrane, and/or the endothelium. In some embodiments, the central region of the corneal tissue scaffold is thus configured to be substantially transparent to light. In some embodiments, regions of the corneal tissue scaffold surrounding the central, substantially transparent, region, may have a different composition of corneal layers, comprising at least some of the stromal layer, pre-Descemet layer, the Descemet membrane, and/or the endothelium.

[00120] In some embodiments, the pre-processed corneal tissue scaffold of the present system comprises corneal tissue derived from a donor human cornea. In some embodiments, initially, the corneal tissue is collected from a donor. The collected corneal tissue may then be preserved and transported in conventional tissue preservation manner to a suitable processing location or facility for evaluation, preparation, processing and storage.

[00121] In some embodiments, the corneal tissue is then prepared by performing deep lamellar dissection (e.g. pneumatic, hydro-assisted, viscoelastic-assisted and/or manual dissection) which separates (i) between the posterior stroma and the pre-Descemet layer, or, alternatively, (ii) between the pre-Descemet layer and the Descemet membrane. A partial thickness trephination and anterior keratectomy is performed to remove the donor anterior corneal lamella. The deep posterior stroma (e.g. the bubble roof) is removed to create a recess, leaving the layers posterior thereto, i.e., pre-Descemet layer, the Descemet membrane, and/or the endothelium, intact. A full-thickness trephination is then performed to obtain the corneal tissue scaffold.

[00122] The obtained corneal tissue scaffold may then be decontaminated, dehydrated, sterilized, and packaged for use by surgeons and other medical professionals in appropriate surgical procedures as further detailed herein.

[00123] In some embodiments, the corneal tissue scaffold of the present system may further be pre-processed using any one or more suitable preprocessing methods and techniques, to stabilize and protect the corneal tissue scaffold during preparation, storage, and transportation. In some embodiments, preprocessing methods and techniques according to the present invention may include, but are not limited to: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, decontamination, sterilization, and the like.

[00124] In some embodiments, the preprocessing prevents the corneal tissue scaffold from decomposing, putrefying, becoming infected, and/or fracturing during storage and transportation, and allows the corneal tissue scaffold to be stored at room temperature or at a temperature lower than room temperature. In some embodiments, the preprocessing also helps maintain the corneal tissue scaffold so that it has similar material properties to those of live or hydrated tissue or treated tissue. In some embodiments, the preprocessing allows for direct implantation of the corneal tissue scaffold into a recipient subject without further processing or with minimal processing after removal from the packaging.

[00125] In some embodiments, the pre-processed donor corneal tissue scaffold of the present disclosure is configured for implantation in a recipient subject, to replace at least some of the stromal layers, pre-Descemet layer, the Descemet membrane, and/or the

endothelial layer in the subject, in preparation for further implantation of a device of the present disclosure, as further detailed herein. In such embodiments, the pre-processed corneal tissue scaffold of the present disclosure is configured for implantation in conjunction with a full-thickness transplant procedure, in which a full-thickness resection of the patient's cornea is performed, followed by replacement with an implant and/or system comprising at least of the corneal tissue scaffold of the present disclosure.

[00126] In yet another aspect of the present disclosure, a system is provided comprising (i) a device configured for surgical implantation within the eye, and (ii) a pre-processed corneal tissue scaffold derived from a donor cornea and comprising at least some of the stromal layers, pre-Descemet layer, the Descemet membrane, and/or the endothelial layer.

[00127] In some embodiments, the device of the present system comprises an intracorneal implant with an optical stem. In some embodiments, the optical stem is configured to transmit light from an ambient environment and/or an extraocular light source, through the eye, along an optical path, through a light-projecting posterior port, and onto the retina. In some embodiments, the optical stem defines a light-transparent pathway for transmitting light from the ambient environment and/or an extraocular light source through the eye along an optical path, wherein the pathway defined by the optical stem may comprise one or more optional external optical elements, such as optical lenses.

[00128] In some embodiments, the optical stem comprises an optical device that forms an image beyond its light-projecting posterior port (e.g., when the device of the present system is implanted in the eye, the image is projected on the retina) based on light entering a light-receiving anterior port located at an anterior end of the optical stem. In some embodiments, the optical stem has a light-receiving anterior port close to the anterior surface, extending axially through the cornea to a light-projecting posterior port of the optical stem, closer to the posterior surface of the cornea. In some embodiments, the anterior end of the optical stem lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface. In some embodiments, the anterior end of the optical stem sits proximately to the eye's surface, fully or partially underneath a thin conjunctival flap layer. In some embodiments, the anterior end of the optical stem may comprise a curved anterior surface which acts as an anterior-end focusing optical element, and/or one or more

separately-formed external optical elements. In some embodiments, the anterior end of the optical stem may be configured to receive one or more external optical elements. In some embodiments, the anterior end of the optical stem may comprise a facility configured for a removably and/or adjustably mounting one or more external optical elements. In some embodiments, the external elements may be colored or feature a design configured for cosmesis and, or to impart a natural appearance to the eye (e.g. the external optical elements may be colored to resemble/mimic the natural color of the iris).

[00129] In some embodiments, the optical stem includes inner optical and/or imaging components, such as lenses, which assist in providing a focused image on the retina. In other embodiments, the optical stem is simply a transparent path that allows external light or imaging components to form the image on the retina.

[00130] In other embodiments, the optical stem includes an image generator incorporating any suitable image display and/or projection technology, such as liquid crystal display (LCD) element that has an illuminator element optically coupled thereto, a LED projector, a laser diode projector, a LED array, and the like. In some embodiments, the image generator is configured to receive an image data signal from an extraocular source (such as an extraocular imaging device), and to generate an optical image signal that is projected in a posterior direction through the light-projecting posterior port, onto the retina of the eye.

[00131] In some embodiments, the intracorneal implant of the present system generally defines a convex body having a convexity which substantially follows the convexity of the cornea. In some embodiments, the implant comprises a central optical part and a peripheral haptic part. In some embodiments, the central optical part comprises a circumferentially-continuous annular body member configured to receive and retain an optical stem of the present device therein. In some embodiments, the peripheral haptic part of the implant comprises two or more angularly-spaced haptics that extend laterally from a peripheral edge of the annular body member.

[00132] In some embodiments, a corneal tissue scaffold of the present system may comprise various compositions of corneal layers at different regions thereof. For example, the corneal tissue scaffold may comprise, at a central, substantially transparent, region thereof, the pre-Descemet layer, the Descemet membrane, and/or the endothelium. In some

embodiments, the central region of the corneal tissue scaffold is thus configured to be substantially transparent to light. In some embodiments, regions of the corneal tissue scaffold surrounding the central, substantially transparent region, may have a different composition of corneal layers, comprising at least some of the stromal layer, pre-Descemet layer, the Descemet membrane, and/or the endothelium.

[00133] In some embodiments, the pre-processed corneal tissue scaffold of the present system comprises corneal tissue derived from a donor human cornea. In some embodiments, initially, the corneal tissue is collected from a donor. The collected corneal tissue may then be preserved and transported in conventional tissue preservation manner to a suitable processing location or facility for evaluation, preparation, processing and storage.

[00134] In some embodiments, the donor corneal tissue is then prepared by performing deep lamellar dissection (e.g. pneumatic, hydro-assisted, viscoelastic-assisted and/or manual dissection) which separates (i) between the posterior stroma and the pre-Descemet layer, or, alternatively, (ii) between the pre-Descemet layer and the Descemet membrane. A partial thickness trephination and anterior keratectomy is performed to remove the donor anterior corneal lamella. The deep posterior stroma (e.g. the bubble roof) is removed to create a recess, leaving the layers posterior thereto, i.e., pre-Descemet layer, the Descemet membrane, and/or the endothelium, intact. A full-thickness trephination is then performed to obtain the corneal tissue scaffold.

[00135] The obtained corneal tissue scaffold may then be decontaminated, dehydrated, sterilized, and packaged for use by surgeons and other medical professionals in appropriate surgical procedures as further detailed herein.

[00136] In some embodiments, the corneal tissue scaffold of the present system may further be pre-processed using any one or more suitable preprocessing methods and techniques, to stabilize and protect the corneal tissue scaffold during preparation, storage, and transportation. In some embodiments, preprocessing methods and techniques according to the present invention may include, but are not limited to: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, decontamination, sterilization, and the like. In some embodiments, the preprocessing prevents the corneal tissue scaffold from decomposing, putrefying, becoming infected,

and/or fracturing during storage and transportation, and allows the corneal tissue scaffold to be stored at room temperature or at a temperature lower than room temperature. In some embodiments, the preprocessing also helps maintain the corneal tissue scaffold so that it has similar material properties to those of live or hydrated tissue or treated tissue. In some embodiments, the preprocessing allows for direct implantation of the corneal tissue scaffold into a recipient subject without further processing or with minimal processing after removal from the packaging.

[00137] In some embodiments of the present system, the corneal tissue scaffold and the device are pre-assembled, such that a light-projecting posterior port of the device abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50 μ m) that is substantially transparent to light, posteriorly to the light-projecting posterior port of the device. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium.

[00138] In some embodiments, the present system, in its pre-assembled configuration comprising the device pre-mounted to a corneal tissue scaffold, is configured for surgical implantation in a recipient, in conjunction with a full-thickness transplant procedure, in which a full-thickness resection of the patient's cornea is performed, followed by placement (e.g. suturing) of the present system in place.

[00139] In some embodiments, the device and the corneal tissue scaffold form separate parts of the present system, wherein the corneal tissue scaffold is configured for surgical implantation in a recipient subject, to replace at least some of stromal layers, pre-Descemet layer, the Descemet membrane, and/or the endothelial layer in the subject, in preparation for further implantation of an intracorneal implant of the present system, as further detailed herein. In such embodiments, the pre-processed corneal tissue scaffold of the present system is configured for implantation in conjunction with a full-thickness transplant procedure, in which a full-thickness resection of the patient's cornea is performed.

[00140] In some embodiments, after implantation of the corneal tissue scaffold, the device is implanted within the recipient's cornea such that a light-projecting posterior port of the device abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50 μ m) that is substantially transparent to light, posteriorly to the light-projecting posterior port of the device. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium.

[00141] In some embodiments, the very thin layer of corneal tissue acts as a barrier such that the intracorneal implant of the present disclosure does not extend into the anterior chamber, thereby avoiding potential complications including device luxation, hypotony, glaucoma, retroprosthetic membrane formation, or intraocular infection.

[00142] In accordance with some aspects of the present invention, a device of the present disclosure provides an intracorneal implant configured for surgical implantation within the cornea of an eye, wherein the intracorneal implant comprises an image generator mounted to the intracorneal implant, and configured and operable to receive an image data signal from an extraocular source and to generate an image projection light beam (e.g., light beam modulated with visual image information) to be projected on the retina of the eye, for generating an image thereon.

[00143] In some embodiments, the device of the present disclosure may be dimensioned and configured for surgical implantation within the eye, traversing or completely replacing any opaque tissue layers of the cornea, and wherein only substantially transparent corneal tissue is present posterior to the device.

[00144] In some embodiments, the device of the present disclosure may be dimensioned and configured for surgical implantation within the eye, such that is present posteriorly to the light-projecting posterior port of the device.

[00145] In some embodiments, the device of the present disclosure may be configured for surgical implantation within the eye, such that a light-projecting posterior port of the device abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g.,

having a thickness of approximately 10-50 μ m) that is substantially transparent to light, located posteriorly to the light-projecting posterior port of the device. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium. In some embodiments, the very thin layer of corneal tissue acts as a barrier such that the device does not extend into the anterior chamber, thereby avoiding potential complications including device luxation, hypotony, glaucoma, retroprosthetic membrane formation, or intraocular infection.

[00146] In some embodiments, the device of the present disclosure comprises an intracorneal implant dimensioned to fit within a cornea. In some embodiments, the intracorneal implant defines a planar body having a convexity which substantially conforms to the convexity of the cornea, with opposing convex anterior face (facing the anterior surface of the eye) and concave posterior face (facing the retina of the eye).

[00147] In some embodiments, the intracorneal implant comprises an inner platform portion located about an axis of circular symmetry of the implant, and a peripheral portion, comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of the inner platform. In some embodiments, the intracorneal implant further comprises a peripheral skirt portion which defines an outer circular perimeter of the intracorneal implant, wherein the one or more angularly-spaced arms connect between the inner platform and the peripheral skirt portion.

[00148] In some embodiments, an intracorneal implant of a device of the present disclosure may further comprise two or more angularly-spaced haptics that extend laterally from a peripheral edge of the implant. The haptics may function structurally to position and center the intracorneal implant at a desired location, e.g., to align with an optical axis of the eye, within the pocket formed in the cornea during surgery.

[00149] In some embodiments, one or more openings formed within the intracorneal implant of the present disclosure, e.g., located about the one or more connecting arms or the peripheral skirt, may be configured to allow adaptation of the device within the cornea, so as to obtain long-term fixation of the intracorneal implant in a desired position.

[00150] In some embodiments, the intracorneal implant of the present disclosure comprises one or more of: an image generator, an image projection controller including a hardware processor and a memory storage, an optical assembly, a wireless receiver module, and a wireless power receiving element.

[00151] In some embodiments, the device of the present disclosure comprises an image generator mounted to the intracorneal implant, and configured and operable to receive an image data signal from an extraocular source and to generate an image projection light beam (e.g., light beam modulated with visual image information) to be projected on the retina of the eye through a light-projecting posterior port, for generating an image thereon. Visual image information, as the term is used herein, can encompass any optically-communicated information including optical reproductions of an object or a scene, and/or optically-represented information, such as by text, symbols or color.

[00152] In some embodiments, the image generator is configured to receive an image data signal from an extraocular source and to generate an image projection light beam capable of traversing through any semi-opaque, and/or substantially opaque corneal tissue that is present anterior to the device, to reach the retina of the eye.

[00153] In some embodiments, the device of the present disclosure may be configured to receive an image data signal from an image data source that is external to the eye, via a non-optical data transmission modality, such as radio frequency (RF) or similar data transmission, wherein the non-optical data transmission modality is capable of traversing impaired or opaque layers of the eye (e.g., cornea, conjunctiva or other forms of tissue flaps) that are otherwise fully or partially impermeable to visible light.

[00154] Accordingly, in some embodiments, the device of the present disclosure is configured to receive a digital image data signal from an external source via a non-optical data transmission path, e.g., short-range RF transmission; to process the digital image data encoded in the image data signal; to generate a light beam modulated with the image information encoded in the digital image data; and to project the generated light beam onto the retina, via an optical transmission path which may comprise an optical assembly comprising, e.g., one or more focusing optics and/or the lens of the eye.

[00155] In some embodiments, a device of the present disclosure comprises a wireless receiver module configured to receive wirelessly an image data signal representative of image information, via a non-optical wireless transmission modality, e.g., a short-range RF communication protocol.

[00156] In some embodiments, a device of the present disclosure comprises an image projection controller which receives the input image data received by the wireless receiver module and optionally stores the image data in a memory storage module; processes the digital image data encoded in the signal, to generate and reconstruct a visual image therefrom; and operates an image generator to generate a light beam based on the image data and project the generated light beam onto the retina.

[00157] In some embodiments, a device of the present disclosure comprises an image generator for displaying and/or projecting an optical image signal representative of visual images of the type suitable for detection by a retina. In some embodiments, the image generator can incorporate any suitable image display and/or projection technology, such as liquid crystal display (LCD) element that has an illuminator element optically coupled thereto, a LED projector, a laser diode projector, a LED array, and the like. In some embodiments, the image generator comprises an optical assembly comprising any suitable focusing or other optics.

[00158] In some embodiments, the device of the present disclosure may further include a power source configured for providing electrical power to the device. In some embodiments, the power source is configured to receive power from an external power source using wireless power transmission. This is done in order to avoid using wired power connections to an external power source, or internal batteries. Wired power connections to an external power source must pass through the surface of the eye, and thus involve several practical disadvantages, as well as risks of infection, etc. Similarly, powering the device using replaceable batteries installed or mounted within the implantable device itself is impractical, as batteries are bulky, and surgical intervention will be required in order to replace them. Accordingly, in some embodiments, the present disclosure provides for transmitting power to the device into the eye inductively. Thus, for example, a primary (external) inductive coil may be placed in the vicinity of the eye, e.g., positioned about a lens area, or encased

within the rim, of a pair of glasses, and a secondary (internal) reception coil within the device may be used to receive the power transmitted by the primary coil. Accordingly, in some embodiments, the power source may be configured to be charged or to receive power via wireless power transmission, e.g., via inductive power transfer or any other suitable wireless power transmission technique.

[00159] In some embodiments, the wireless power and data transmission are carried out via transmitted light, wherein an extraocular unit is configured to transmit, via a light beam, a combined power and image data signal to the intracorneal implant. In some embodiments, the present disclosure provides for wireless and/or data transfer between an extraocular unit and the device, via transmitted light. In some embodiments, power and data transmission may be performed concurrently, such that a light-transmitted power signal may be transmitted between an extraocular unit and an intracorneal implant, wherein the power signal may encode data during at least a portion of its transmission duration. Thus, in some embodiments, a device of the present disclosure includes a wireless receiver module configured to receive power and image data signal transmitted by an extraocular unit, via a transmitted light signal. In some embodiments, the wireless receiver module may comprise, e.g., a photovoltaic cell.

[00160] In yet another aspect, a system is provided comprising an intracorneal implant configured for surgical implantation within the cornea of an eye; and an extraocular image capture unit in wireless power and data communication with the intracorneal implant, configured to transmit power and image data wirelessly to the intracorneal implant, wherein the image data represents visual images captured by the extraocular unit, and wherein the intraocular implant is configured to generate, from the received image data, an image projection light beam (e.g., light beam modulated with visual image information), and to project the generated light beam on the retina of the eye, for generating the captured visual images thereon.

[00161] In some embodiments, the extraocular unit of the present system comprises at least an imaging device for capturing visual images; an image processing module, comprising one or more hardware processors and a memory storage, for processing and storing the digital image data, to generate an image data signal for transmitting to the intracorneal

implant; a wireless transmitter to transmit the image data signal to the intracorneal implant, using, e.g., any suitable short-range RF communication protocol; and a power source to power the extraocular unit and/or the intracorneal unit, e.g., using wireless power transmission.

[00162] In some embodiments, an extraocular unit of a system of the present disclosure may be formed by several components disposed on a conventional spectacle frame, or coupled to another head-worn element such as a helmet, headband, etc.

[00163] In some embodiments, the intracorneal implant of the present system comprises one or more of: an image projection controller including a hardware processor and a memory storage; an image generator; an optical assembly; a wireless receiver module; and a wireless power receiving element.

[00164] In some embodiments, the intraocular implant of the present system may be dimensioned and configured for surgical implantation within the eye, traversing or completely replacing any opaque tissue layers of the cornea, and wherein only substantially transparent corneal tissue is present posterior to the intraocular implant.

[00165] In some embodiments, the intraocular implant of the present system may be dimensioned and configured for surgical implantation within the eye, such that a layer of corneal tissue that is partially transparent, partially semi-transparent, and/or partially opaque is present posteriorly to the light-projecting posterior port of the device.

[00166] In some embodiments, the intraocular implant of the present system may be configured for surgical implantation within the eye, such that a light-projecting posterior port of the intraocular implant abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50µm) that is substantially transparent to light, located posteriorly to the light-projecting posterior port of the intraocular implant. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium. In some embodiments, the very thin layer of corneal tissue acts as a barrier such that the intraocular implant does not extend into the anterior chamber, thereby avoiding potential complications

including intraocular implant luxation, hypotony, glaucoma, retroprosthetic membrane formation, or intraocular infection.

[00167] In some embodiments, the intraocular implant of the present system comprises an intracorneal implant dimensioned to fit within a cornea. In some embodiments, the intracorneal implant defines a planar body having a convexity which substantially conforms to the convexity of the cornea, with opposing convex anterior face (facing the anterior surface of the eye) and concave posterior face (facing the retina of the eye). In some embodiments, the intracorneal implant is.

[00168] In some embodiments, the intracorneal implant comprises an inner platform portion located about an axis of circular symmetry of the implant, and a peripheral portion, comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of the inner platform. In some embodiments, the intracorneal implant further comprises a peripheral skirt portion which defines an outer circular perimeter of the intracorneal implant, wherein the one or more angularly-spaced arms connect between the inner platform and the peripheral skirt portion.

[00169] In some embodiments, an intraocular implant of the present system may further comprise two or more angularly-spaced haptics that extend laterally from a peripheral edge of the implant. The haptics may function structurally to position and center the intracorneal implant at a desired location, e.g., to align with an optical axis of the eye, within the pocket formed in the cornea during surgery.

[00170] In some embodiments, one or more openings formed within the intracorneal implant of the present system, e.g., located about the one or more connecting arms or the peripheral skirt, may be configured to allow adaptation of the intraocular implant within the cornea, so as to obtain long-term fixation of the intracorneal implant in a desired position.

[00171] In some embodiments, the intraocular implant of the present system comprises an image generator mounted to the intracorneal implant, and configured and operable to output an image projection light beam (e.g., light beam modulated with image information) to be projected on the retina of the eye, for generating an image thereon.

[00172] In some embodiments, the image generator is configured to output an image projection light beam capable of traversing through any transparent, semi-opaque, and/or

substantially opaque corneal tissue that is present posteriorly to the light-projecting posterior port of the device, to reach the retina of the eye.

[00173] In some embodiments, the intraocular implant of the present system may be configured to receive an image data signal from an extraocular unit of the present system, via a non-optical data transmission modality, such as radio frequency (RF) or similar data transmission, wherein the non-optical data transmission modality is capable of traversing impaired or opaque layers of the eye (e.g., cornea, conjunctiva or other forms of tissue flaps) that are otherwise fully or partially impermeable to visible light.

[00174] Accordingly, in some embodiments, the intraocular implant of the present system is configured to receive a digital image data signal from an extraocular unit via a non-optical data transmission path, e.g., short-range RF transmission; to process the digital image data encoded in the image data signal, to generate a light beam modulated/patterned with image information the digital image data; and to project the generated light beam onto the retina, via an optical transmission path which may comprise one or more focusing optics and/or the lens of the eye.

[00175] In some embodiments, an intraocular implant of the present system comprises a wireless receiver module in wireless communication with a wireless transmitter of the extraocular unit of the present system, and configured to receive wirelessly an image data signal representative of image information, via a non-optical wireless transmission modality, e.g., a short-range RF communication protocol.

[00176] In some embodiments, an intraocular implant of the present system comprises an image projection controller which receives the input image data received by the wireless receiver module from the extraocular unit, and optionally stored by the memory storage module; processes the digital image data encoded in the signal, to generate and reconstruct a visual image therefrom; and operates an image generator to modulate light beam based on the image data, to be projected onto the retina.

[00177] In some embodiments, an intraocular implant of the present system comprises an image generator for displaying and/or projecting an optical image signal representative of visual images of the type suitable for detection by a retina. In some embodiments, the image generator can incorporate any suitable image display and/or projection technology, such as

liquid crystal display (LCD) element that has an illuminator element optically coupled thereto, a LED projector, a laser diode projector, a LED array, and the like. In some embodiments, the image generator comprises an optical assembly comprising any suitable focusing or other optics.

[00178] In some embodiments, the intraocular implant of the present system may further include a power source configured for providing electrical power to the intraocular implant. In some embodiments, the power source is configured to receive power from an external power source using wireless power transmission. This is done in order to avoid using wired power connections to an external power source, or internal batteries. Wired power connections to an external power source must pass through the surface of the eye, and thus involve several practical disadvantages, as well as risks of infection, etc. Similarly, powering the intraocular implant using replaceable batteries installed or mounted within the implantable intraocular implant itself is impractical, as batteries are bulky, and surgical intervention will be required in order to replace them. Accordingly, in some embodiments, the present system provides for transmitting power to the intraocular implant into the eye inductively. Thus, for example, a primary (external) inductive coil may be placed in the vicinity of the eye, e.g., positioned about a lens area, or encased within the rim, of a pair of glasses, and a secondary (internal) reception coil within the intraocular implant may be used to receive the power transmitted by the primary coil. Accordingly, in some embodiments, the power source may be configured to be charged or to receive power via wireless power transmission, e.g., via inductive power transfer or any other suitable wireless power transmission technique.

[00179] In some embodiments, the wireless power and data transmission are carried out via transmitted light, wherein the extraocular unit is configured to transmit, via a light beam, a combined power and image data signal to the intracorneal implant. In some embodiments, the present system provides for wireless and/or data transfer between an extraocular unit and an intracorneal implant, via transmitted light. In some embodiments, power and data transmission may be performed concurrently, such that a light-transmitted power signal may be transmitted between an extraocular unit and an intracorneal implant, wherein the power signal may encode data during at least a portion of its transmission duration.

[00180] Thus, in some embodiments, the extraocular unit of the present system comprises a transmitter configured to transmit power and/or data signals via transmitted light. In some embodiments, the transmitter is configured to transmit one or both of power and data during any given time interval. For example, during data transmission portions, the signal may carry information that is encoded by variations in amplitude of the power signal, or by any other suitable modulation technique. Similarly, in some embodiments, an intracorneal implant of the present system of the present includes a wireless receiver module configured to receive the power and image data signal transmitted by the extraocular unit, via a transmitted light signal. In some embodiments, the wireless receiver module may comprise, e.g., a photovoltaic cell.

[00181] In yet another aspect, a system is provided comprising an intracorneal implant configured for surgical implantation within the cornea of an eye; and an extraocular image capture unit in wireless power and data communication with the intracorneal implant.

[00182] In some embodiments, the extraocular unit of the present system comprises at least an imaging device for capturing visual images; an image processing module, comprising one or more hardware processors and a memory storage, for processing and storing the digital image data, to generate an image data signal for transmitting to the intracorneal implant; a wireless transmitter to transmit the image data signal to the intracorneal implant, using, e.g., any suitable short-range RF communication protocol; a power source to power the extraocular unit and/or the intracorneal unit, e.g., using wireless power transmission.

[00183] In some embodiments, the extraocular unit of a system of the present disclosure may be formed by several components disposed on a conventional spectacle frame, or coupled to another head-worn element such as a helmet, headband, etc.

[00184] In some embodiments, the intracorneal implant of the present disclosure comprises one or more of: an image projection controller including a hardware processor and a memory storage; an image generator; an optical assembly; a wireless receiver module; and a wireless power receiving element.

[00185] In some embodiments, the intraocular implant may be dimensioned and configured for surgical implantation within the eye, traversing or completely replacing any

opaque tissue layers of the cornea, and wherein only substantially transparent corneal tissue is present posterior to the intraocular implant.

[00186] In some embodiments, the intraocular implant may be dimensioned and configured for surgical implantation within the eye, such that a layer of corneal tissue that is partially transparent, partially semi-transparent, and/or partially opaque is present posteriorly to the light-projecting posterior port of the device.

[00187] In some embodiments, the intraocular implant of the present system may be configured for surgical implantation within the eye, such that a light-projecting posterior port of the intraocular implant abuts or is substantially in contact engagement with a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50 μ m) that is substantially transparent to light, located posteriorly to the light-projecting posterior port of the intraocular implant. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium. In some embodiments, the very thin layer of corneal tissue acts as a barrier such that the intraocular implant does not extend into the anterior chamber, thereby avoiding potential complications including intraocular implant luxation, hypotony, glaucoma, retroprosthetic membrane formation, or intraocular infection.

[00188] In some embodiments, the intraocular implant of the present system comprises an intracorneal implant dimensioned to fit within a cornea. In some embodiments, the intracorneal implant defines a planar body having a convexity which substantially conforms to the convexity of the cornea, with opposing convex anterior face (facing the anterior surface of the eye) and concave posterior face (facing the retina of the eye). In some embodiments, the intracorneal implant is.

[00189] In some embodiments, the intracorneal implant comprises an inner platform portion located about an axis of circular symmetry of the implant, and a peripheral portion, comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of the inner platform. In some embodiments, the intracorneal implant further comprises a peripheral skirt portion which defines an outer circular perimeter of the intracorneal implant,

wherein the one or more angularly-spaced arms connect between the inner platform and the peripheral skirt portion.

[00190] In some embodiments, an intraocular implant of the present system may further comprise two or more angularly-spaced haptics that extend laterally from a peripheral edge of the implant. The haptics may function structurally to position and center the intracorneal implant at a desired location, e.g., to align with an optical axis of the eye, within the pocket formed in the cornea during surgery.

[00191] In some embodiments, one or more openings formed within the intracorneal implant of the present system, e.g., located about the one or more connecting arms or the peripheral skirt, may be configured to allow adaptation of the intraocular implant within the cornea, so as to obtain long-term fixation of the intracorneal implant in a desired position.

[00192] In some embodiments, the intraocular implant of the present system comprises an image generator mounted to the intracorneal implant, and configured and operable to generate an image pattern on a panel, such as a liquid crystal display (LCD) panel, wherein the generated image pattern is to be projected on the retina of the eye, for generating an image thereon.

[00193] In some embodiments, an intraocular implant of the present system comprises a wireless receiver module in wireless communication with a wireless transmitter of the extraocular unit of the present system, and configured to receive wirelessly an image data signal representative of image information, via a non-optical wireless transmission modality, e.g., a short-range RF communication protocol. In some embodiments, the wireless receiver module is configured to receive an image data signal from the extraocular unit of the present system, via a non-optical data transmission modality, such as radio frequency (RF) or similar data transmission, wherein the non-optical data transmission modality is capable of traversing impaired or opaque layers of the eye (e.g., cornea, conjunctiva or other forms of tissue flaps) that are otherwise fully or partially impermeable to visible light.

[00194] Accordingly, in some embodiments, the wireless receiver module of the intraocular implant of the present system is configured to receive a digital image data signal from an extraocular unit via a non-optical data transmission path, e.g., short-range RF

transmission; to process the digital image data encoded in the image data signal, to generate an image pattern or a series of image patterns on a display panel; and to project the generated image pattern onto the retina, via an optical transmission path which may comprise one or more focusing optics and/or the lens of the eye.

[00195] In some embodiments, an intraocular implant of the present system comprises an image projection controller which receives the input image data received by the wireless receiver module from the extraocular unit, and optionally stored by the memory storage module; processes the digital image data encoded in the signal, to generate and reconstruct a visual image therefrom; and operates a display panel to form an image pattern therein, to be projected onto the retina.

[00196] In some embodiments, an intraocular implant of the present system comprises an image generator for displaying an optical image representative of visual images of the type suitable for detection by a retina. In some embodiments, the image generator can incorporate any suitable image display, such as liquid crystal display (LCD) element that has an illuminator element optically coupled thereto, and the like. In some embodiments, the image generator comprises an optical assembly comprising any suitable focusing or other optics.

[00197] In some embodiments, the intraocular implant of the present system may further include a power source configured for providing electrical power to the intraocular implant. In some embodiments, the power source is configured to receive power from an external power source using wireless power transmission.

[00198] In some embodiments, the present system comprises an external illumination source, which may be included in the extraocular unit, and may be configured to illuminate the image generator of the intracorneal implant (e.g., an LCD panel), so as to project the image displayed therein onto the retina of the eye.

[00199] In some embodiments, the present system comprises an intraocular illumination source, which may be mounted or coupled to the image generator of the intracorneal extraocular unit, and may be configured to illuminate the image generator of the intracorneal implant (e.g., an LCD panel), so as to project the image displayed therein onto the retina of the eye. Thus, in some embodiments, the image generator may comprise an LCD panel configured to display a visual image thereon. In some embodiments, the LCD panel may

comprise a backlight illumination source or another similar illumination source integrated within the intracorneal implant.

[00200] In some embodiments, the wireless power and data transmission are carried out via transmitted light, wherein the extraocular unit is configured to transmit, via a light beam, a combined power and image data signal to the intracorneal implant. In some embodiments, the present disclosure provides for wireless and/or data transfer between an extraocular unit and an intracorneal implant, via transmitted light. In some embodiments, power and data transmission may be performed concurrently, such that a light-transmitted power signal may be transmitted between an extraocular unit and an intracorneal implant, wherein the power signal may encode data during at least a portion of its transmission duration.

[00201] Thus, in some embodiments, the extraocular unit of the present system comprises a transmitter configured to transmit power and/or data signals via transmitted light. In some embodiments, the transmitter is configured to transmit one or both of power and data during any given time interval. For example, during data transmission portions, the signal may carry information that is encoded by variations in amplitude of the power signal, or by any other suitable modulation technique. Similarly, in some embodiments, an intracorneal implant of the present system of the present includes a wireless receiver module configured to receive the power and image data signal transmitted by the extraocular unit, via a transmitted light signal. In some embodiments, the wireless receiver module may comprise, e.g., a photovoltaic cell.

[00202] Reference is made to Figs. 1A-1C which schematically illustrate, in perspective (Fig. 1A), perspective cross-section (Fig. 1B), and side cross-section view (Fig. 1C), an exemplary device **100** of the present disclosure, comprising an intracorneal implant **200** and an optical stem **300**.

[00203] Reference is also made to Figs. 1D-1E which schematically illustrate, in exploded perspective (Fig. 1D) and side (Fig. 1E) views, device **100**, comprising an intracorneal implant **200** and an optical stem **300**, as implanted within eye **101**.

[00204] In some embodiments, intracorneal implant **200** is configured for surgical implantation within the cornea of the eye **101**. In some embodiments, intracorneal implant

200 generally comprises a central optical part, configured to receive and retain an optical stem **300** of the device **100**, and a peripheral haptic part comprising two or more haptics.

[00205] In some embodiments, device **100** comprises an optical stem **300** configured to transmit light from an ambient environment and/or an external light source, through the eye **101**, along an optical path and onto the retina. In some embodiments, optical stem **300** defines a light-transparent pathway, represented by a dashed line in Figs. 1D-1E, for transmitting light from the ambient environment and/or an extraocular light source through the eye.

[00206] In some embodiments, after implantation anterior corneal lamella **102**, consisting of a previously-removed recipient anterior corneal lamella, donor corneal tissue, or a corneal tissue scaffold, may be sutured in place to fully or partially cover the cornea and the implanted device.

[00207] Figs. 2A-2E show an exemplary intracorneal implant **200** of device **100** (shown in Figs. 1A-1C), in top perspective (Fig. 2A), bottom perspective (Fig. 2B), side (Fig. 2C), top (Fig. 2D), and bottom (Fig. 2E) views, according to some embodiments of the present disclosure.

[00208] In some embodiments, intracorneal implant **200** is configured for surgical implantation within the cornea of the eye. In some embodiments, intracorneal implant **200** generally comprises a central optical part comprising an anchor body **202**, and a peripheral haptic part comprising two or more haptics **204**.

[00209] In some embodiments, intracorneal implant **200** defines a planar body having a convexity which substantially conforms to the convexity of the cornea, with opposing convex anterior face (facing the anterior surface of the eye, shown in Fig. 2A) and concave posterior face (facing the retina of the eye, shown in Fig. 2B).

[00210] In some embodiments, intracorneal implant **200** is dimensioned to fit within a cornea. For example, intracorneal implant **200** may have an overall span between opposing edges thereof of, e.g., 6-12mm (e.g., 9mm), an overall planar thickness of between 0.02-1.50mm, and a convexity having a curvature of between 32-47 diopters.

[00211] Optionally, the central optical part comprises a circumferentially-continuous annular anchor body **202** which defines a central aperture **202a** configured to receive and retain optical stem **300** therein. However, in other embodiments, as shall be further detailed below, anchor body **202** may include an integrally-formed optical stem **300**.

[00212] Anchor body **202** can be a ring, a rim, a cannula, a cylinder, or any other suitable three-dimensional shape which can define a circular or cylindrical aperture and/or form an optical stem (such as optical stem **300** which will be described in detail hereinbelow), and to which haptics **204** can be attached.

[00213] In some embodiments, intracorneal implant **200**, including anchor body **202** and haptics **204**, may be fashioned of any suitable biologically-compatible material, e.g., any metal, metal alloy (such as nitinol, stainless steel, and the like). In some embodiments, the material can be a polymer, e.g., an acrylate polymer, polycarbonate, polymethyl methacrylate (PMMA), polyvinyl chloride (PVC), polyolefin copolymers, fluoropolymers (e.g. PTFE), polyamides, polyimides, polyesters, polyurethane, copolymers thereof, silicone, a cross-linked silicone polymer, and combinations thereof.

[00214] In some embodiments, all the components of implant **200** can be made of the same material. In some embodiments, at least two of the components of implant **200** are made of different materials. One or more of the materials comprising intracorneal implant **200** can be transparent, substantially transparent, or optically transparent. One or more of the materials comprising intracorneal implant **200** can be biocompatible.

[00215] In some embodiments, intracorneal implant **200** may be fashioned integrally as a unitary intracorneal implant of a single material, or may be assembled from two or more separate components, wherein each component may be made of a different material. In some embodiments, intracorneal implant **200** or any portion thereof may be made of a hard or non-deformable material, a shape-memory material, and/or a flexible or deformable material. In some embodiments, intracorneal implant **200** or any portion thereof may have a coating of, e.g., hydroxyapatite or a similar material. For example, the anchor body **202** and haptics **204** may be made of a different material, or alternatively be made of similar materials having different mechanical properties.

[00216] In some embodiments, the peripheral haptic part of implant **200** comprises two or more angularly-spaced haptics **204** that extend laterally from anchor body **202**, e.g., from an outer peripheral edge thereof. In some embodiments, haptics **204** extend outwardly from an outer peripheral edge of anchor body **202**. The haptics **204** may function structurally to center and anchor an implanted intracorneal implant **200** in place. Each of haptics **204** includes a proximal end which is connected to the outer peripheral edge of anchor body **202**, and a projecting segment culminating in a distal end. In some embodiments, between 2 and 6 haptics **204** may be used. In some embodiments, the haptics **204** may be divided into opposing pairs, each of which extends outwardly and away from anchor body **202** at opposite ends thereof. The haptics **204** can have any suitable shape, dimensions, and contour, as known in the art. The haptics **204** included in any given intracorneal implant **200** can be all of the same, or vary, in shape and dimensions.

[00217] During implantation of intracorneal implant **200**, each of the haptics **204** may be manipulated so as to center the intracorneal implant **200** as close to the optical axis of the eye as possible, as well as to ensure that the intracorneal implant **200** has the desired placement in the rotational direction in the X-Y plane, and secure it in place inside the cornea.

[00218] In some embodiments, at least one of haptics **204** comprises one or more openings **206**. In some embodiments, each of haptics **204** comprises a series of spaced-part openings **206** along at least a portion of its length. The openings **206** can be any suitable shape or dimensions, such as any regular shapes and regular polygons (e.g. circles, semi-circles, ellipses, squares, triangles, hexagons, octagons, and rectangles) and irregular shapes and polygons. The number of openings **206** on each haptic **204** can be between 0-20 or more openings. The openings **206** can be positioned anywhere on the haptics **204**.

[00219] In some embodiments, openings **206** are configured to allow adaptation of the intracorneal implant **200** within the cornea through the openings **206** and fixation of the intracorneal implant **200** within the surrounding corneal tissue. In this manner, once intracorneal implant **200** has been implanted, and the eye has healed, intracorneal implant **200** becomes substantially anchored in place by the growth and remodeling of surrounding tissue.

[00220] Figs. 3A-3C are overview illustrations, in cross-sectional side (Fig. 3A), exploded perspective (Fig. 3B) and exploded side (Fig. 3C) views, of an exemplary optical stem **300** of a device **100** of the present disclosure, configured to be implanted within the cornea of the eye, and to transmit light from an ambient environment and/or an extraocular light source, through the eye, along an optical path (as marked by a dashed line in Figs. 3B-3C) and onto the retina.

[00221] In some embodiments, optical stem **300** defines a light-transparent pathway for transmitting light from the ambient environment and/or an extraocular light source through the eye along an optical path, wherein the pathway defined by the optical stem may comprise at least one optical element, such as an optical lens.

[00222] In other embodiments, optical stem **300** includes an image generator incorporating any suitable image display and/or projection technology, such as liquid crystal display (LCD) element that has an illuminator element optically coupled thereto, a LED projector, a laser diode projector, a LED array, and the like. In some embodiments, the image generator is configured to receive an image data signal from an extraocular source (such as an extraocular imaging device), and to generate an optical image signal that is projected in a posterior direction through the light-projecting posterior port, onto the retina of the eye.

[00223] In some embodiments, optical stem **300** is configured to project an image beyond its light-projecting posterior port at its posterior end **300b** (e.g., when device **100** is implanted in the eye, the image is projected on the retina) based on light entering a light-receiving anterior port at anterior end **300a** of the optical stem, which defines an anterior-most end of intracorneal implant **200**. In some embodiments, the optical stem has a light-receiving anterior port at anterior end **300a**, closest to the eye's anterior surface. The optical stem extends axially through the cornea to a light-projecting posterior port located at posterior end **300b** of the optical stem, closer to the posterior surface of the cornea. In some embodiments, the anterior end **300a** of the optical stem defines an anterior-most point of the device **100**, and lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface. In some embodiments, the anterior end **300a** of the optical stem sits proximately to the eye's anterior surface, fully or partially underneath a thin conjunctival flap layer. In some embodiments, at least a portion of the anterior end of

optical stem **300** is exposed through the eye's anterior surface and forms a means for accepting external optical elements of device **100**, as shall be further described below.

[00224] In some embodiments, the anterior end **300a** of the optical stem may comprise an anterior surface which acts as an optical element, e.g., a focusing lens. In some embodiments, as shall be further detailed below, anterior end **300a** is configured to receive one or more external optical elements.

[00225] In some embodiments, the optical stem **300** includes one or more internal optical and/or imaging components, such as lenses, which assist in providing a focused image on the retina, wherein the optical components of optical stem **300** are optically-aligned with the light-transparent pathway defined by optical stem **300**. In other embodiments, the optical stem **300** is simply a transparent path that allows external light or imaging components to pass through and project from the light-projecting posterior port and onto the retina. In other embodiments, optical stem **300** includes an image generator incorporating any suitable image display and/or projection technology, such as liquid crystal display (LCD) element that has an illuminator element optically coupled thereto, a LED projector, a laser diode projector, a LED array, and the like. In some embodiments, the image generator is configured to receive an image data signal from an extraocular source (such as an extraocular imaging device), and to generate an optical image signal that is projected in a posterior direction through the light-projecting posterior port, onto the retina of the eye.

[00226] In some embodiments, optical stem **300** comprises at least an inner optical lens **302** (further detailed with reference to Figs. 4A-4B), which may be received within aperture **202a**, or optionally be integrally formed with intracorneal implant **200** in lieu of aperture **202a**. In some embodiments, inner optical lens **302** may be configured for mounting directly within aperture **202a** of intracorneal implant **200**. In some embodiments, inner optical lens **302** may be integrally formed with intracorneal implant **200**, e.g., approximately centrally located with respect to anchor body **202**, wherein in such case, anchor body **202** does not feature the aperture **202a**.

[00227] In some embodiments, inner optical lens **302** may be configured for mounting within a separate lens housing **304**, wherein lens housing **304** is configured to be received within aperture **202a** of intracorneal implant **200**. Lens housing **304** may comprise a

cylinder or tube-like portion that houses inner optical lens **302** through which light passes in order to project images to the retina. The lens housing **304** used herein may be made from any appropriate and biologically compatible material, such as polymethylmethacrylate (PMMA), polysulfone, trimethyl terminated polydimethylsiloxane (PDMS), polystyrene-polyisobutylene-polystyrene (SIBS) etc. The lens housing **304** may be any size sufficient to accommodate vision, such as to permit an appropriate amount of light to pass through.

[00228] In some embodiments, optical lens **302** may be integrally formed with the lens housing **304**. In some embodiments, lens housing **304** may be integrally formed with intracorneal implant **200**, e.g., approximately centrally located with respect to anchor body **202**, wherein in such case, anchor body **202** does not feature the aperture **202a**. In some embodiments, optical lens **302** and lens housing **304** may both be integrally formed with intracorneal implant **200**, e.g., such that lens housing **304** and optical lens **302** are approximately centrally located with respect to anchor body **202**, wherein in such case, anchor body **202** does not feature the aperture **202a**.

[00229] Reference is now made to Figs. 4A-4B which show, in perspective (Fig. 4A) and side (Fig. 4B) views, an exemplary inner optical lens **302** of the present disclosure, such as may be used in conjunction with device **100**.

[00230] In some embodiments, inner optical lens **302** may be any convex, concave, monofocal, multifocal, Fresnel, diffractive, prismatic, focusing, or other type of lens that can be used to treat refractive error (such as myopia, hyperopia, or astigmatism). In some embodiments, inner optical lens **302** may be configured, alone or in combination with one or more additional inner and or external lenses, to focus an image onto the retina.

[00231] In some embodiments, inner optical lens **302** may be integrally-formed with the central optical part of intracorneal implant **200**, e.g., integrally-formed with anchor body **202**, such that inner optical lens **302** forms an optical lens within aperture **202a**. In other embodiments, inner optical lens **302** is formed separately of intracorneal implant **200**, and may be configured to be received and retained within aperture **202a**, e.g., by mounting inner optical lens **302** within aperture **202a** using a precision fit, a press fit, a click-fit connector, a threaded coupling, an annular groove-and-channel engagement, by fusing, by bonding between an inner peripheral edge of anchor body **202** which defines aperture **202a** and a

peripheral edge of inner optical lens **302**, and/or any other suitable mounting method or technique. In some embodiments, inner optical lens **302** may be configured to be mounted within aperture **202a** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of inner optical lens **302** and aperture **202a**.

[00232] Reference is now made to Figs. 5A-5D which show, in front perspective (Fig. 5A), back perspective (Fig. 5B), side (Fig. 5C), and top (Fig. 5D) views, an exemplary intracorneal lens housing **304** of the present disclosure, such as may be used in conjunction with device **100** and inner optical lens **302**.

[00233] In some embodiments, lens housing **304** defines any substantially cylindrical or tube-like body configured to be attached or mounted within anchor body **202**, e.g., within aperture **202a**, and oriented in relation to the eye such that lens housing **304** defines a light-transparent pathway for transmitting light from the ambient environment and/or an extraocular light source through the eye along an optical path. In some embodiments, lens housing **304** may comprise a base portion **304a** configured to be received and mounted within aperture **202a** of anchor body **202**, e.g., using a precision fit, a press fit, a click-fit, an annular groove-and-channel engagement, a threaded engagement, by fusing, by bonding between an inner peripheral edge of anchor body **202** which defines aperture **202a** and a peripheral edge of base portion **304a**, and/or any other suitable mounting method or technique. In some embodiments, base portion **304a** may be configured to be mounted within aperture **202a** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of base portion **304a** and aperture **202a**.

[00234] In some embodiments, lens housing **304** comprises a larger-diameter lens holding portion **304b** configured to receive and retain inner optical lens **302** therein. In some embodiments, lens housing **304** may be configured to be mounted within aperture **202a** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of lens housing **304** and aperture **202a**.

[00235] In some embodiments, lens housing **304** may be fashioned of any suitable biologically-compatible material, e.g., any metal, metal alloy (such as nitinol, stainless steel,

and the like). In some embodiments, the material can be a polymer, e.g., an acrylate polymer, polymethyl methacrylate (PMMA), polyvinyl chloride (PVC), polyolefin copolymers, fluoropolymers (e.g. PTFE), polyamides, polyimides, polyesters, polyurethane, copolymers thereof, silicone, a cross-linked silicone polymer, and combinations thereof.

[00236] It should be noted that any two or more of the components of intracorneal implant **200**, including anchor body **202** and haptics **204**, and/or the components of optical stem **300**, including optical lens **302** and lens housing **304**, may be constructed as a single unit or piece, from a single material, using any suitable manufacturing process such as, but not limited to, molding, additive printing, and the like.

[00237] Fig. 6 is an exploded perspective view of an exemplary device **100** of the present disclosure, including intracorneal implant **200** and optical stem **300**, configured to transmit light from an ambient environment and/or an extraocular light source, through the eye, along an optical path (as marked by a dashed line) and onto the retina. In some embodiments, device **100** further comprises optional external optical elements which are extra-ocular, including, e.g., end plate **310** and/or external optical lens **316**, which may be mounted to anterior end **300a** of optical stem **300**, as shall be further described below. In some embodiments, external optical lens **316** is integrally-formed with end plate **310**.

[00238] Reference is made to Figs. 7A-7D which show in front perspective (Fig. 7A), back perspective (Fig. 7B), side (Fig. 7C), and top (Fig. 7D) views, an exemplary external anterior end plate **310** which may be further comprised in device **100**.

[00239] In some embodiments, the anterior end **300a** of optical stem **300** may be configured for mounting one or more optional external optical elements of device **100**, which may provide device **100** with an external optical lens **316** that may be easily accessible post-surgically for optical adjusting and/or upgrading purposes, e.g., for adjusting a refractive or focusing power of device **100**.

[00240] As noted above and as shall be further explained below, in some embodiments, upon implantation of device **100**, the anterior end **300a** of optical stem **300** may be configured to be positioned substantially at, is flush with, or slightly proud of, the eye's anterior surface. In some embodiments, the anterior end **300a** of the optical stem **300** sits proximately to the

eye's surface, fully or partially underneath a thin conjunctival flap layer. In some embodiments, at least a portion of the anterior end **300a** of optical stem **300** is exposed to the ambient environment through the eye's anterior surface.

[00241] In all such embodiments, the present disclosure provides for an end plate **310** which may be removably and/or adjustably attachable to anterior end **300a**, e.g., magnetically removably attachable to anterior end **300a**. In some embodiments, end plate **310** may be removably attachable to anterior end **300a**, e.g., magnetically removably attachable to anterior end **300a**. In some embodiments, end plate **310** may be adjustably attachable to anterior end **300a**, for example, by rotating end plate **310** about a central axis thereof to adjust optical properties of an external lens received therein. In some embodiments, end plate **310** may be configured for attaching to anterior end **300a** in a manner which ensures a specific desired angular placement of end plate **310** relative to anterior end **300a**.

[00242] In some embodiments, end plate **310** may define a generally circular curved-surface body having a convexity which substantially conforms to the convexity of the anterior surface of the cornea, with opposing convex anterior face **310a** and concave posterior face **310b**. In some embodiments, end plate **310** has a centrally-located raised annular flange **312** on its posterior face **310b**, which annular flange **312** defines a through opening **314**. In some embodiments, end plate **310** may be attachable to anterior end **300a** and oriented in relation to the eye, such that end plate **310**, through its opening **314**, defines a light-transparent pathway for transmitting light from the ambient environment and/or an extraocular light source through the eye along an optical path.

[00243] With continued reference to Figs. 7A-7D and reference to Figs. 8A-8B, in some embodiments, anterior end plate **310** may be configured for receiving one or more optical elements therein, such as an external optical lens **316**. In some embodiments, external optical lens **316** may be a rotationally asymmetrical lens about its optical axis, configured to adjust the optical properties of lens **316** in relation to an optical axis defined by the optical pathway shown by a dashed line in Fig. 6. External optical lens **316** may be removably received and adjusted within opening **314** of end plate **310** (e.g., by rotating it about its central axis). Alternatively, external optical lens **316** may be fixedly mounted within

opening **314** of end plate **310**, wherein end plate **310** may be adjusted about its central axis when attached to anterior end **300a** of optical stem **300**. In some embodiments, external optical lens **316** can be oriented within anterior end plate **310**, to adjust and fine-tune the optical properties of lens **316** in relation to an optical axis defined by the optical pathway shown by a dashed line in Fig. 6. In some embodiments, end plate **310** can be adjusted relative to anterior end **300a** of optical stem **300** with an appropriate tool, thereby causing lens **316** to change or adjust and fine-tune the optical properties of lens **316** in relation to an optical axis defined by the optical pathway shown by a dashed line in Fig. 6.

[00244] In some embodiments, one or more of end plate **310** and external optical lens **316** may be custom-made for a particular patient, to adjust and correct any deficiencies resulting from the optical specification of the implanted device. These parts may then be mounted post-implantation and adjusted in-situ, to modify or fine-tune the refractive and focusing powers of external optical lens **316** according to the need of the particular patient.

[00245] In some embodiments, one or more of end plate **310** and external lens **316** may be colored or feature a design configured for cosmesis and/or to impart a natural appearance to the eye (e.g. the anterior end of end plate **310** may be colored to resemble/mimic the natural color of the iris).

[00246] It should be noted that end plate **310** and external optical lens **316** may be constructed as a single unit or piece, from a single material, using any suitable manufacturing process such as, but not limited to, molding, additive printing, and the like.

[00247] Reference is made to Figs. 9A-9D, which show, in exploded perspective (Fig. 9A), exploded side (Fig. 9B) and cross-sectional (Figs. 9C and 9D) views, an exemplary embodiment of a device **110** of the present disclosure, comprising an intracorneal implant **210**, an inner optical lens **322**, an end plate **330** and an external optical lens **326**. In some embodiments, intracorneal implant **210** is configured for surgical implantation within the cornea of the eye. In some embodiments, intracorneal implant **210** generally comprises a central optical part comprising a lens housing body **212**, and a peripheral haptic part comprising two or more haptics **204** similar to those described with reference to Figs. 2A-2E. In some embodiments, lens housing body **212** defines a cylinder or tube-like body that houses lens **322** oriented in vision-facilitating relation to the eye through which light passes

in order to project an image to the retina, and comprising an annular flange **212a** raised in the anterior direction. In some embodiments, an anterior rim of flange **212a** defines an anterior-most end **210a** of intracorneal implant **210**.

[00248] In some embodiments, intracorneal implant **210**, including lens housing body **212** and haptics **204**, may be fashioned of any suitable biologically-compatible material, e.g., any metal, metal alloy (such as nitinol, stainless steel, and the like). In some embodiments, the material can be a polymer, e.g., an acrylate polymer, polymethyl methacrylate (PMMA), polyvinyl chloride (PVC), polyolefin copolymers, fluoropolymers (e.g. PTFE), polyamides, polyimides, polyesters, polyurethane, copolymers thereof, silicone, a cross-linked silicone polymer, and combinations thereof.

[00249] In some embodiments, inner optical lens **322** may be integrally formed with the central optical part of intracorneal implant **210**, e.g., integrally-formed with lens housing body **212**. In other embodiments, optical lens **322** is formed separately of intracorneal implant **210**, and may be configured to be received and retained within lens housing body **212**, e.g., by mounting optical lens **322** within lens housing body **212** using a precision fit, a press fit, a click-fit connector, an annular groove-and-channel engagement, a threaded coupling, by fusing, by bonding between an inner peripheral edge of lens housing body **212** and a peripheral edge of optical lens **322**, and/or any other suitable mounting method or technique. In some embodiments, optical lens **322** may be configured to be mounted within lens housing body **212** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of optical lens **322** and lens housing body **212**.

[00250] In some embodiments, upon implantation, the anterior end **210a** of the lens housing body **212**, which defines an anterior-most point of the device **110**, lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface. In some embodiments, the anterior end **210a** of the lens housing body **212** sits proximately to the eye's anterior surface, fully or partially underneath a thin conjunctival flap layer. In some embodiments, at least a portion of the anterior end **210a** of lens housing body **212** is exposed through the eye's anterior surface and forms a means for accepting external optical elements of device **110**, such as end plate **330** and/or one or more external lenses, which

may thus be easily accessible post-surgically for adjusting and/or upgrading purposes, e.g., for adjusting a refractive or focusing power of device **110**.

[00251] Fig. 9D shows a cross-sectional view of an exemplary variation of device **110**, wherein an external lens **327** is integrally-formed with an end plate **331**.

[00252] Reference is made to Figs. 10A-10C, which show, in exploded perspective (Fig. 10A), exploded side (Fig. 10B) and cross-sectional (Fig. 10C) views, an exemplary embodiment of device **120** of the present disclosure, comprising an intracorneal implant **220**, an inner optical lens **322**, an end plate **330** and an external optical lens **326**. In some embodiments, intracorneal implant **220** is configured for surgical implantation within the cornea of the eye. In some embodiments, intracorneal implant **220** generally comprises a central optical part comprising a lens housing body **222**, and a peripheral haptic part comprising two or more haptics **204** similar to those described with reference to Figs. 2A-2E. In some embodiments, lens housing body **222** defines a cylinder or tube-like body that houses lens **322** oriented in relation to the eye through which light passes in order to project an image to the retina, and comprising an annular flange **222a** raised in the anterior direction. In some embodiments, an anterior edge or rim of flange **222a** defines an anterior-most end **220a** of intracorneal implant **220**.

[00253] In some embodiments, intracorneal implant **220**, including lens housing body **222** and haptics **204**, may be fashioned of any suitable biologically-compatible material, e.g., any metal, metal alloy (such as nitinol, stainless steel, and the like). In some embodiments, the material can be a polymer, e.g., an acrylate polymer, polymethyl methacrylate (PMMA), polyvinyl chloride (PVC), polyolefin copolymers, fluoropolymers (e.g. PTFE), polyamides, polyimides, polyesters, polyurethane, copolymers thereof, silicone, a cross-linked silicone polymer, and combinations thereof.

[00254] In some embodiments, inner optical lens **322** may be integrally formed with the central optical part of intracorneal implant **220**, e.g., integrally-formed with lens housing body **222**. In other embodiments, optical lens **322** is formed separately of intracorneal implant **220**, and may be configured to be received and retained within lens housing body **222**, e.g., by mounting optical lens **322** within lens housing body **222** using a precision fit, a press fit, a click-fit connector, an annular groove-and-channel engagement, a threaded

coupling, by fusing, by bonding between an inner peripheral edge of lens housing body **222** and a peripheral edge of optical lens **322**, and/or any other suitable mounting method or technique. In some embodiments, optical lens **322** may be configured to be mounted within lens housing body **222** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of optical lens **322** and lens housing body **222**.

[00255] In some embodiments, upon implantation, the anterior end **220a** of the lens housing body **222**, which defines an anterior-most point of the device **120**, lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface. In some embodiments, the anterior end **220a** of the lens housing body **222** sits proximately to the eye's anterior surface, fully or partially underneath a thin conjunctival flap layer. In some embodiments, at least a portion of the anterior end of lens housing body **222** is exposed through the eye's anterior surface and forms a means for accepting external optical elements of device **120**, such as end plate **330** and/or one or more external optical lenses **326**, that may thus be easily accessible post-surgically for adjusting and/or upgrading purposes, e.g., for adjusting a refractive or focusing power of device **120**.

[00256] In some embodiments, device **120** further comprises a magnetic coupling system configured for magnetically removably attaching end plate **330** to anterior end **220a**. In some embodiments, end plate **330** may be removably and rotatably attachable to anterior end **220a**, e.g., magnetically removably and rotatably attachable to anterior end **220a**. In some embodiments, flange **222a** may comprise an annular magnetic ring **223** located proximately to an anterior end of flange **222a**. Similarly, end plate **330** may comprise an annular magnetic ring **224** located proximately to a light-projecting posterior port of end plate **330**. Thus, when end plate **330** is positioned about anterior end **220a** of device **120**, magnetic rings **223** and **224** attract each other and act to secure end plate **330** to the anterior end **220a** of device **120**.

[00257] Reference is made to Figs. 11A-11D, which show, in exploded perspective (Fig. 11A), exploded side (Fig. 11B) and cross-sectional (Figs. 11C and 11D) views, an exemplary embodiment of device **130** of the present disclosure, comprising an intracorneal implant **230**, an inner optical lens **332**, an end plate **330**, and an external optical lens **326**.

In some embodiments, intracorneal implant **230** is configured for surgical implantation within the cornea of the eye. In some embodiments, intracorneal implant **230** generally comprises a central optical part comprising an inner optical lens **332** and a peripheral haptic part comprising two or more haptics **204** similar to those described with reference to Figs. 2A-2E. In some embodiments, inner optical lens **332** may be integrally formed with the central part of intracorneal implant **230**. In other embodiments, optical lens **332** is formed separately of intracorneal implant **230**, and may be configured to be received and retained within the central optical part of intracorneal implant **230**, e.g., by mounting optical lens **332** using a precision fit, a press fit, an annular groove-and-channel engagement, a click-fit connector, a threaded coupling, by fusing, by bonding between an inner peripheral edge of the central optical part of intracorneal implant **230** and a peripheral edge of optical lens **332**, and/or any other suitable mounting method or technique. In some embodiments, optical lens **332** may be configured to be mounted within the central part of intracorneal implant **230** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of optical lens **332** and the central optical part of intracorneal implant **230**.

[00258] In some embodiments, device **130** further comprises a separate tubular extension **232** which defines a cylinder or tube-like body that extends in the anterior direction from the central optical part of intracorneal implant **230**, oriented in relation to the eye through which light passes in order to project images to the retina. In some embodiments, an anterior edge or rim of tubular extension **232** defines an anterior-most end **230a** of intracorneal implant **230**.

[00259] In some embodiments, intracorneal implant **230**, including tubular extension **232** and haptics **204**, may be fashioned of any suitable biologically-compatible material, e.g., any metal, metal alloy (such as nitinol, stainless steel, and the like). In some embodiments, the material can be a polymer, e.g., an acrylate polymer, polymethyl methacrylate (PMMA), polyvinyl chloride (PVC), polyolefin copolymers, fluoropolymers (e.g. PTFE), polyamides, polyimides, polyesters, polyurethane, copolymers thereof, silicone, a cross-linked silicone polymer, and combinations thereof.

[00260] In some embodiments, upon implantation, the anterior end **230a** of the tubular extension **232**, which defines an anterior-most point of the intracorneal implant **230**, lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface. In some embodiments, the anterior end **230a** of the tubular extension **232** sits proximately to the eye's anterior surface, fully or partially underneath a thin conjunctival flap layer. In some embodiments, at least a portion of the anterior end of tubular extension **232** is exposed through the eye's anterior surface and forms a means for accepting external optical elements of device **130**, such as end plate **330** and/or one or more external optical lenses **326**, that may thus be easily accessible post-surgically for adjusting and/or upgrading purposes, e.g., for adjusting a refractive or focusing power of device **130**.

[00261] In some embodiments, tubular extension **232** may be coupled to the central optical part of intracorneal implant **230** such that a through inner bore defined by tubular extension **232** is oriented in a relation to the eye to create a light-transparent pathway for transmitting light therethrough. In some embodiments, tubular extension **232** may be coupled to the central optical part of intracorneal implant **230** using, e.g., a precision fit, a press fit, a click-fit, an annular groove-and-channel engagement, a threaded coupling, by fusing, by bonding between an inner peripheral edge of tubular extension **232** and a peripheral edge of the central optical part of intracorneal implant **230**, and/or any other suitable mounting method or technique. In some embodiments, as can be seen in the variations illustrated in cross-sectional view in Fig. 11D, tubular extension **232** may be coupled to the central optical part of intracorneal implant **230** by a click system comprising, e.g., an annular protrusion **232a** on an inner peripheral edge of tubular extension **232**, configured to engage a corresponding annular groove on a peripheral edge of the central optical part of intracorneal implant **230** (or vice-versa). In some embodiments, tubular extension **232** may be coupled to the central optical part of intracorneal implant **230** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of tubular extension **232** and the central optical part of intracorneal implant **230**.

[00262] In some embodiments, device **130** further comprises a magnetic coupling system configured for magnetically removably attaching end plate **330** to anterior end **230a**. In some embodiments, end plate **330** may be removably and rotatably attachable to anterior end **230a**, e.g., magnetically removably and rotatably attachable to anterior end **230a**. In

some embodiments, tubular extension **232** may comprise an annular magnetic ring located proximately to an anterior end of tubular extension **232**. Similarly, end plate **330** may comprise an annular magnetic ring located proximately to a light-projecting posterior port of end plate **330**. Thus, when end plate **330** is positioned about anterior end **230a** of device **130**, the respective magnetic rings attract each other and act to secure end plate **330** to the anterior end **230a** of device **130**.

[00263] Figs. 11E-11G show exemplary tubular extensions **233**, **234**, **235** comprising a magnetic coupling system configured for magnetically removably attaching end plate **330** to anterior end **230a**.

[00264] In some embodiments, exemplary tubular extension **233** (Fig. 11E) may comprise one or more, e.g., 1, 2, 3, 4, 5, 6 or more, e.g., magnets **236**, **237**, **238** substantially equally annularly-spaced an anterior end of tubular extension **233**. Similarly, end plate **330** may comprise a corresponding set of annularly-spaced magnets located proximately to a light-projecting posterior port of end plate **330**. Thus, when end plate **330** is positioned about anterior end **230a** of device **130**, the respective magnets attract each other and act to secure end plate **330** to the anterior end **230a** of device **130**.

[00265] In some embodiments, exemplary tubular extension **234** (Fig. 11F) may comprise one or more, e.g., 1, 2, 3, 4, 5, 6 or more, e.g., magnets **236**, **237**, **238** that are annularly-spaced an anterior end of tubular extension **233** in a non-symmetrical manner. Similarly, end plate **330** may comprise a corresponding set of magnets located proximately to a light-projecting posterior port of end plate **330**. The non-symmetrical arrangement is configured to ensure a specific desired angular placement of end plate **330** relative to tubular extension **234**. Thus, when end plate **330** is positioned about anterior end **230a** of device **130**, the respective magnets attract each other and act to secure end plate **330** to the anterior end **230a** of device **130** in the specific desired angular placement.

[00266] In some embodiments, exemplary tubular extension **235** (Fig. 11G) may comprise one or more, e.g., 1, 2, 3, 4, 5, 6 or more, e.g., magnets **236**, **237**, **238** annularly-spaced an anterior end of tubular extension **235**. Similarly, end plate **330** may comprise a corresponding set of annularly-spaced magnets located proximately to a light-projecting posterior port of end plate **330**. In addition, tubular extension **235** may comprise an indexing

pin **239** projecting from an anterior end of tubular extension **235**, configured to engage a corresponding opening is located proximately to a light-projecting posterior port of end plate **330**. The engagement of indexing pin **239** and the corresponding opening is configured to lock a specific desired angular placement of end plate **330** relative to tubular extension **235**. Thus, when end plate **330** is positioned about anterior end **230a** of device **130**, the respective magnets attract each other and act to secure end plate **330** to the anterior end **230a** of device **130**, while indexing pin **239** ensures the specific desired angular placement.

[00267] Reference is made to Figs. 12A-12C, which show, in exploded perspective (Fig. 12A), exploded side (Fig. 12B) and cross-sectional (Fig. 12C) views, an exemplary embodiment of device **140** of the present disclosure, comprising an intracorneal implant **240**, an inner optical lens **342**, an end plate **330** and/or an external optical lens **326**. In some embodiments, intracorneal implant **240** is configured for surgical implantation within the cornea of the eye. In some embodiments, intracorneal implant **240** generally comprises a central optical part comprising an annular anchor body **242** which defines a central aperture **242a** configured to receive and retain an inner optical lens **342** therein. In some embodiments, anchor body **242** may define a circumferentially-continuous annular ring or may have an opening portion **242b** at a side thereof. In some embodiments, the peripheral haptic part comprises two or more haptics **204** similar to those described with reference to Figs. 2A-2E.

[00268] Anchor body **242** can be a ring, a rim, a cannula, a cylinder, or any other suitable three-dimensional shape which can define a circular or cylindrical aperture and to which haptics **204** can be attached.

[00269] In some embodiments, inner optical lens **342** may be integrally-formed with the central optical part of intracorneal implant **240**, e.g., integrally-formed with anchor body **242**, such that optical lens **342** forms an optical lens within aperture **242a**. In other embodiments, optical lens **342** is formed separately of intracorneal implant **240**, and may be configured to be received and retained within aperture **242a**, e.g., by mounting optical lens **342** within aperture **242a** using a precision fit, a press fit, a click-fit, a threaded coupling, an annular groove-and-channel engagement, by fusing, by bonding between an inner peripheral edge of anchor body **242** which defines aperture **242a** and a peripheral edge

of optical lens **342**, and/or any other suitable mounting method or technique. In some embodiments, optical lens **342** may be configured to be mounted within aperture **242a** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of optical lens **342** and aperture **242a**.

[00270] In some embodiments, inner optical lens **342** may be integrally formed with the central optical part of intracorneal implant **240**. In other embodiments, optical lens **342** is formed separately of intracorneal implant **240**, and may be configured to be received and retained within the central optical part of intracorneal implant **240**, e.g., by mounting optical lens **342** using a precision fit, a press fit, a click fit, a threaded coupling, by fusing, by bonding between an inner peripheral edge of the central optical part of intracorneal implant **240** and a peripheral edge of optical lens **342**, and/or any other suitable mounting method or technique. In some embodiments, optical lens **342** may be configured to be mounted within the central optical part of intracorneal implant **240** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of optical lens **342** and the central optical part of intracorneal implant **240**.

[00271] In some embodiments, device **140** further comprises a separate tubular extension **244** which defines a cylinder or tube-like body that extends in the anterior direction from the central optical part of intracorneal implant **240**, oriented in relation to the eye through which light passes in order to project images to the retina. In some embodiments, an anterior edge or rim of tubular extension **244** defines an anterior-most end **240a** of intracorneal implant **240**.

[00272] In some embodiments, intracorneal implant **240**, including anchor body **242**, and haptics **204**, may be fashioned of any suitable biologically-compatible material, e.g., any metal, metal alloy (such as nitinol, stainless steel, and the like). In some embodiments, the material can be a polymer, e.g., an acrylate polymer, polymethyl methacrylate (PMMA), polyvinyl chloride (PVC), polyolefin copolymers, fluoropolymers (e.g. PTFE), polyamides, polyimides, polyesters, polyurethane, copolymers thereof, silicone, a cross-linked silicone polymer, and combinations thereof.

[00273] In some embodiments, upon implantation, the anterior end **240a** of the tubular extension **244**, which defines an anterior-most point of the intracorneal implant **240**, lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface. In some embodiments, the anterior end **240a** of the tubular extension **244** sits proximately to the eye's anterior surface, fully or partially underneath a thin conjunctival flap layer. In some embodiments, at least a portion of the anterior end of tubular extension **244** is exposed through the eye's anterior surface and forms a means for accepting external optical elements of device **140**, such as end plate **330** and/or one or more external optical lenses **326**, that may thus be easily accessible post-surgically for adjusting and/or upgrading purposes, e.g., for adjusting a refractive or focusing power of device **140**.

[00274] In some embodiments, tubular extension **244** may be coupled to the central optical part of intracorneal implant **240** such that a through inner bore defined by tubular extension **244** is oriented in relation to the eye to create a light-transparent pathway for transmitting light therethrough. In some embodiments, tubular extension **244** may be coupled to the central optical part of intracorneal implant **240** using, e.g., a precision fit, a press fit, a threaded coupling, a click-fit connector, by fusing, by bonding between an inner peripheral edge of tubular extension **244** and a peripheral edge of the central optical part of intracorneal implant **240**, and/or any other suitable mounting method or technique. In some embodiments, tubular extension **244** may be coupled to the central optical part of intracorneal implant **240** by circumferentially-engaging an anterior portion of optical lens **342** using, e.g., a precision fit, a press fit, a threaded coupling, by an annular channel-and-groove engagement, by a click system, by fusing, by bonding between an inner peripheral edge of tubular extension **244** and a peripheral edge of the central optical part of intracorneal implant **240**, and/or any other suitable mounting method or technique. In some embodiments, tubular extension **244** may be coupled to the central optical part of intracorneal implant **240** in a sealed coupling or engagement configured to prevent passage or migration of biological agents or other contaminants through the coupling of tubular extension **244** and the central optical part of intracorneal implant **240**.

[00275] Reference is made to Figs. 13A-13F, which illustrate the functional steps in a process **1300** for the preparation of an exemplary pre-processed corneal tissue scaffold derived from a donor cornea.

[00276] The particular series of steps depicted in conjunction with process **1300** is not intended to be limiting. Other sequences of steps may also be performed according to alternative embodiments without departing from the techniques of this disclosure. For example, alternative embodiments of the present invention may perform the steps outlined above in a different order or in parallel. Moreover, the individual steps may include multiple sub-steps that may be performed in various sequences as appropriate. Furthermore, additional steps may be added or removed depending on the particular applications.

[00277] In some embodiments, the corneal tissue scaffold may be configured for use in conjunction with a device of the present disclosure, such as any one or more of devices **100** (described with reference to Figs. 1A-1C, 3D-3E, and 6), device **110** (described with reference to Figs. 9A-9D), **120** (described with reference to Figs. 10A-10C), **130** (described with reference to Figs. 11A-11D), and/or **140** (described with reference to Figs. 12A-12C).

[00278] In some embodiments, a corneal tissue scaffold of the present disclosure may comprise various compositions of corneal layers at different regions thereof. For example, the corneal tissue scaffold of the present disclosure may comprise, at a central substantially transparent region thereof, a very thin layer of corneal tissue (e.g., having a thickness of approximately 10-50 μ m), that is substantially transparent to light. In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium. Accordingly, a generally circular central region or portion of the corneal tissue scaffold may comprise (i) only the pre-Descemet layer, or (ii) the pre-Descemet layer in combination with the Descemet membrane, or (iii) the pre-Descemet layer in combination with the Descemet membrane and the endothelium. In some embodiments, the central region of the corneal tissue scaffold is thus configured to be substantially transparent to light, and to be located so as to fall along an optical path of a device of the present disclosure configured to transmit light from an ambient environment and/or an external light source, through the eye, along an optical path and onto the retina. In some embodiments, regions of the corneal tissue scaffold surrounding the central substantially transparent region, may have a different composition of corneal layers,

comprising at least some of the stromal layer, pre-Descemet layer, the Descemet membrane, and/or the endothelium.

[00279] With continued reference to Fig. 13A, in step **1302**, and as shown in Fig. 13B, process **1300** may begin with in step **1302**, by receiving a donor cornea **1320**.

[00280] In step **1304**, as shown in Fig. 13C, a deep lamellar dissection (e.g. pneumatic, hydro-assisted, viscoelastic-assisted and/or manual dissection) is performed in the donor cornea **1320** with a bubble **1326** formation which separates between the posterior stroma and a very thin layer of corneal tissue **1327** having a thickness of approximately 10-50µm, and substantially transparent to light). In some embodiments, thin layer **1327** comprises at least the pre-Descemet layer. In some embodiments, thin layer **1327** comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, thin layer **1327** comprises the pre-Descemet layer, the Descemet membrane, and the endothelium.

[00281] In Step **1306**, as shown in Fig. 13D, a partial thickness trephination and anterior keratectomy is performed in the stromal layers of donor cornea **1320**, to remove the anterior corneal lamella **1322** leaving the posterior corneal layers **1324**.

[00282] In step **1308**, as shown in Fig. 13E, the deep posterior stroma (e.g., within or around the region above the bubble **1326**) is removed to create a recess **1328**, while leaving thin posterior layer **1327** intact.

[00283] In step **1310**, as shown in Fig. 13F, a full-thickness trephination is performed to remove the entire corneal tissue scaffold **1329**, including posterior stroma **1324** and separated thin layer **1327**, from the donor cornea **1320**.

[00284] In some embodiments, optionally, the anterior corneal lamella **1322** removed as shown in Fig. 13D, is used for constructing a preassembled system of the present disclosure.

[00285] In some embodiments, the corneal tissue scaffold **1329** is then pre-processed using any one or more suitable preprocessing method and techniques, to stabilize and protect the corneal tissue scaffold **1329** during preparation, storage, and transportation.

[00286] In step **1312**, the corneal tissue scaffold obtained in step **1310** may then be decontaminated, dehydrated, sterilized, and packaged for use by surgeons and other medical professionals in appropriate surgical procedures as further detailed herein.

[00287] In some embodiments, further processing methods and techniques according to the present invention may include, but are not limited to: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, sterilization, and the like.

[00288] In some embodiments, the preprocessing prevents the corneal tissue scaffold **1329** from decomposing, putrefying, becoming infected, and/or fracturing during storage and transportation, and allows the corneal tissue scaffold **1329** to be stored at room temperature or at a temperature lower than room temperature. In some embodiments, the preprocessing also helps maintain the corneal tissue scaffold **1329** so that it has similar material properties to those of live or hydrated tissue or treated tissue. In some embodiments, the preprocessing allows for direct implantation of the corneal tissue scaffold **1329** into a recipient subject without further processing or with minimal processing after removal from the packaging.

[00289] Figs. 14A-14D illustrate an exemplary process **1400** for constructing a preassembled system **1411** of the present disclosure, comprising the corneal tissue scaffold with the pre-mounted device of the present disclosure. The corneal tissue scaffold may be the exemplary corneal tissue scaffold **1329** described with reference to Figs. 13A-13F; the device may be any one of exemplary devices **100** (described with reference to Figs. 1A-1C, 3D-3E, and 6), device **110** (described with reference to Figs. 9A-9D), **120** (described with reference to Figs. 10A-10C), **130** (described with reference to Figs. 11A-11D), and/or **140** (described with reference to Figs. 12A-12C).

[00290] The particular series of steps depicted in conjunction with process **1400** is not intended to be limiting. Other sequences of steps may also be performed according to alternative embodiments without departing from the techniques of this disclosure. For example, alternative embodiments of the present invention may perform the steps outlined above in a different order or in parallel. Moreover, the individual steps may include multiple sub-steps that may be performed in various sequences as appropriate. Furthermore, additional steps may be added or removed depending on the particular applications.

[00291] With continued reference to Fig. 14A and as shown in Fig. 14B, process **1400** begins in step **1402** by receiving a device **100-140** and a corneal tissue scaffold **1329**.

[00292] In step **1404**, as shown in Fig. 14C, device **100-140** is mounted to a corneal tissue scaffold **1329**.

[00293] In step **1406**, as shown in Fig. 14D, the previously-removed anterior corneal lamella **1420** from the donor cornea (see, for example, the description with reference to Fig. 13D) is sutured **1426** in place.

[00294] Figs. 15A-15F show the functional steps in an exemplary process **1500** for surgical implantation of a preassembled system of the present disclosure, such as exemplary preassembled system **1411** described with reference to Figs. 14A-14D, in the cornea of a recipient.

[00295] The particular series of steps depicted in conjunction with process **1500** is not intended to be limiting. Other sequences of steps may also be performed according to alternative embodiments without departing from the techniques of this disclosure. For example, alternative embodiments of the present invention may perform the steps outlined above in a different order or in parallel. Moreover, the individual steps may include multiple sub-steps that may be performed in various sequences as appropriate. Furthermore, additional steps may be added or removed depending on the particular applications.

[00296] In addition, the various healing and/or tissue regeneration stages, which may be necessary or advisable in practice between some of the various steps of this exemplary process, have been omitted in the interest of conciseness.

[00297] With continued reference to Fig. 15A, as shown in Fig. 15B, process **1500** begins in step **1502**, by performing full thickness trephination in a recipient cornea **1520**, to remove the anterior corneal lamella **1522**, and create a hollow aperture **1523**.

[00298] In step **1504**, as shown in Fig. 15C, preassembled system **1411** may be implanted in cornea **1520**, within the aperture **1523**, and sutured **1526**.

[00299] In step **1506**, as shown in Fig. 15D, a thin conjunctival flap layer **1523** may be positioned over an anterior surface of cornea **1520**, to cover implanted preassembled system **1411**.

[00300] In step **1508**, as shown in Fig. 15E, a central opening **1524** may be formed in the thin conjunctival flap layer **1523**, correspondingly to an anterior end of the optical stem of

the implanted device, such that the anterior end of the optical stem lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface.

[00301] In step **1510**, as shown in Fig. 15F, optional external optical elements, including, e.g., end plate **1510** and external optical lens **1516** may be mounted to the anterior end of the device **100-140**, which is part of preassembled system **1411**.

[00302] Figs. 16A-16G show the functional steps in an exemplary process **1600** for surgical implantation of a pre-processed corneal tissue scaffold, such as exemplary corneal tissue scaffold **1329** described with reference to Figs. 13A-13F, followed by an implantation of a device of the present technique therewithin.

[00303] The particular series of steps depicted in conjunction with process **1600** is not intended to be limiting. Other sequences of steps may also be performed according to alternative embodiments without departing from the techniques of this disclosure. For example, alternative embodiments of the present invention may perform the steps outlined above in a different order or in parallel. Moreover, the individual steps may include multiple sub-steps that may be performed in various sequences as appropriate. Furthermore, additional steps may be added or removed depending on the particular applications.

[00304] In addition, the various healing and/or tissue regeneration stages, which may be necessary or advisable in practice between some of the various steps of this exemplary process, have been omitted in the interest of conciseness.

[00305] After full thickness trephination of the recipient cornea, implantation of exemplary corneal tissue scaffold **1329** is performed and then followed by an implantation of a device **100-140** of the present disclosure, which may be any one of exemplary devices **100** (described with reference to Figs. 1A-1C, 3D-3E, and 6), device **110** (described with reference to Figs. 9A-9D), **120** (described with reference to Figs. 10A-10C), **130** (described with reference to Figs. 11A-11D), and/or **140** (described with reference to Figs. 12A-12C).

[00306] With continued reference to Fig. 16A, and as shown in Fig. 16B, process **1600** begins in step **1602**, where corneal tissue scaffold **1329** is implanted and sutured **1626** within a recess **1621** created by full thickness trephination of the recipient cornea **1620**.

[00307] Recipient cornea **1620** can be prepared by first performing a partial trephination and anterior keratectomy in the stromal layers, to remove the recipient anterior corneal lamella of the recipient cornea, and then a full-thickness trephination to create recess **1621**.

[00308] In step **1604**, as shown in Fig. 16C, device **100-140** is implanted and fixated in place.

[00309] In step **1606**, as shown in Figs. 16D-16E, a central aperture **1623** is made within the anterior corneal lamella **1622** (which may be the previously-removed recipient anterior corneal lamella, or a donor anterior corneal lamella). Anterior corneal lamella **1622** is then sutured **1627** to cover the implanted device **100-140**, such that an anterior end of device **100-140** extends through aperture **1623**.

[00310] In step **1608**, as shown in Fig. 16F, a thin conjunctival flap layer **1624** may be positioned over the anterior surface of cornea **1622**. A central opening **1628** is then formed in thin conjunctival flap layer **1622**, correspondingly to an anterior end of the optical stem of device **100-140**, such that the anterior end of the optical stem lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface.

[00311] In step **1610**, as shown in Fig. 16G, optional external elements, including, e.g., end plate **1610** and external optical lens **1616** may be mounted to the anterior end of the device **100-140**.

[00312] Figs. 17A-17J show the functional steps in an exemplary process **1700** for surgical implantation of a device **100-140** of the present disclosure, which may be any one of exemplary devices **100** (described with reference to Figs. 1A-1C, 3D-3E, and 6), device **110** (described with reference to Figs. 9A-9D), **120** (described with reference to Figs. 10A-10C), **130** (described with reference to Figs. 11A-11D), and/or **140** (described with reference to Figs. 12A-12C).

[00313] The particular series of steps depicted in conjunction with process **1700** is not intended to be limiting. Other sequences of steps may also be performed according to alternative embodiments without departing from the techniques of this disclosure. For example, alternative embodiments of the present invention may perform the steps outlined above in a different order or in parallel. Moreover, the individual steps may include multiple

sub-steps that may be performed in various sequences as appropriate. Furthermore, additional steps may be added or removed depending on the particular applications.

[00314] With continued reference to Fig. 17A, and as shown in Figs. 17B-17C, process **1700** begins in step **1702**, with preparation of recipient cornea **1720**.

[00315] As shown in Fig. 17C, a deep lamellar dissection (e.g. pneumatic, hydro-assisted, viscoelastic-assisted and/or manual dissection) is performed in the donor cornea **1720** with a bubble **1728** formation which separates between the posterior stroma and a very thin layer of corneal tissue **1729** having a thickness of approximately 10-50µm, and substantially transparent to light. In some embodiments, thin layer **1729** comprises at least the pre-Descemet layer. In some embodiments, thin layer **1729** comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, thin layer **1729** comprises the pre-Descemet layer, the Descemet membrane, and the endothelium.

[00316] In step **1704**, as shown in Fig. 17D, a partial thickness trephination and anterior keratectomy is then performed in the stromal layers of donor cornea **1720**, to remove the anterior corneal lamella **1722**, leaving the posterior stromal layers **1726**.

[00317] In step **1706**, as shown in Fig. 17E, a removal of deep posterior stroma within or around the region above the bubble **1728** is performed in the posterior stroma **1726**, to create a recess **1731**, while leaving thin posterior layer **1729** having a thickness of approximately 10-50µm, and substantially transparent to light). In some embodiments, the very thin layer comprises at least the pre-Descemet layer. In some embodiments, the very thin layer comprises the pre-Descemet layer in addition to the Descemet membrane. In some embodiments, the very thin layer comprises the pre-Descemet layer, the Descemet membrane, and the endothelium.

[00318] In step **1708**, as shown in Fig. 17F, device **100-140** is implanted in place and fixated **1725**, such that a light-projecting posterior port of the optical stem of device **100-140** is positioned through recess **1731**.

[00319] In step **1710**, as shown in Figs. 17G-17H, a central aperture **1733** is made within the anterior corneal lamella **1722** (e.g. the previously-removed recipient anterior corneal lamella or donor anterior corneal lamella). Anterior corneal lamella **1722** is then sutured

1727 to cover the implanted device **100-140**, such that an anterior end of device **100-140** extends through aperture **1733**.

[00320] In step **1712**, as shown in Fig. 17I, a thin conjunctival flap layer **1724** may be positioned over the anterior surface of cornea **1720**. A central opening **1734** is then formed in thin conjunctival flap layer **1724**, correspondingly to an anterior end of the optical stem of device **100-140**, such that the anterior end of the optical stem lies just beneath, is substantially at the level of, is flush with, or is slightly proud of, the eye's anterior surface.

[00321] In step **1714**, as shown in Fig. 17J, optional external elements, including, e.g., end plate **1710** and external optical lens **1716** may be mounted to the anterior end of the device **100-140**.

[00322] Fig. 18A is a schematic illustration of an exemplary system for intracorneal projecting of images onto a retina, according to some embodiments of the present disclosure.

[00323] In some embodiments, a system of the present disclosure comprises an extraocular image capture unit **1800** configured to capture one or more still visual images or moving visual images (video).

[00324] Extraocular image capture unit **1800** as described herein is only an exemplary embodiment of the present invention, and in practice may be implemented in any combination of both hardware and software components. Extraocular unit **1800** may have more or fewer components and modules than shown, may combine two or more of the components, or may have a different configuration or arrangement of the components. Extraocular unit **1800** may include any additional component enabling it to function as an operable computer system, such as a motherboard, data busses, power supply, a network interface card, a display, an input device (e.g., keyboard, pointing device, touch-sensitive display), etc. (not shown).

[00325] In some embodiments, extraocular unit **1800** may comprise an image processing module **1810** comprising one or more hardware processor(s) **1810a**, and a memory storage device **1810b**, comprising, e.g., a random-access memory (RAM) and one or more non-transitory computer-readable storage device(s).

[00326] Storage device **1810b** may have stored thereon program instructions and/or components configured to operate hardware processor **1810a** of image processing module **1810**. The program instructions may include one or more software modules, such as one or more image processing algorithms. The software components may include an operating system having various software components and/or drivers for controlling and managing general system tasks (e.g., memory management, storage device control, power management, etc.), and facilitating communication between various hardware and software components.

[00327] In some embodiments, extraocular unit **1800** comprises an imaging device **1804**, which may be any suitable digital imaging device configured for capturing still or video images of scenes, objects, and/or any other optically-represented information, such as by text, symbols or color. In some embodiments, imaging processing module **1810** is configured to implement any suitable one or more image processing algorithms, and has an image signal generator for generating digital data signals that can represent a visual images captured by imaging device **1804**. In some embodiments, storage device **1810b** may include an electrical circuit data memory of the type that is suitable for storing electrical digital image data signals.

[00328] In some embodiments, extraocular unit **1800** may comprise a wireless transmitter or a transceiver **1806** configured to transmit an image data signal using non-optical data transmission modalities, e.g., any suitable short-range RF transmission protocol, digital or analog, such as Bluetooth, ZigBee, and the like.

[00329] In some embodiments, extraocular unit **1800** may comprise a power source **1808** which may include, e.g., a rechargeable battery pack comprising one or more battery cells of the type commonly used for providing a portable battery supply, and a facility for short-range wireless power transmission. In some embodiments, the battery pack may provide power to a primary inductive coil **1808a**. The primary inductive coil **1808a** may send power wirelessly **1816**, e.g., through skin, bone, eye tissue, etc., to a secondary reception inductive coil within an intracorneal implant, as shall be further described below.

[00330] In some embodiments, the functions of wireless data transmission and wireless power transmission may both be conducted by the primary inductive coil **1808a**, wherein

the primary inductive coil **1808a** may be configured for joint transmission of power and data.

[00331] In some embodiments, extraocular unit **1800** may be in wireless data **1814** and wireless power **1816** communication with an exemplary intracorneal implant **1820**, configured for surgical implantation within the cornea of an eye.

[00332] In some embodiments, intraocular implant **1820** may be dimensioned and configured for surgical implantation within the eye, traversing or completely replacing any opaque tissue layers of the cornea, and wherein only substantially transparent corneal tissue is present posterior to the device.

[00333] In some embodiments, exemplary intracorneal implant **1820** may be dimensioned and configured for surgical implantation within the cornea of an eye, such that a layer of corneal tissue that is partially transparent, partially semi-transparent, and/or partially opaque is present posteriorly to the light-projecting posterior port of the device.

[00334] As shall be further detailed below, intracorneal implant **1820** is dimensioned to fit within a cornea. In some embodiments, intracorneal implant **1820** defines a planar body having a convexity which substantially conforms to the convexity of the cornea, with opposing convex anterior face (facing the anterior surface of the eye) and concave posterior face (facing the retina of the eye).

[00335] In some embodiments, intracorneal implant **1820** comprises an inner platform portion **1824** located about an axis of circular symmetry of the implant, and a peripheral portion, comprising one or more angularly-spaced arms **1826** that extend laterally from a peripheral edge of inner platform **1824**. In some embodiments, intracorneal implant **1820** further comprises a peripheral skirt portion **1828** which defines an outer circular perimeter of intracorneal implant **1820**, wherein the one or more arms **1826** connect between inner platform **1824** and peripheral skirt portion **1828**.

[00336] In some embodiments, exemplary intracorneal implant **1820** is dimensioned to fit within a cornea, posteriorly to any opaque corneal tissue layers, and to generate images that are detectable by a healthy retina or a healthy portion of a retina of the eye. For example, intracorneal implant **1820** may have an overall span between opposing edges thereof of,

e.g., 6-12mm (e.g., 9mm), an overall planar thickness of between 0.02-1.50mm, and a convexity having a curvature of between 32-47 diopters.

[00337] In some embodiments, exemplary intracorneal implant **1820** comprises one or more components mounted to intracorneal implant **1820**, including, e.g., an image projection controller **1830**, comprising, e.g., a hardware processor and memory storage device, an image generator **1834** mounted to inner platform portion **1824**, a wireless receiver or transceiver **1836**, a wireless power receiving element **1838**, and optical assembly **1840**.

[00338] Fig. 18B is a schematic illustration of a second exemplary system for intracorneal projecting of images onto a retina, according to some embodiments of the present disclosure.

[00339] In some embodiments, a second exemplary system of the present disclosure comprises an extraocular image capture unit **1801** configured to capture one or more still visual images, or moving visual images (video).

[00340] Extraocular image capture unit **1801** as described herein is only an exemplary embodiment of the present invention, and in practice may be implemented in any combination of both hardware and software components. Extraocular unit **1801** may have more or fewer components and modules than shown, may combine two or more of the components, or may have a different configuration or arrangement of the components. Extraocular unit **1801** may include any additional component enabling it to function as an operable computer system, such as a motherboard, data busses, power supply, a network interface card, a display, an input device (e.g., keyboard, pointing device, touch-sensitive display), etc. (not shown).

[00341] In some embodiments, extraocular unit **1801** may comprise an image processing module **1810** comprising one or more hardware processor(s) **1810a**, and a memory storage device **1810b**, comprising, e.g., a random-access memory (RAM) and one or more non-transitory computer-readable storage device(s).

[00342] Storage device **1810b** may have stored thereon program instructions and/or components configured to operate hardware processor **1810a** of image processing module **1810**. The program instructions may include one or more software modules, such as one or more image processing algorithms. The software components may include an operating

system having various software components and/or drivers for controlling and managing general system tasks (e.g., memory management, storage device control, power management, etc.), and facilitating communication between various hardware and software components.

[00343] In some embodiments, extraocular unit **1801** comprises an imaging device **1804**, which may be any suitable digital imaging device configured for capturing still or video images of scenes, objects, and/or any other optically-represented information, such as by text, symbols or color. In some embodiments, imaging processing module **1810** is configured to implement any suitable one or more image processing algorithms, and has an image signal generator for generating digital data signals that can represent a visual images captured by imaging device **1804**. In some embodiments, storage device **1810b** may include an electrical circuit data memory of the type that is suitable for storing electrical digital image data signals.

[00344] In some embodiments, extraocular unit **1801** may comprise a wireless transmitter or a transceiver **1806** configured to transmit an image data signal using non-optical data transmission modalities, e.g., any suitable short-range RF transmission protocol, digital or analog, such as Bluetooth, ZigBee, and the like.

[00345] In some embodiments, extraocular unit **1801** may comprise a power source **1808** which may include, e.g., a rechargeable battery pack comprising batteries of the type commonly used for providing a portable battery supply, and a facility for short-range wireless power transmission. In some embodiments, the battery pack may provide power to a primary inductive coil **1808a**. The primary inductive coil **1808a** may send power wirelessly **1816**, e.g., through skin, bone, eye tissue, etc., to a secondary reception inductive coil within an intracorneal implant, as shall be further described below.

[00346] In some embodiments, the functions of wireless data transmission and wireless power transmission may both be carried out by the primary inductive coil **1808a**, wherein the primary inductive coil **1808a** may be configured for joint transmission of power and data.

[00347] In some embodiments, extraocular unit **1801** may comprise an illumination source **1813** for illuminating a liquid crystal display (LCD) mounted to the intracorneal implant. In

some embodiments, illumination source **1813** may comprise any suitable illumination source, e.g., one or more light emitting diodes (LEDs), such as white light-emitting LEDs, color LEDs, or high intensity power LEDs. In some embodiments, illumination source **1813** may be configured to emit sufficient illumination so as to traverse impaired or opaque corneal layers that are at least partially impermeable to visible light, and to reach the intracorneal implant **1821** implanted within the cornea of the eye.

[00348] Extraocular unit **1801** may be in wireless data **1814** and wireless power **1816** communication, as well as in illumination communication **1818**, with an intracorneal implant **1821** configured for surgical implantation within the cornea of an eye.

[00349] In some embodiments, exemplary intracorneal implant **1821** may be dimensioned and configured for surgical implantation within the cornea of an eye, at a position that is posterior to any opaque tissue layers of the cornea, and where transparent corneal tissue or no corneal tissue is present posterior to the image generator of the device.

[00350] As shall be further detailed below, intracorneal implant **1821** is dimensioned to fit within a cornea. In some embodiments, intracorneal implant **1821** defines a planar body having a convexity which substantially conforms to the convexity of the cornea, with opposing convex anterior face (facing the anterior surface of the eye) and concave posterior face (facing the retina of the eye).

[00351] In some embodiments, intracorneal implant **1821** comprises an inner platform portion **1824** located about an axis of circular symmetry of the implant, and a peripheral portion, comprising one or more angularly-spaced arms **1826** that extend laterally from a peripheral edge of inner platform **1824**. In some embodiments, intracorneal implant **1821** further comprises a peripheral skirt portion **1828** which defines an outer circular perimeter of intracorneal implant **1821**, wherein the one or more arms **1826** connect between inner platform **1824** and peripheral skirt portion **1828**.

[00352] In some embodiments, exemplary intracorneal implant **1821** is dimensioned to fit within a cornea, traversing or completely replacing any opaque tissue layers of the cornea, and wherein only substantially transparent corneal tissue is present posterior to the device.

[00353] In some embodiments, exemplary intracorneal implant **1821** is dimensioned to fit within a cornea, such that a layer of corneal tissue that is partially transparent, partially

semi-transparent, and/or partially opaque is present posteriorly to the light-projecting posterior port of the device.

[00354] For example, intracorneal implant **1821** may have an overall span between opposing edges thereof of, e.g., 6-12mm (e.g., 9mm), an overall planar thickness of between 0.020-1.5mm, and a convexity having a curvature of between 32-47 diopters.

[00355] In some embodiments, intracorneal implant **1821** comprises one or more components mounted to intracorneal implant **1821**, including, e.g., an image projection controller **1830**, a memory storage device **1832**, an LCD panel **1835** mounted to inner platform portion **1824**, a wireless receiver or transceiver **1836**, a wireless power receiving element **1838**, and an optical assembly **1840**.

[00356] In some embodiments, LCD panel **1835** does not include a backlight or any similar illumination source integrated within intracorneal implant **1821**. By way of explanation, an LCD panel display comprises a matrix of pixels which may be controllably darkened or made transparent, to represent any pattern or image. LCD panels typically do not emit light directly, but rather rely on using an integrated backlight to produce images. The power requirements of the LCD panel itself are minimal, while those of the backlight are significantly higher. Accordingly, in the context of an LCD panel mounted to a device implanted within a cornea, it would be advantageous to eliminate the need for an integrated backlight within the implanted device, and instead rely on an external illumination source. This may lead to a significant reduction in power consumption, physical footprint, and complexity of the implanted device. Accordingly, in some embodiments, LCD panel **1835** is configured to be illuminated by external illumination source **1813** of extraocular unit **1800**.

[00357] Fig. 18C is a schematic illustration of a third exemplary system for intracorneal projecting of images onto a retina, according to some embodiments of the present disclosure.

[00358] Extraocular image capture unit **1802** as described herein is only an exemplary embodiment of the present invention, and in practice may be implemented in any combination of both hardware and software components. Extraocular unit **1802** may have more or fewer components and modules than shown, may combine two or more of the

components, or may have a different configuration or arrangement of the components. Extraocular unit **1802** may include any additional component enabling it to function as an operable computer system, such as a motherboard, data busses, power supply, a network interface card, a display, an input device (e.g., keyboard, pointing device, touch-sensitive display), etc. (not shown).

[00359] In some embodiments, extraocular unit **1802** may comprise an image processing module **1810** comprising one or more hardware processor(s) **1810a**, and a memory storage device **1810b**, comprising, e.g., a random-access memory (RAM) and one or more non-transitory computer-readable storage device(s).

[00360] Storage device **1810b** may have stored thereon program instructions and/or components configured to operate hardware processor **1810a** of image processing module **1810**. The program instructions may include one or more software modules, such as one or more image processing algorithms. The software components may include an operating system having various software components and/or drivers for controlling and managing general system tasks (e.g., memory management, storage device control, power management, etc.), and facilitating communication between various hardware and software components.

[00361] In some embodiments, extraocular unit **1802** comprises an imaging device **1804**, which may be any suitable digital imaging device configured for capturing still or video images of scenes, objects, and/or any other optically-represented information, such as by text, symbols or color. In some embodiments, imaging processing module **1810** is configured to implement any suitable one or more image processing algorithms, and has an image signal generator for generating digital data signals that can represent a visual images captured by imaging device **1804**. In some embodiments, storage device **1810b** may include an electrical circuit data memory of the type that is suitable for storing electrical digital image data signals.

[00362] In some embodiments, extraocular unit **1802** may comprise a power source **1808** which may include, e.g., a rechargeable battery pack comprising batteries of the type commonly used for providing a portable battery supply, and a facility for short-range wireless power transmission.

[00363] In some embodiments, extraocular unit **1802** may comprise an illumination source **1813** for illuminating a liquid crystal display (LCD) mounted to the intracorneal implant. In some embodiments, illumination source **1813** may comprise any suitable illumination source, e.g., one or more light emitting diodes (LEDs), such as white light-emitting LEDs, color LEDs, or high intensity power LEDs. In some embodiments, illumination source **1813** may be configured to emit sufficient illumination so as to traverse impaired or opaque corneal layers that are at least partially impermeable to visible light, and to reach the intracorneal implant **1822** implanted within the cornea of the eye.

[00364] In some embodiments, extraocular unit **1802** may comprise a light beam source **1815** configured to transmit a light beam comprising a power signal and/or a data signal encoding information. In some embodiments, light beam source **1815** may comprise a visible light source or an invisible light source (e.g., an infrared light source). In some embodiments, light beam source **1815** may be selected from the group consisting of: LED, laser diode, and the like. In some embodiments, light beam source **1815** may be configured to perform the functions of wireless data transmission and wireless power transmission.

[00365] Accordingly, extraocular unit **1802** may be in illumination communication **1818**, as well as in wireless data and wireless power communication **1819**, with an intracorneal implant **1822** configured for surgical implantation within the cornea of an eye.

[00366] In some embodiments, exemplary intracorneal implant **1822** may be dimensioned and configured for surgical implantation within the cornea of an eye, traversing or completely replacing any opaque tissue layers of the cornea, and wherein only substantially transparent corneal tissue is present posterior to the device.

[00367] In some embodiments, exemplary intracorneal implant **1822** may be dimensioned and configured for surgical implantation within the cornea of an eye, such that a layer of corneal tissue that is partially transparent, partially semi-transparent, and/or partially opaque is present posteriorly to the light-projecting posterior port of the device.

[00368] In some embodiments, intracorneal implant **1822** defines a planar body having a convexity which substantially conforms to the convexity of the cornea, with opposing convex anterior face (facing the anterior surface of the eye) and concave posterior face (facing the retina of the eye).

[00369] In some embodiments, intracorneal implant **1822** comprises an inner platform portion **1824** located about an axis of circular symmetry of the implant, and a peripheral portion, comprising one or more angularly-spaced arms **1826** that extend laterally from a peripheral edge of inner platform **1824**. In some embodiments, intracorneal implant **1822** further comprises a peripheral skirt portion **1828** which defines an outer circular perimeter of intracorneal implant **1822**, wherein the one or more arms **1826** connect between inner platform **1824** and peripheral skirt portion **1828**.

[00370] In some embodiments, exemplary intracorneal implant **1822** is dimensioned to fit within a cornea, posteriorly to any opaque corneal tissue layers, and to generate images that are detectable by a healthy retina or a healthy portion of a retina of the eye. For example, intracorneal implant **1822** may have an overall span between opposing edges thereof of, e.g., 6-12mm (e.g., 9mm), an overall planar thickness of between 0.020-1.5mm, and a convexity having a curvature of between 32-47 diopters.

[00371] In some embodiments, receiver **1837** comprises, e.g., a photovoltaic cell for receiving power and a photodiode for receiving data transmitted by light beam source **1815** over wireless data and wireless power communication **1819**.

[00372] Fig. 18D illustrates an exemplary extraocular unit **1844** of the present disclosure, wherein the various components of the extraocular unit are mounted to a pair of spectacles to be worn by a user, including, but not limited to, imaging device **1804**, transmitter/transceiver **1806**, primary inductive coil **1808a**, power source **1808**, image processing module **1810**, and/or illumination source **1813**. However, in other exemplary embodiments, the various components of extraocular unit **1800** may be mounted to any one or more head-worn elements, such as a helmet, headband, headgear, etc. In some embodiments, imaging device **1804** may be advantageously located to approximate a point-of-view of either or both eyes of the wearer.

[00373] Fig. 18E shows an exemplary illumination source **1813** of the present disclosure, described with reference to Figs. 18B-18C, which may be mounted within the lens area of the spectacles (as shown in Fig. 18D), such that the illumination source **1813** is configured to illuminate the intracorneal implant **1820** implanted within the cornea of the eye. Thus, illumination source **1813** may be mounted to the lens area of a pair of spectacles to be worn

by a user, such that illumination source **1813** aligns with an optical axis **X-X** of the eye and can illuminate an LCD panel mounted to the intracorneal implant **1820**, so as to project an image displayed by the LCD panel onto the retina of the eye (e.g., via an optical transmission path which may comprise the lens of the eye and/or one or more focusing optic of the present disclosure). In some embodiments, primary inductive coil **1808a** may be mounted, e.g., in the surrounding area of illumination source **1813**.

[00374] Figs. 19A-19D show front perspective (19A), posterior (19B), anterior (19C), and side (19D) views, respectively, of an exemplary intracorneal implant **1820**, according to some embodiments of the present disclosure.

[00375] In some embodiments, intracorneal implant **1820** defines a planar body having a convexity which substantially conforms to the convexity of the cornea, with opposing concave posterior face (facing the retina of the eye, as shown in Fig. 19A) and convex anterior face (facing the anterior surface of the eye, as shown in Fig. 19B).

[00376] In some embodiments, intracorneal implant **1820** comprises an inner platform portion **1824** located about an axis of circular symmetry of the implant, and a peripheral portion, comprising one or more angularly-spaced arms **1826** that extend laterally from a peripheral edge of inner platform **1824**. In some embodiments, the inner platform portion **1824** comprises at least 1, 2, 3, 4, 5, or more arms **1826**.

[00377] In some embodiments, intracorneal implant **1820** further comprises a peripheral skirt portion **1828** which defines an outer circular perimeter of intracorneal implant **1820**, wherein the one or more arms **1826** connect between inner platform **1824** and peripheral skirt portion **1828**.

[00378] In some embodiments, intracorneal implant **1820** may be dimensioned and configured for surgical implantation within the cornea of an eye, traversing or completely replacing any opaque tissue layers of the cornea, and wherein only substantially transparent corneal tissue is present posterior to the device.

[00379] In some embodiments, intracorneal implant **1820** is dimensioned and configured for surgical implantation within the cornea of an eye, such that a layer of corneal tissue that is partially transparent, partially semi-transparent, and/or partially opaque is present posteriorly to the light-projecting posterior port of the device.

[00380] In some embodiments, exemplary intracorneal implant **1820** is dimensioned to fit within a cornea, posteriorly to any opaque corneal tissue layers, and to generate images that are detectable by a healthy retina or a healthy portion of a retina of the eye. For example, intracorneal implant **1820** may have an overall span between opposing edges thereof of, e.g., 6-12mm (e.g., 9mm), an overall planar thickness of between 0.02-1.50mm, and a convexity having a curvature of between 32-47 diopters.

[00381] In some embodiments, intracorneal implant **1820** may be fashioned of any suitable biologically-compatible material, e.g., any metal, metal alloy (such as nitinol, stainless steel, and the like), and/or polymer. In some embodiments, intracorneal implant **1820** may be fashioned integrally as a unitary intracorneal implant of a single material, or may be assembled from two or more separate components, wherein each component may be made of a different material. In some embodiments, intracorneal implant **1820** or any portion thereof may be made of a hard or non-deformable material, a shape-memory material, and/or a flexible or deformable material. In some embodiments, intracorneal implant **1820** or any portion thereof may have a coating of, e.g., an epoxy material, and the like.

[00382] In some embodiments, intracorneal implant **1820** is shaped to define one or more openings, e.g., as defined by the spaces between peripheral skirt portion **1828**, inner platform portion **1824**, and the one or more arms **1826**. In some embodiments, the one or more openings are configured to allow adaptation of the intracorneal implant **1820** within the cornea through the openings and fixation of the intracorneal implant **1820** within the surrounding corneal tissue. In this manner, once intracorneal implant **1820** has been implanted, and the eye has healed, intracorneal implant **1820** becomes substantially anchored in place by the growth and remodeling of surrounding tissue. In some embodiments, one or more openings define a total opening surface area that is between, e.g., 30-50% of the total intracorneal implant **1820** surface area.

[00383] In some embodiments, image generator **1834** may be dimensioned and configured to be coupled to inner platform portion **1824**, so as to display and/or project through a light-projecting posterior port **1834a** an image in a posterior direction in relation to a surface of the eye, towards and onto the retina of the eye (e.g., via an optical transmission path which

may comprise the lens of the eye and/or one or more focusing optic of the present disclosure).

[00384] In some embodiments, image projection controller **1830** receives an input image data received by wireless receiver module **1836** and optionally stores the image data in a memory storage module. Image projection controller **1830** processes the digital image data encoded in the signal, to generate and reconstruct a visual image therefrom, and operates image generator **1834** to generate a light beam based on the image data, and to project the generated light beam onto the retina. In some embodiments, image projection controller **1830** may be implemented as one or more circuitry modules coupled to any part of intracorneal implant **1820**, for example, to one or more posterior surfaces of arms **1826**, as shown in Figs. 19A and 19B.

[00385] In some embodiments, image generator **1834** is configured and operable to receive an image data signal from an extraocular source and to generate an image projection light beam (e.g., light beam modulated with visual image information) to be projected on the retina of the eye through light-projecting posterior port **1834a**, for generating an image thereon. In some embodiments, image generator **1834** is configured to output an image projection light beam capable of traversing through any transparent, semi-opaque, and/or substantially opaque corneal tissue that is present posteriorly to the light-projecting posterior port of the device, to reach the retina of the eye.

[00386] In some embodiments, image generator **1834** includes a display element connected to image projection controller **1830**. Image generator **1834** can generate and project an image projection light beam onto the retina of the eye. In some embodiments, image generator **1834** may comprise, e.g., a color or monochrome liquid crystal display (LCD), and a backlight source.

[00387] In other embodiments, image generator **1834** comprises a micro-optical array mounted on a flexible printed circuit board ("PCB") substrate to support the electronic and optical components. The micro-display may comprise miniaturized pixels each with a size within a range, e.g., from 2 microns to 100 microns. The micro-display can be coupled to and supported by inner platform portion **1824** of intracorneal implant **1820**. In some embodiments, the micro-display may be monochromatic or polychromatic. In some

embodiments, the micro-display forms an array of pixels, characterized by a pixel size and a pixel pitch. As described herein, pixel sizes may range from 2 microns to 100 microns, and the pixel pitch may range from 10 microns to 1.0 mm, for example.

[00388] In some embodiments, image generator **1834** may be configured to receive illumination from an extraocular unit of the present disclosure, e.g., exemplary extraocular unit **1801** in Fig. 18B and **1802** in Fig 18C. In such embodiments, the extraocular unit may be configured to provide the illumination source for an LCD panel of image generator **1834**.

[00389] Optical assembly **1840** may be mounted posteriorly to image generator **1834** and optically coupled therewith, to focus or apply any other suitable or desirable optical manipulation to the image projection light beam generate and projected by image generator **1834**. Optical assembly **1840** may include, e.g., an adjustable imaging lens, which may act like the crystalline lens of a normal healthy eye, which focuses the images transmitted through the cornea onto the retina at the back of the eye.

[00390] In some embodiments, wireless receiver or transceiver **1836** may be implemented as electric circuitry coupled to any part of intracorneal implant **1820**, for example, to one or more posterior surfaces of arms **1826**, as shown in Figs. 19A and 19B. Wireless receiver or transceiver **1836** may be configured to be in wireless data communication with wireless transmitter or transceiver **1806** of extraocular unit **1800**, to receive an image data signal transmitted by transmitter or transceiver **1806** using non-optical data transmission modalities, e.g., any suitable short-range RF transmission protocol, such as Bluetooth, ZigBee, and the like.

[00391] In some embodiments, a power receiving element **1838** may be implemented as a secondary reception inductive coil, mounted onto intracorneal implant **1820**, e.g., disposed about a posterior surface of peripheral skirt portion **1828**, and/or at any other suitable location. In some embodiments, power receiving element **1838** comprises an inductive coil made from wound wire. Alternatively, the secondary reception inductive coil may be made from a thin film polymer sandwich with wire traces deposited between layers of thin film polymer.

[00392] In some embodiments, the functions of wireless data reception and wireless power reception may both be carried out by the wireless power receiving element **1838**, wherein

the secondary reception inductive coil **1838** may be configured for joint reception of power and data.

[00393] Fig. 20 is a schematic illustration of an exemplary intracorneal implant **1820** comprising a plurality of haptics **1842**. In some embodiments, an intracorneal implant **1820** of the present disclosure may further comprise one or more haptics **1842** that extend laterally from a peripheral edge of the implant. The haptics may function structurally to center the intracorneal implant within the pocket formed in the cornea during surgery.

[00394] The haptics **1842** extend outward from peripheral skirt portion **1828** of intracorneal implant **1820**, and are spaced apart from each other. Each of haptics **1842** includes a proximal end which is connected to the outer peripheral edge of peripheral skirt portion **1828**, and a projecting segment culminating in a distal end.

[00395] In some embodiments, between 2 and 6 haptics **1842** may be used. In some embodiments, the haptics **1842** may be divided into opposing pairs, each of which extends outwardly and away from peripheral skirt portion **1828** at opposite ends thereof.

[00396] During implantation of intracorneal implant **1820**, each of the haptics **1842** may be manipulated so as to center the intracorneal implant **1820** as close to the optical axis of the eye as possible, as well as to ensure that the intracorneal implant **1820** has the desired placement in the rotational direction in the X-Y plane, and secure it in place inside the cornea.

[00397] Figs. 21A-21D illustrate steps in the process for surgical implantation of an intracorneal implant **1820** within the cornea **2100**.

[00398] In some embodiments, an intracorneal implant of the present disclosure may be configured for surgical implantation within the cornea using any suitable surgical method, e.g., by:

- Creating a partial anterior corneal stromal flap or lamella, performing deep lamellar dissection to create a recess, and positioning the implant in a recess beneath the flap or lamella.

- Creating a partial anterior corneal stroma flap or lamella, forming a hollow pocket within the cornea, positioning the implant within the pocket and securing the implant with the corneal flap or lamella.
- Creating a partial anterior corneal stroma flap or lamella, forming a hollow pocket within the cornea, positioning an implant which is pre-assembled preoperatively or assembled intraoperatively within a corneal tissue scaffold; and securing the implant with the corneal flap or lamella. The corneal tissue scaffold may be the exemplary corneal tissue scaffold **1329** described with reference to Figs. 13A-13F.
- Conjunctival flap surgery or mucous membrane grafting to permanently cover the cornea may also be performed concurrently or sequentially after surgical implantation.

[00399] Fig. 21A illustrates the human eye. Shown are the cornea **2100**, iris **2102**, lens **2104**, vitreous region **2106**, retina **2108**, and optical nerve **2110**.

[00400] Fig. 21B shows a pocket **2120** formed in the cornea **2100**, configured to receive an intracorneal implant **1820** of the present disclosure. In some embodiments, pocket **2120** may be formed using any suitable surgical method, e.g., by creating a partial anterior corneal stromal flap or lamella, performing deep lamellar dissection to create pocket **2120**, and positioning intracorneal implant **1820** in pocket **2120** beneath the flap or lamella. In other embodiments, pocket **2120** may be formed by creating a partial anterior corneal stroma flap or lamella, forming a hollow pocket within the cornea, positioning intracorneal implant **1820** within the pocket, and securing intracorneal implant **1820** with the corneal flap or lamella.

[00401] Fig. 21C shows intracorneal implant **1820** implanted within a pocket **2120** within cornea **2100**.

[00402] Fig. 21D shows a corneal lamella **2122** placed and sutured over the pocket **2120**, to complete the implantation process. In some embodiments, conjunctival flap surgery or mucous membrane grafting to permanently cover the cornea may also be performed concurrently or sequentially after surgical implantation of intracorneal implant **1820** within pocket **2120**.

[00403] Fig. 21E shows optional optical assembly **1840** in detail and as implanted within the eye. Optical assembly **1840** may be mounted posteriorly of intracorneal implant **1820**, and optically coupled therewith, to focus the projected image onto the retina. Optical assembly **1840** may comprise any suitable one or more optical lenses or other optical elements. In some embodiments, optical assembly **1840** may be configured to focus the projected optical image onto the retina, e.g., in conjunction with, or in the absence of, the natural lens of the eye **2104**. In some embodiments, optical assembly **1840** may include, e.g., an adjustable imaging lens, which may act like the crystalline lens of a normal healthy eye, which focuses the images transmitted through the cornea onto the retina at the back of the eye.

[00404] Fig. 22 shows a cross-sectional view of an eye having an intracorneal implant **1820** implanted within cornea **2100**. As can be seen, image generator **1834** is configured to project images onto retina **2108** (e.g., via an optical transmission path which may comprise the lens of the eye and/or one or more optical assembly of the present disclosure).

[00405] The descriptions of the various embodiments of the present invention have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the embodiments disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the described embodiments. The terminology used herein was chosen to best explain the principles of the embodiments, the practical application or technical improvement over technologies found in the marketplace, or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

[00406] In the description and claims, each of the terms “substantially,” “essentially,” and forms thereof, when describing a numerical value, means up to a 20% deviation (namely, $\pm 20\%$) from that value. Similarly, when such a term describes a numerical range, it means up to a 20% broader range – 10% over that explicit range and 10% below it).

[00407] In the description, any given numerical range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range, such that each such subrange and individual numerical value constitutes an embodiment of the invention. This applies regardless of the breadth of the range. For

example, description of a range of integers from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6, etc., as well as individual numbers within that range, for example, 1, 4, and 6. Similarly, description of a range of fractions, for example from 0.6 to 1.1, should be considered to have specifically disclosed subranges such as from 0.6 to 0.9, from 0.7 to 1.1, from 0.9 to 1, from 0.8 to 0.9, from 0.6 to 1.1, from 1 to 1.1 etc., as well as individual numbers within that range, for example 0.7, 1, and 1.1.

[00408] The descriptions of the various embodiments of the present invention have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the explicit descriptions. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the described embodiments. The terminology used herein was chosen to best explain the principles of the embodiments, the practical application or technical improvement over technologies found in the marketplace, or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

[00409] In the description and claims of the application, each of the words “comprise,” “include,” and “have,” as well as forms thereof, are not necessarily limited to members in a list with which the words may be associated.

[00410] Where there are inconsistencies between the description and any document incorporated by reference or otherwise relied upon, it is intended that the present description controls.

CLAIMS

What is claimed is:

1. A device comprising:

an intracorneal implant dimensioned and adapted for implantation within the cornea of an eye, said intracorneal implant defining a planar body having a convexity which substantially conforms to the convexity of the cornea, said intracorneal implant comprising:

- (i) a central optical part comprising an optical stem having an anterior end and extending axially through the cornea to a posterior end, and
- (ii) a peripheral haptic part comprising two or more angularly-spaced haptics that extend laterally from said central optical part,

wherein, when said intracorneal implant is implanted within said cornea, said anterior end is located substantially at the anterior surface of said eye, and said posterior end abuts or is substantially in contact engagement with a thin layer of corneal tissue located posteriorly to said posterior end.

2. The device of claim 1, wherein said optical stem is configured to project an image in a posterior direction, through said thin layer of corneal tissue, and onto the retina of said eye.

3. The device of claim 2, wherein said anterior end is a light-receiving end, and wherein said optical stem defines a light-transparent pathway oriented for transmitting light received at said anterior end from an extraocular light source through said optical stem and through said thin layer of corneal tissue, onto the retina of said eye.

4. The device of claim 2, wherein said optical stem includes an image generator configured to receive an image data signal from an extraocular source, and to project an image in a posterior direction, through said thin layer of corneal tissue, onto the retina of said eye.

5. The device of any one of claims 1-4, wherein said optical stem comprises at least one optical lens.

6. The device of any one of claim 1-5, wherein said thin layer of corneal tissue is substantially transparent.

7. The device of any one of claim 1-6, wherein said thin layer of corneal tissue has a thickness of approximately 10-50 μ m.

8. The device of any one of claim 1-7, wherein said thin layer of corneal tissue comprises, in at least a central portion thereof, the pre-Descemet layer and the Descemet membrane of said cornea.

9. The device of any one of claim 1-7, wherein said thin layer of corneal tissue further comprises, in at least said central portion thereof, the Descemet membrane of said cornea.

10. The device of any one of claim 8 or 9, wherein said thin layer of corneal tissue further comprises, in at least said central portion thereof, the endothelial layer of said cornea.

11. The device of any one of claim 1-10, wherein said thin layer of corneal tissue is part of a corneal tissue scaffold configured for surgical implantation in said eye within a through-recess formed by a full-thickness corneal trephination in said eye.

12. The device of claim 11, wherein said thin layer of corneal tissue forms a central, substantially transparent, region of said corneal tissue scaffold.

13. The device of any one of claims 11-12, wherein said corneal tissue scaffold is preprocessed using at least one of the following techniques: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, and sterilization.

14. The device of any one of claims 1-13, wherein each of said haptics comprises at least one opening configured to facilitate fixation and adaptation of the device with the corneal tissue through the at least one opening, when said device is implanted within said cornea.

15. The device of any one of claims 1-14, wherein, when said intracorneal implant is implanted within said cornea, at least a portion of said anterior end is exposed through the anterior surface of said eye.

16. The device of claim 15, wherein said anterior end is configured for mounting at least one external optical element.

17. The device of claim 16, wherein said at least one external optical element is removably mounted to said anterior end.

18. A method comprising:

providing an intracorneal implant dimensioned and adapted for implantation within the cornea of an eye, said intracorneal implant defining a planar body having a convexity which substantially conforms to the convexity of the cornea, said intracorneal implant comprising:

- (i) a central optical part comprising an optical stem having an anterior end and extending axially through the cornea to a posterior end, and
- (ii) a peripheral haptic part comprising two or more angularly-spaced haptics that extend laterally from said central optical part; and

implanting said intracorneal implant within said cornea, such that said anterior end is located substantially at the anterior surface of said eye, and said posterior end is in contact engagement with a thin layer of corneal tissue located posteriorly to said posterior end.

19. The method of claim 18, wherein said optical stem is configured to project an image in a posterior direction, through said thin layer of corneal tissue, and onto the retina of said eye.

20. The method of claim 19, wherein said anterior end is a light-receiving end, and wherein said optical stem defines a light-transparent pathway oriented for transmitting light received at said anterior end from an extraocular light source through said optical stem and through said thin layer of corneal tissue, onto the retina of said eye.

21. The method of claim 19, wherein said optical stem includes an image generator configured to receive an image data signal from an extraocular source, and to project an image in a posterior direction, through said thin layer of corneal tissue, and onto the retina of the eye; and wherein said method further comprises receiving, by said image generator, an image data signal from an extraocular source, and projecting said image in a posterior direction, through said thin layer of corneal tissue, and onto the retina of the eye.

22. The method of any one of claims 18-21, wherein said optical stem comprises at least one optical lens.

23. The method of any one of claim 18-22, wherein said thin layer of corneal tissue is substantially transparent.

24. The method of any one of claim 18-23, wherein said thin layer of corneal tissue has a thickness of approximately 10-50 μ m.

25. The method of any one of claim 18-24, wherein said thin layer of corneal tissue comprises, in at least a central portion thereof, the pre-Descemet layer and the Descemet membrane of said cornea.

26. The method of any one of claim 18-24, wherein said thin layer of corneal tissue further comprises, in at least said central portion thereof, the Descemet membrane of said cornea.

27. The method of any one of claim 25 or 26, wherein said thin layer of corneal tissue further comprises, in at least said central portion thereof, the endothelial layer of said cornea.

28. The method of any one of claim 18-27, wherein said thin layer of corneal tissue is part of a corneal tissue scaffold configured for surgical implantation in said eye within a through-recess formed by a full-thickness corneal trephination in said eye.

29. The method of claim 28, wherein said thin layer of corneal tissue forms a central, substantially transparent, region of said corneal tissue scaffold.

30. The method of any one of claims 11-29, wherein said corneal tissue scaffold is preprocessed using at least one of the following techniques: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, decontamination, and sterilization.

31. The method of any one of claims 18-30, wherein each of said haptics comprises at least one opening configured to facilitate fixation and adaptation of the intracorneal implant with the corneal tissue through the at least one opening, when said intracorneal implant is implanted within said cornea.

32. The method of any one of claims 18-31, wherein, when said intracorneal implant is implanted within said cornea, at least a portion of said anterior end is exposed through the anterior surface of said eye.

33. The method of claim 32, wherein said anterior end is configured for mounting at least one external optical element.

34. The method of claim 33, wherein said at least one external optical element is removably mounted to said anterior end.

35. An implantable corneal tissue scaffold device, comprising:

a central portion defining a recess having a posterior end comprising a thin layer of corneal tissue, wherein said thin layer of corneal tissue comprises at least the pre-Descemet layer and the Descemet membrane, or at least the pre-Descemet layer; and

a peripheral portion of corneal tissue which surrounds said recess, comprising one or more of: posterior layers of the stroma of the cornea, the pre-Descemet layer, the Descemet membrane, and the endothelial layer,

wherein said implantable corneal tissue scaffold is prepared by:

- (i) performing, in a cornea, a deep lamellar dissection which separates between the deep posterior stroma of the cornea and the pre-Descemet layer or between the pre-Descemet layer and the Descemet membrane;
- (ii) performing, in said cornea, a partial trephination and removal of anterior layers of the stroma of the cornea;

- (iii) removing a central portion of deep posterior stroma of said cornea to create said recess, and
- (iv) performing a full-thickness trephination to remove the entire implantable corneal tissue scaffold device comprising said central portion and said peripheral portion, from said cornea.

36. The implantable corneal tissue scaffold device of claim 35, wherein said corneal tissue scaffold device has a diameter of 5-11 mm.

37. The implantable corneal tissue scaffold device of any one of claim 35 or 36, wherein said thin layer of corneal tissue has a thickness of between 10-50 μ m, and wherein said peripheral portion has a thickness of between 100-500 μ m.

38. The implantable corneal tissue scaffold device of any one of claim 35-37, wherein said thin layer of corneal tissue is substantially transparent.

39. The implantable corneal tissue scaffold device of any one of claims 35-38, wherein said cornea is a donor cornea.

40. The implantable corneal tissue scaffold device of any one of claims 35-39, wherein said recess has a diameter of between 3-7 mm.

41. The implantable corneal tissue scaffold device of any one of claims 35-40, wherein said deep lamellar dissection is performed using one or more of: pneumatic dissection, hydro-assisted dissection, viscoelastic-assisted dissection, and manual dissection.

42. The implantable corneal tissue scaffold device of any one of claims 35-41, wherein said removed anterior layers of the stroma of the cornea have a thickness of between 100-400 μ m.

43. The implantable corneal tissue scaffold device of any one of claims 35-42, wherein said corneal tissue scaffold device is configured for implanting in an eye within a through-recess formed in said eye by a full-thickness trephination.

44. The implantable corneal tissue scaffold device of any one of claims 35-43, wherein said corneal tissue scaffold device is preprocessed using at least one of the following techniques: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, decontamination, and sterilization.

45. A method comprising:

preparing an implantable corneal tissue scaffold comprising a central portion defining a recess having a posterior end comprising a thin layer of corneal tissue, wherein said thin layer of corneal tissue comprises at least the pre-Descemet layer and the Descemet membrane, or at least the pre-Descemet layer, and a peripheral portion of corneal tissue which surrounds said recess, comprising one or more of: posterior layers of the stroma of the cornea, the pre-Descemet layer, the Descemet membrane, and the endothelial layer, by:

- (i) performing, in a cornea, a deep lamellar dissection which separates between the deep posterior stroma of the cornea and the pre-Descemet layer or between the pre-Descemet layer and the Descemet membrane;
- (ii) performing, in said cornea, a partial trephination and removal of anterior layers of the stroma of the cornea;
- (iii) removing a central portion of deep posterior stroma of said cornea to create said recess, and
- (iv) performing a full-thickness trephination to remove the entire implantable corneal tissue scaffold device comprising said central portion and said peripheral portion, from said cornea.

46. The method of claim 45, wherein said corneal tissue scaffold device has a diameter of 5-11mm.

47. The method of any one of claim 45 or 46, wherein said thin layer of corneal tissue has a thickness of between 10-50 μ m, and wherein said peripheral portion has a thickness of between 100-500 μ m.

48. The method of any one of claim 45-47, wherein said thin layer of corneal tissue is substantially transparent.

49. The method of any one of claims 45-48, wherein said cornea is a donor cornea.

50. The method of any one of claims 45-49, wherein said recess has a diameter of between 3-7mm.

51. The method of any one of claims 45-50, wherein said deep lamellar dissection is performed using one or more of: pneumatic dissection, hydro-assisted dissection, viscoelastic-assisted dissection, and manual dissection.

52. The method of any one of claims 45-51, wherein said removed anterior layers of the stroma of the cornea have a thickness of between 100-400 μm .

53. The method of any one of claims 45-52, further comprising implanting said wherein said corneal tissue scaffold device in an eye within a through-recess formed in said eye by a full-thickness trephination.

54. The method of any one of claims 45-53, further comprising preprocessing said corneal tissue scaffold device using at least one of the following techniques: dehydration, lyophilization, plasticization, gelling, dehydrothermal treatment, mechanical processing, compressing, decontamination, and sterilization.

55. A system comprising:

an implantable corneal tissue scaffold comprising a central portion defining a recess having a posterior end comprising a thin layer of corneal tissue, wherein said thin layer of corneal tissue comprises at least the pre-Descemet layer and the Descemet membrane, or at least the pre-Descemet layer, and a peripheral portion of corneal tissue which surrounds said recess, comprising one or more of: posterior layers of the stroma of the cornea, the pre-Descemet layer, the Descemet membrane, and the endothelial layer; and

an intracorneal implant defining a planar body having a convexity which substantially conforms to the convexity of the cornea, said intracorneal implant comprising:

- (i) a central optical part comprising an optical stem having an anterior end and extending axially through the cornea to a posterior end, and

- (ii) a peripheral haptic part comprising two or more angularly-spaced haptics that extend laterally from said central optical part,

wherein said intracorneal implant is mounted to said implantable corneal tissue scaffold device such that said posterior end abuts or is in contact engagement with said thin layer of corneal tissue.

56. The system of claim 55, further comprising an anterior corneal lamella layer sutured in place over said intracorneal implant.

57. The system of claim 56, wherein said system is intended for surgical implantation within a through-recess formed by a full-thickness corneal trephination in an eye.

58. A device comprising:

a corneal implant dimensioned and adapted for implantation within the cornea of an eye, said implant defining a planar body comprising:

- (i) an inner platform portion located about an axis of circular symmetry of said implant, and
- (ii) a peripheral portion comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of said inner platform;

a wireless communication circuit configured for receiving an image data signal from an extraocular unit;

an image projection controller configured to process said received image data signal to generate an image; and

an image generator mounted to said inner platform portion, configured to project an image projection light beam, based on said generated image, in a posterior direction onto the retina of the eye.

59. The device of claim 58, further comprising a peripheral skirt portion which defines an outer circular perimeter of said implant, wherein said one or more angularly-spaced arms connect between said inner platform and said peripheral skirt portion;

60. The device of any one of claims 58 or 59, wherein said wireless communication circuit comprises a reception inductive coil.

61. The device of claim 60, wherein said reception inductive coil is further configured for receiving power inductively from said extraocular unit.

62. The device of any one of claims 58 or 59, wherein said wireless communication circuit comprises a photovoltaic cell configured to receive a light beam encoding said image data signal.

63. The device of claim 62, wherein said photovoltaic cell is further configured for receiving power from said light beam.

64. The device of any one of claim 58-63, further comprising a memory storage for storing said received image data signal.

65. The device of any one of claim 58-64, wherein said image generator comprises a liquid crystal display device having an illuminator element optically coupled thereto.

66. The device of any one of claim 58-64, wherein said image generator comprises a liquid crystal display device configured for being illuminated by an extraocular illumination source.

67. The device of any one of claim 58-66, wherein said peripheral skirt portion, inner platform portion, and at least one arm, define at least one opening in said planar body, and wherein said at least one opening is configured to facilitate fixation and adaptation of the device with the corneal tissue through the at least one opening, when said device is implanted within said cornea.

68. The device of any one of claim 58-67, further comprising an optical assembly mounted posteriorly of said image generator and optically coupled therewith, configured to focus said projected image onto said retina.

69. The device of any one of claim 58-68, further comprising at least one haptic that extends outwardly from said outer circular perimeter of said implant, wherein said at least one haptic comprises a proximal end which is connected to said outer circular perimeter, and a projecting segment culminating in a distal end.

70. A method comprising:

providing a device comprising:

a corneal implant dimensioned and adapted for implantation within the cornea of an eye, said implant defining a planar body comprising:

- (i) an inner platform portion located about an axis of circular symmetry of said implant, and
- (ii) a peripheral portion comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of said inner platform;

a wireless communication circuit configured for receiving an image data signal from an extraocular unit;

an image projection controller configured to process said received image data signal to generate an image; and

an image generator mounted to said inner platform portion, configured to project an image projection light beam, based on said generated image, in a posterior direction onto the retina of the eye;

implanting said device in the cornea of an eye, such that transparent corneal tissue or no corneal tissue is present posterior to the image generator of the device;

receiving, by said wireless communication circuit, said image data signal;

processing, by said image projection controller, said received image data signal, to generate said image; and

projecting, by said image generator, said image in a posterior direction onto the retina of said eye.

71. The method of claim 70, wherein said device further comprises a peripheral skirt portion which defines an outer circular perimeter of said implant, wherein said one or more angularly-spaced arms connect between said inner platform and said peripheral skirt portion;

72. The method of any one of claims 70 or 71, wherein said wireless communication circuit comprises a reception inductive coil.

73. The method of claim 72, wherein said reception inductive coil is further configured for receiving power inductively from said extraocular unit.

74. The method of any one of claims 70 or 71, wherein said wireless communication circuit comprises a photovoltaic cell configured to receive a light beam encoding said image data signal.

75. The method of claim 74, wherein said photovoltaic cell is further configured for receiving power from said light beam.

76. The method of any one of claim 70-75, wherein said device comprises a memory storage for storing said image data signal.

77. The method of any one of claim 70-76, wherein said image generator comprises a liquid crystal display device having an illuminator element optically coupled thereto, wherein said generating comprises generating by said liquid crystal display device a display representing said image, and wherein said projecting comprises operating said illuminator element to illuminate said liquid crystal display device to project said display onto the retina of said eye.

78. The method of any one of claim 70-76, wherein said image generator comprises a liquid crystal display device configured for being illuminated by an extraocular illumination source, wherein said generating comprises generating by said liquid crystal display device a display representing said image, and wherein said projecting comprises operating said extraocular illumination source to illuminate said liquid crystal display device to project said display onto the retina of said eye.

79. The method of any one of claim 70-78, wherein said peripheral skirt portion, inner platform portion, and at least one arm, define at least one opening in said planar body, and wherein said at least one opening is configured to facilitate fixation and adaptation of the device with the corneal tissue through the at least one opening, when said device is implanted within said cornea.

80. The method of any one of claim 70-79, wherein said device comprises an optical assembly mounted posteriorly of said image generator and optically coupled therewith, configured to focus said projected image onto said retina.

81. The method of any one of claim 70-80, wherein said device comprises at least one haptic that extends outwardly from said outer circular perimeter of said implant, wherein said at least one haptic comprises a proximal end which is connected to said outer circular perimeter, and a projecting segment culminating in a distal end.

82. A system comprising:

a device comprising:

a corneal implant dimensioned and adapted for implantation within the cornea of an eye, said implant defining a planar body comprising:

- (i) an inner platform portion located about an axis of circular symmetry of said implant, and
- (ii) a peripheral portion comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of said inner platform,

a wireless communication circuit configured for receiving an image data signal from an extraocular unit,

an image projection controller configured to process said received image data signal to generate an image, and

an image generator mounted to said inner platform portion, configured to project an image projection light beam, based on said generated image, in a posterior direction onto the retina of the eye; and

an extraocular unit comprising:

at least one imaging device for capturing visual images,

an image processing module for processing and storing said captured visual images as digital image data, and

a wireless communication module for transmitting said digital image data to said device through said wireless communication circuit.

83. The system of claim 82, wherein said device further comprises a peripheral skirt portion which defines an outer circular perimeter of said implant, wherein said one or more angularly-spaced arms connect between said inner platform and said peripheral skirt portion;

84. The system of any one of claims 82 or 83, wherein said wireless communication circuit comprises a reception inductive coil, and wherein said wireless communication module comprises a transmission inductive coil.

85. The system of claim 84, wherein said reception inductive coil is further configured for receiving power inductively from said transmission inductive coil.

86. The system of any one of claims 82 or 83, wherein said wireless communication module comprises a light beam source.

87. The system of claim 86, wherein said wireless communication circuit comprises a photovoltaic cell configured to receive a light beam encoding said image data signal, wherein said light beam is emitted from said light beam source.

88. The system of claim 87, wherein said photovoltaic cell is further configured for receiving power from said light beam.

89. The system of any one of claim 82-88, wherein said device comprises a memory storage for storing said received image data signal.

90. The system of any one of claim 82-88, wherein said image generator comprises a liquid crystal display device having an illuminator element optically coupled thereto.

91. The system of any one of claim 82-90, wherein said image generator comprises a liquid crystal display device, and wherein said extraocular unit comprises an illumination source configured to provide illumination to said liquid crystal display device.

92. The system of claim 91, wherein said illumination source is configured to emit sufficient illumination so as to traverse impaired or opaque layers and to reach said device, when it is implanted within said cornea.

93. The system of any one of claim 82-92, wherein said peripheral skirt portion, inner platform portion, and at least one arm, define at least one opening in said planar body, and wherein said at least one opening is configured to facilitate fixation and adaptation of the

device with the corneal tissue through the at least one opening, when said device is implanted within said cornea.

94. The system of any one of claim 82-93, wherein said device comprises an optical assembly mounted posteriorly of said image generator and optically coupled therewith, configured to focus said projected image onto said retina.

95. The system of any one of claim 82-94, wherein said device comprises at least one haptic that extends outwardly from said outer circular perimeter of said implant, wherein said at least one haptic comprises a proximal end which is connected to said outer circular perimeter, and a projecting segment culminating in a distal end

96. The system of any one of claim 82-95, wherein the components of said extraocular unit are mounted to one of: a spectacle frame, headwear, a helmet, and a headband.

97. A method comprising:

providing a system comprising:

a device comprising

a corneal implant dimensioned and adapted for implantation within the cornea of an eye, said implant defining a planar body comprising:

(i) an inner platform portion located about an axis of circular symmetry of said implant, and

(ii) a peripheral portion comprising one or more angularly-spaced arms that extend laterally from a peripheral edge of said inner platform,

a wireless communication circuit configured for receiving an image data signal from an extraocular unit;

an image projection controller configured to process said received image data signal to generate an image; and

an image generator mounted to said inner platform portion, configured to project an image projection light beam, based on said generated image, in a posterior direction onto the retina of the eye, and

an extraocular unit comprising:

at least one imaging device for capturing visual images,

an image processing module for processing said captured visual images to generate digital image data, and
a wireless communication module for transmitting said digital image data to said device through said wireless communication circuit;
implanting said device in the cornea of an eye, such that transparent corneal tissue or no corneal tissue is present posterior to the image generator of the device;
capturing, by said at least one imaging device of said extraocular unit, at least one visual image;
processing, by said image processing module, said at least one captured visual image, to generate said digital image data,
transmitting, by said wireless communication module, said image data signal,
receiving, by said wireless communication circuit, said image data signal;
processing, by said image projection controller, said received image data signal, to generate said image; and
projecting, by said image generator, said image in a posterior direction onto the retina of said eye.

98. The method of claim 97, wherein said device further comprises a peripheral skirt portion which defines an outer circular perimeter of said implant, wherein said one or more angularly-spaced arms connect between said inner platform and said peripheral skirt portion;

99. The method of any one of claims 97 or 98, wherein said wireless communication circuit comprises a reception inductive coil, and wherein said wireless communication module comprises a transmission inductive coil.

100. The method of claim 99, wherein said reception inductive coil is further configured for receiving power inductively from said transmission inductive coil.

101. The method of any one of claims 97 or 98, wherein said wireless communication module comprises a light beam source.

102. The method of claim 101, wherein said wireless communication circuit comprises a photovoltaic cell configured to receive a light beam encoding said image data signal, wherein said light beam is emitted from said light beam source.

103. The method of claim 102, wherein said photovoltaic cell is further configured for receiving power from said light beam.

104. The method of any one of claim any one of claims 97-103, wherein said device comprises a memory storage for storing said received image data signal.

105. The method of any one of claim 97-104, wherein said image generator comprises a liquid crystal display device having an illuminator element optically coupled thereto, wherein said generating comprises generating by said liquid crystal display device a display representing said image, and wherein said projecting comprises operating said illuminator element to illuminate said liquid crystal display device to project said display onto the retina of said eye.

106. The method of any one of claim 97-104, wherein said image generator comprises a liquid crystal display device, wherein said extraocular unit comprises an illumination source configured to provide illumination to said liquid crystal display device, wherein said generating comprises generating by said liquid crystal display device a display representing said image, and wherein said projecting comprises operating said illumination source to illuminate said liquid crystal display device to project said display onto the retina of said eye.

107. The method of claim 106, wherein said illumination source is configured to emit sufficient illumination so as to traverse impaired or opaque layers and to reach said device, when it is implanted within said cornea.

108. The method of any one of claim 97-107, wherein said peripheral skirt portion, inner platform portion, and at least one arm, define at least one opening in said planar body, and wherein said at least one opening is configured to facilitate fixation and adaptation of the device with the corneal tissue through the at least one opening, when said device is implanted within said cornea.

109. The method of any one of claim 97-108, wherein said device comprises one or more focusing optic mounted posteriorly of said image generator and optically coupled therewith, configured to focus said projected image onto said retina.

110. The method of any one of claim 97-109, wherein said device comprises at least one haptic that extend outwardly from said perimeter, wherein said at least one haptic comprises a proximal end which is connected to said perimeter, and a projecting segment culminating in a distal end, and wherein said implanting comprises adjusting a placement of said device within said cornea by manipulating said at least one haptic.

111. The method of any one of claim 97-110, wherein the components of said extraocular unit are mounted to one of: a spectacle frame, headwear, a helmet, and a headband.

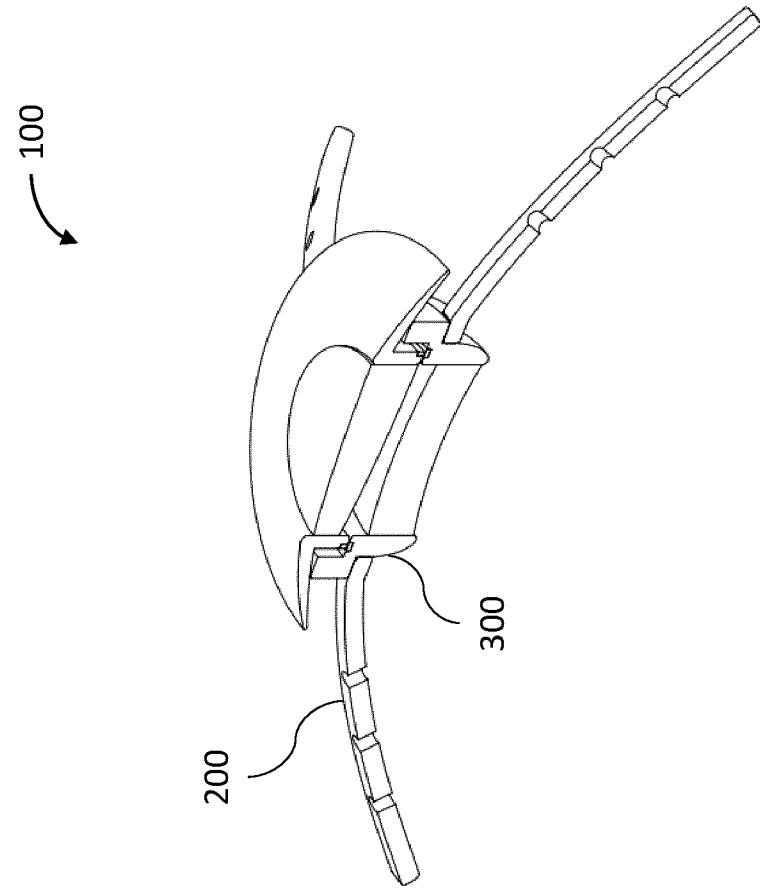


FIG. 1A

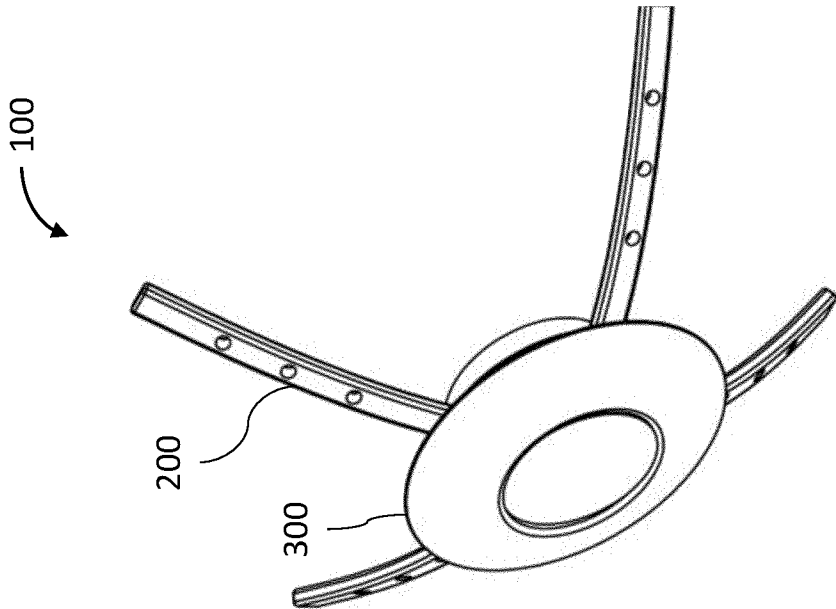


FIG. 1B

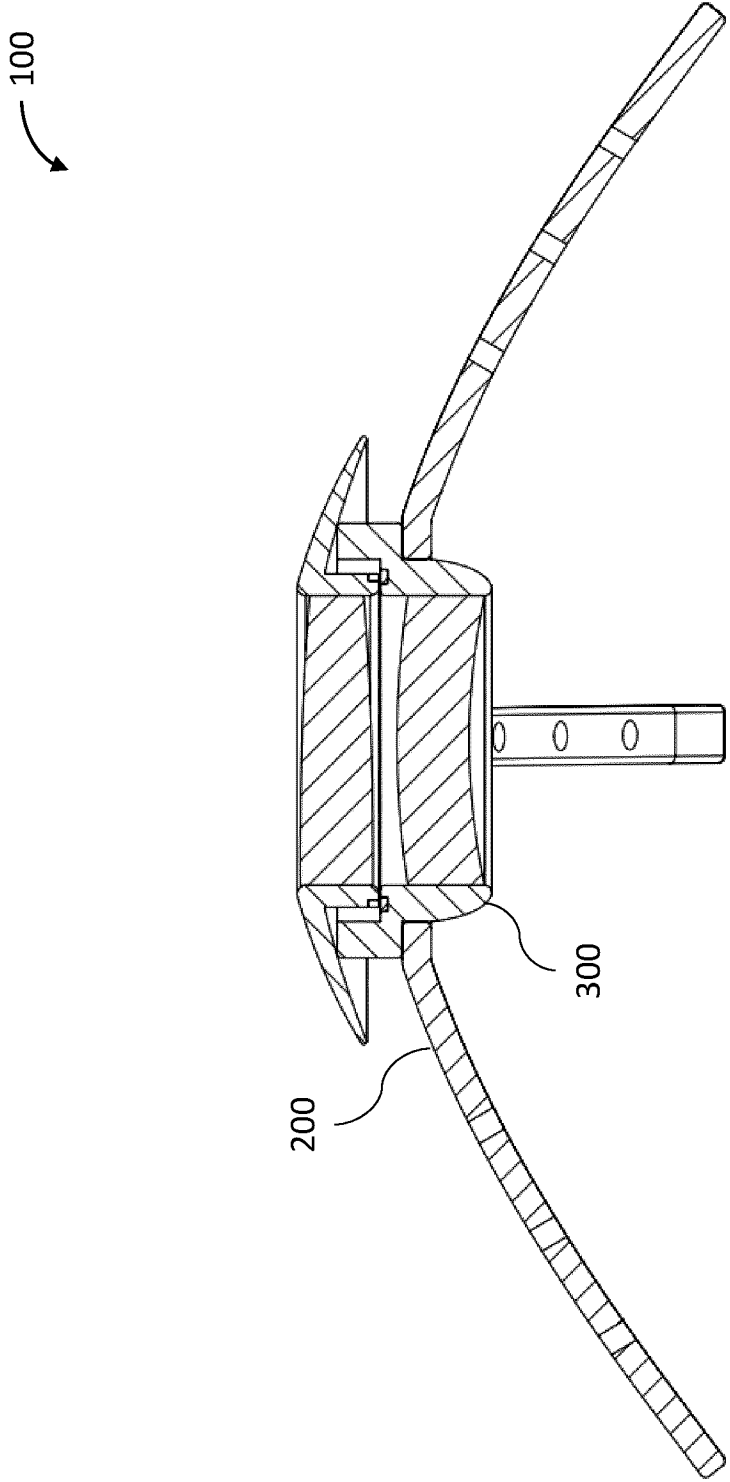


FIG. 1C

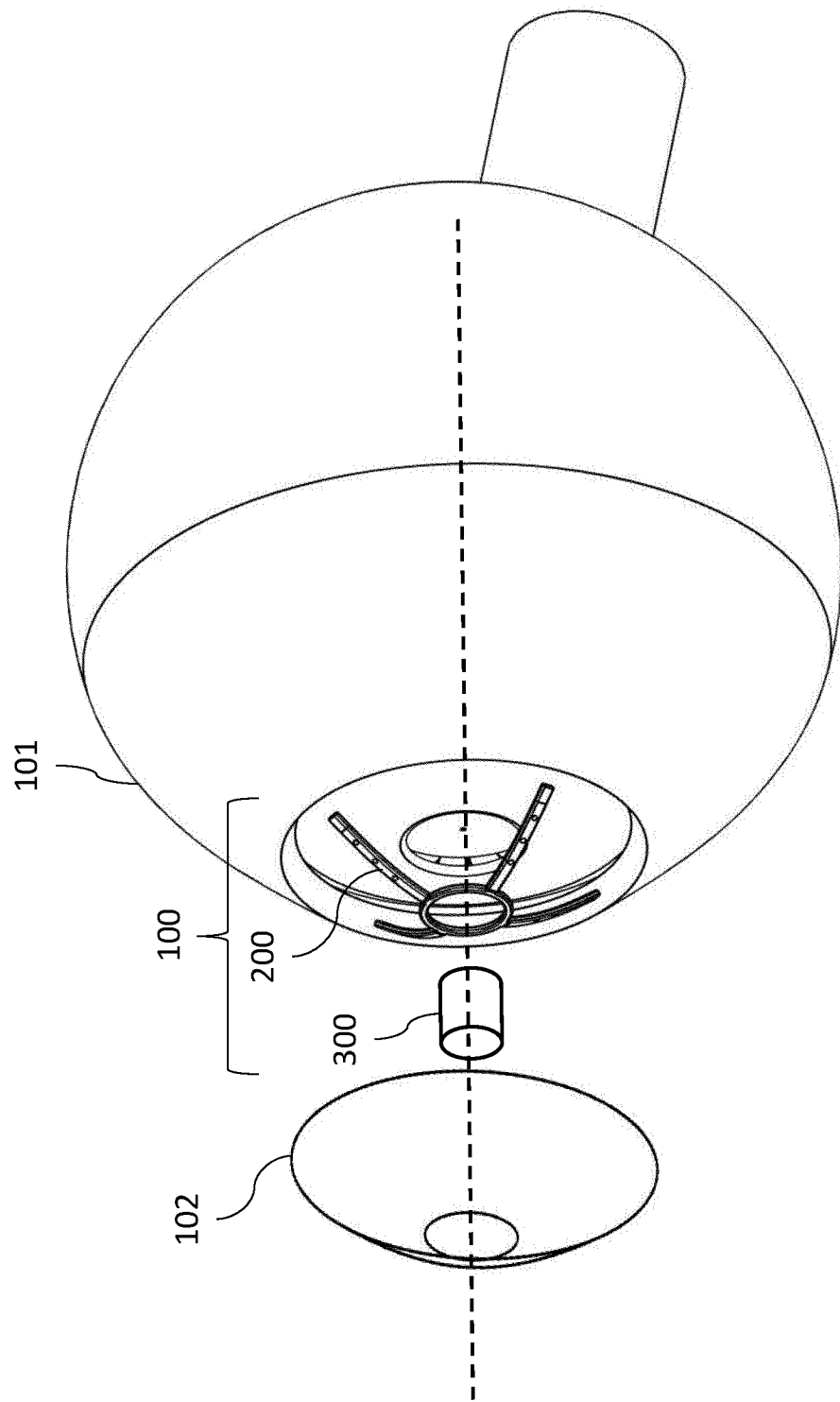


FIG. 1D

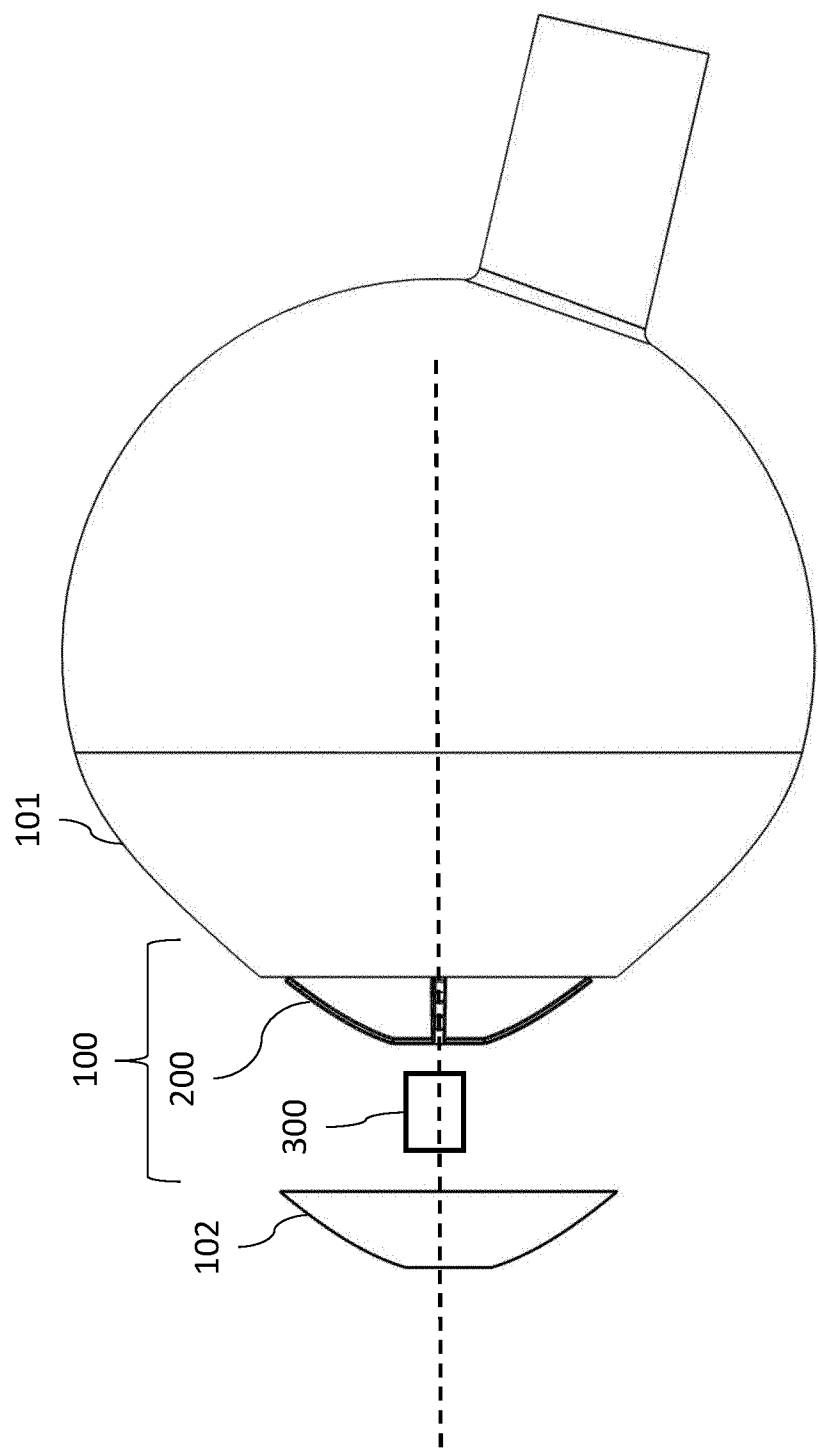


FIG. 1E

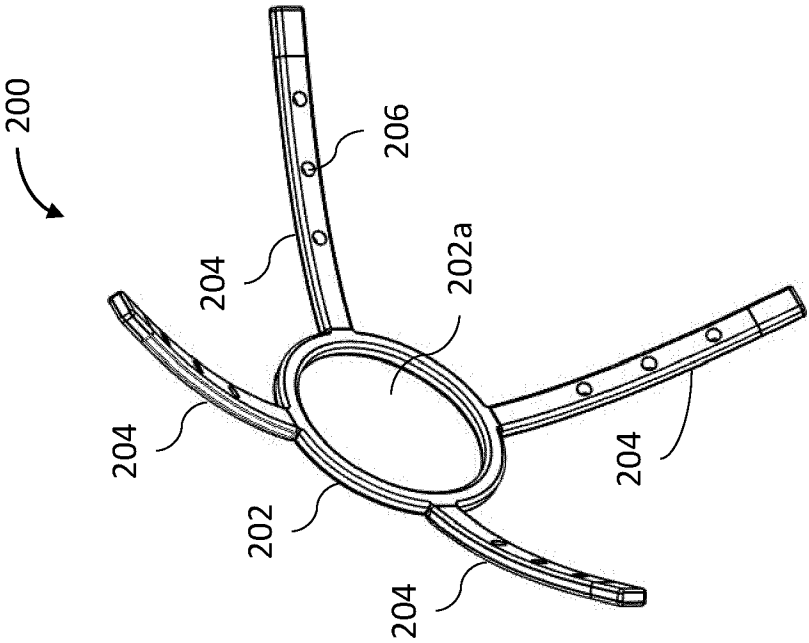


FIG. 2B

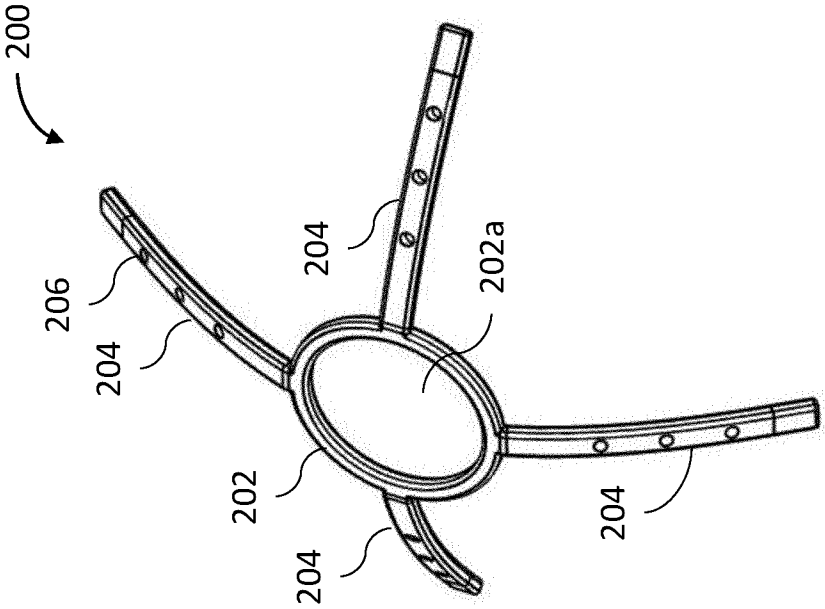


FIG. 2A

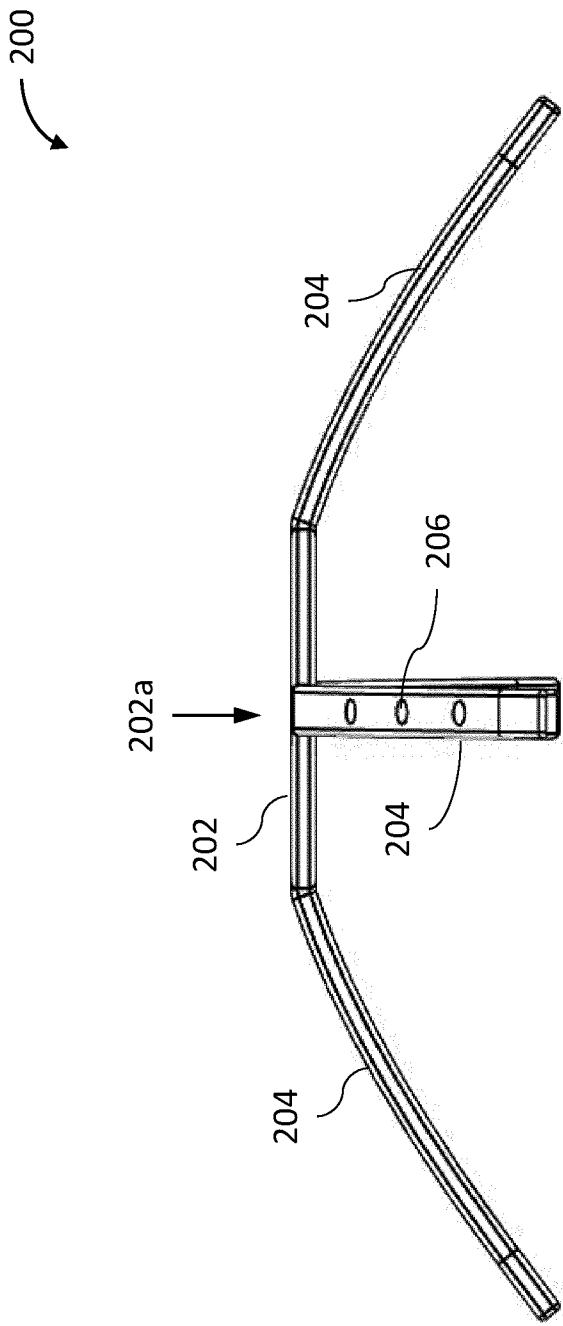


FIG. 2C

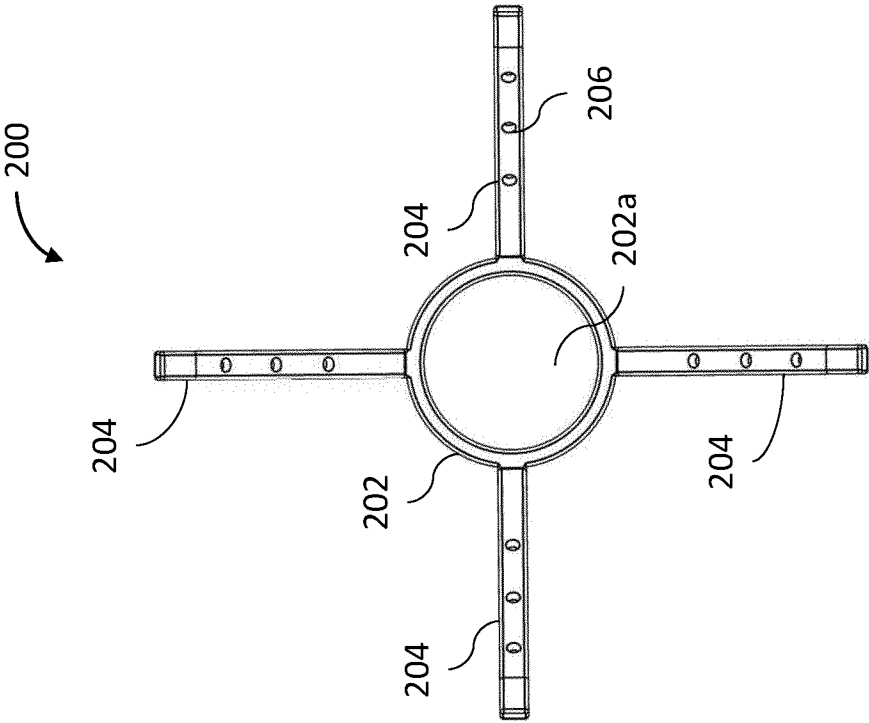


FIG. 2E

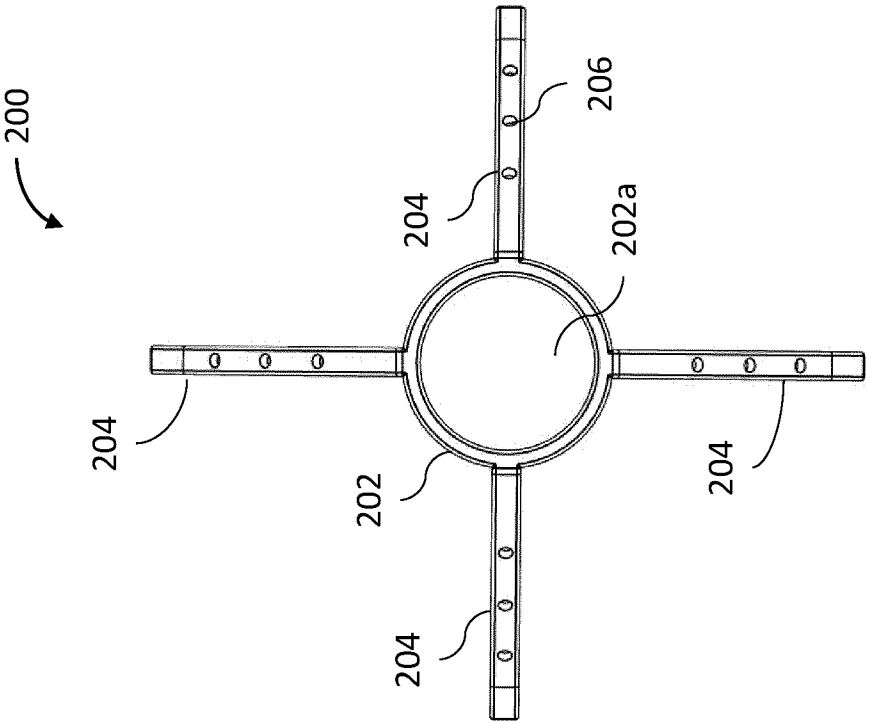


FIG. 2D

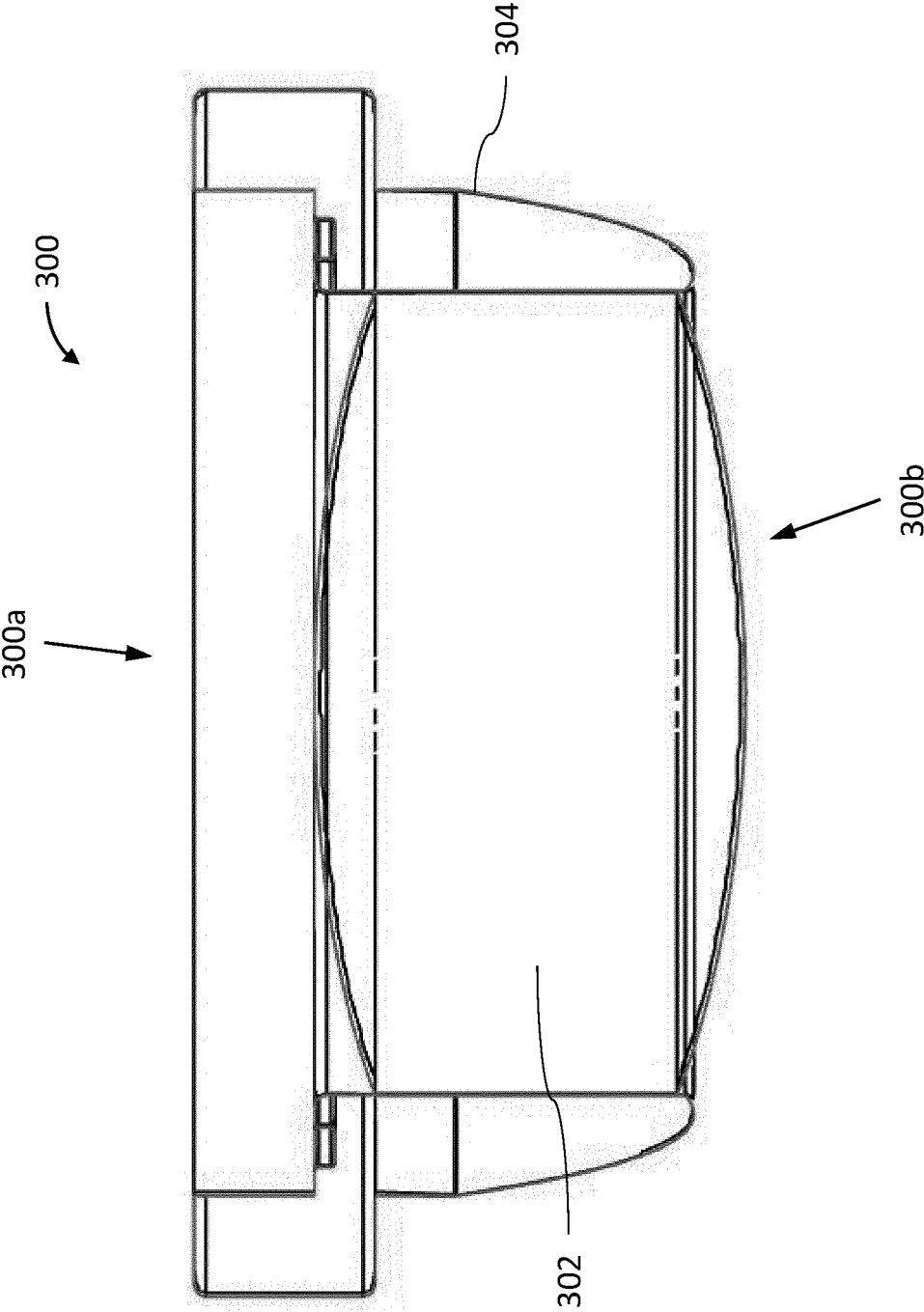


FIG. 3A

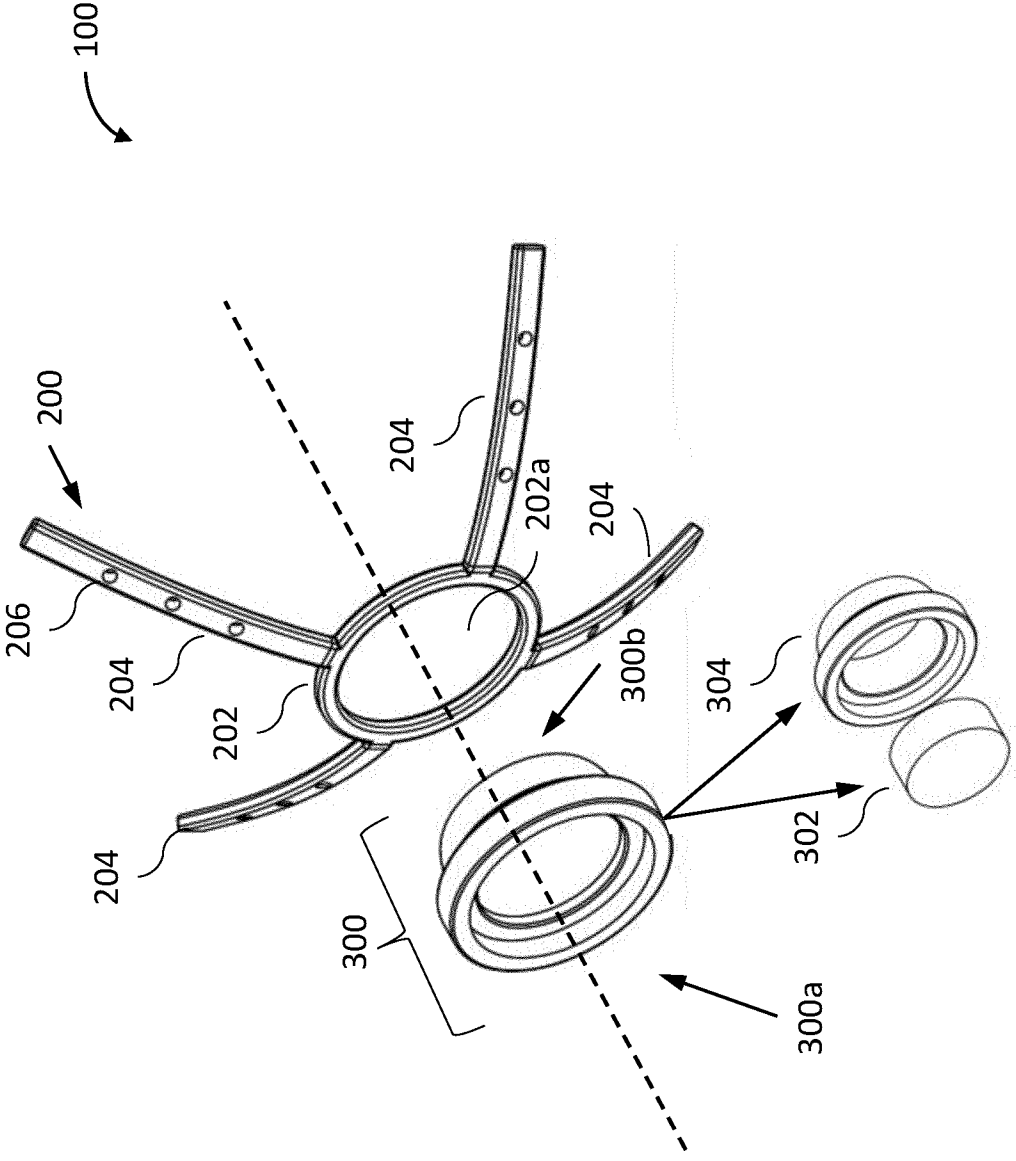


FIG. 3B

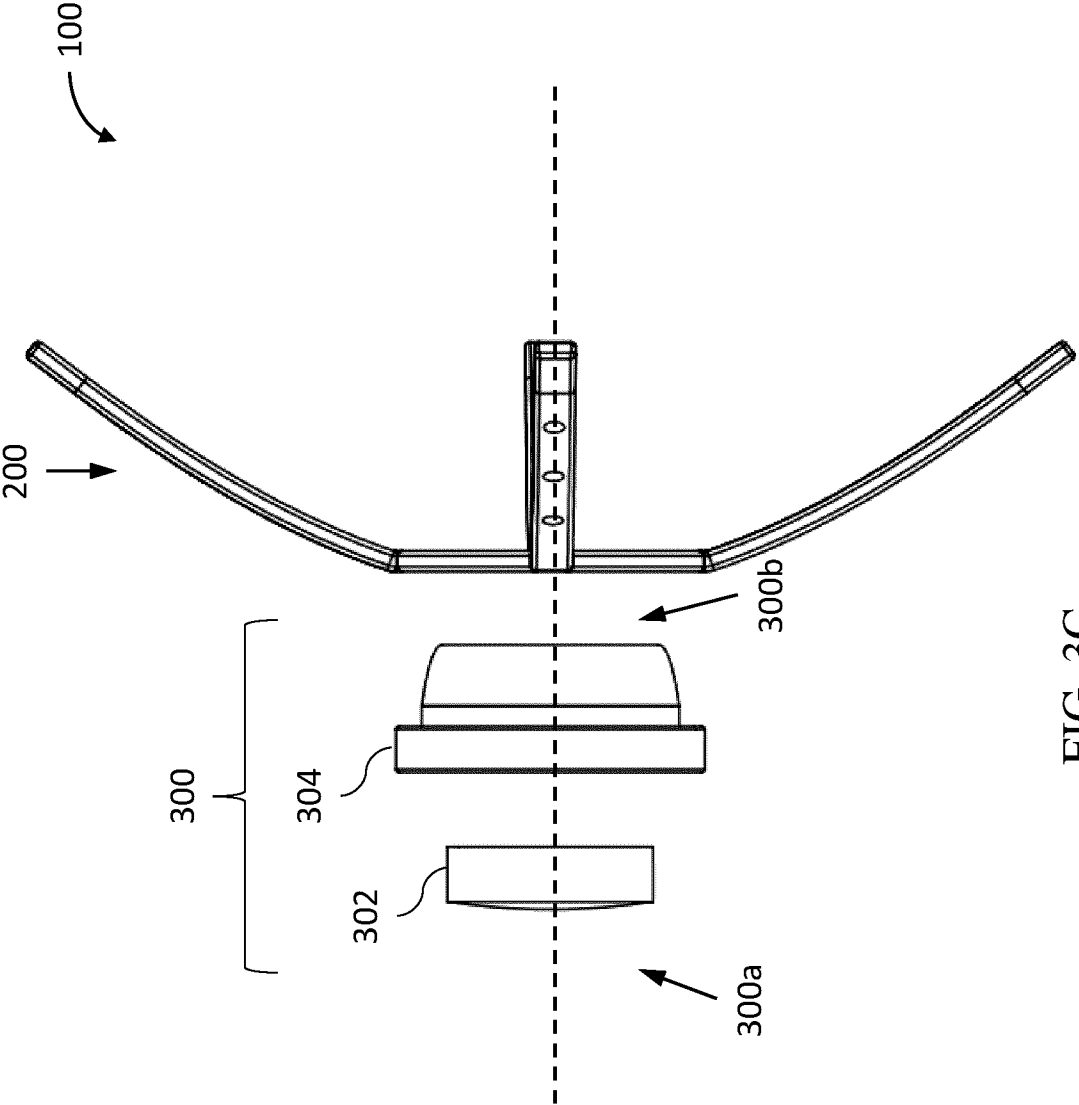


FIG. 3C

302

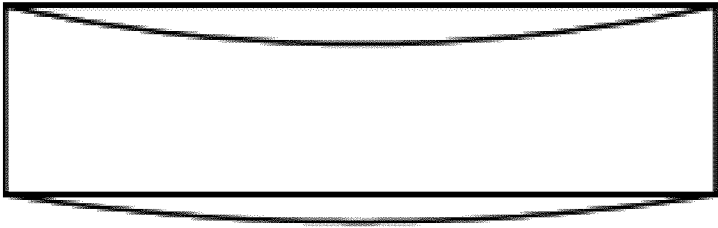


FIG. 4B

302

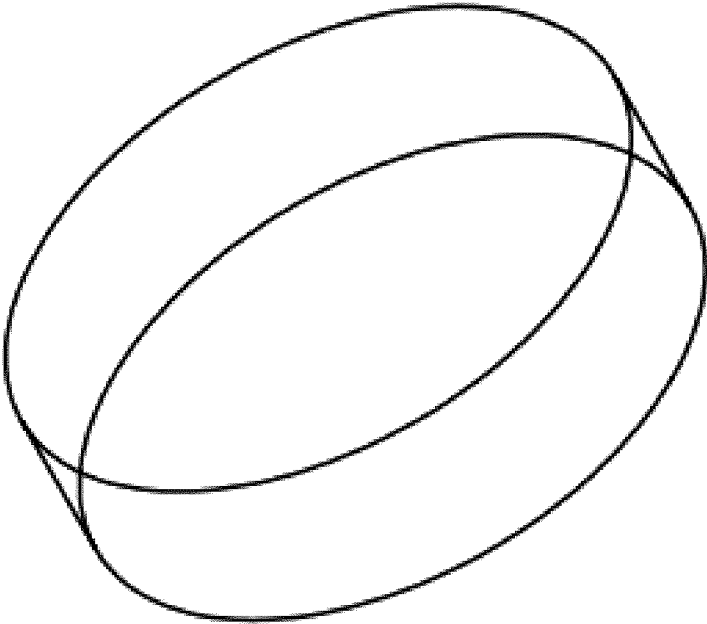


FIG. 4A

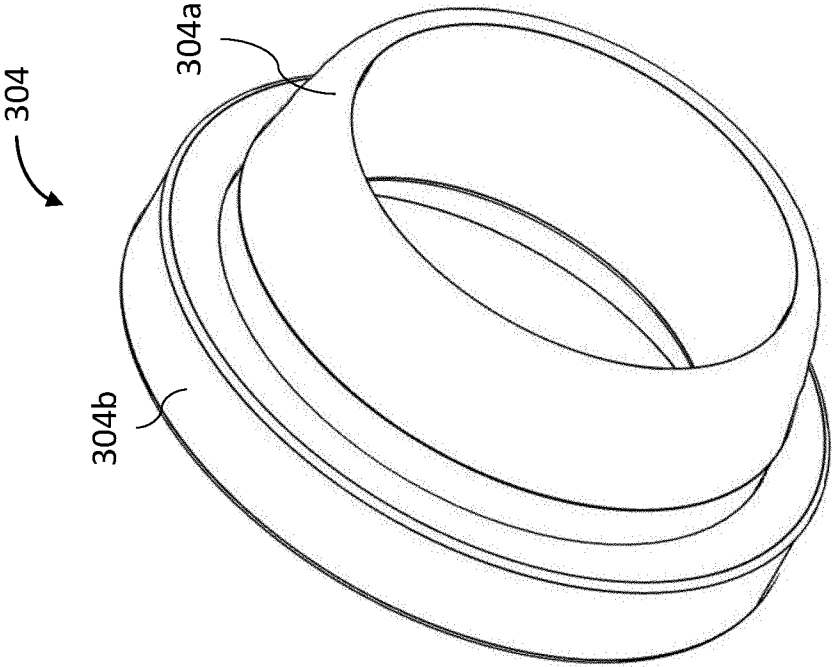


FIG. 5B

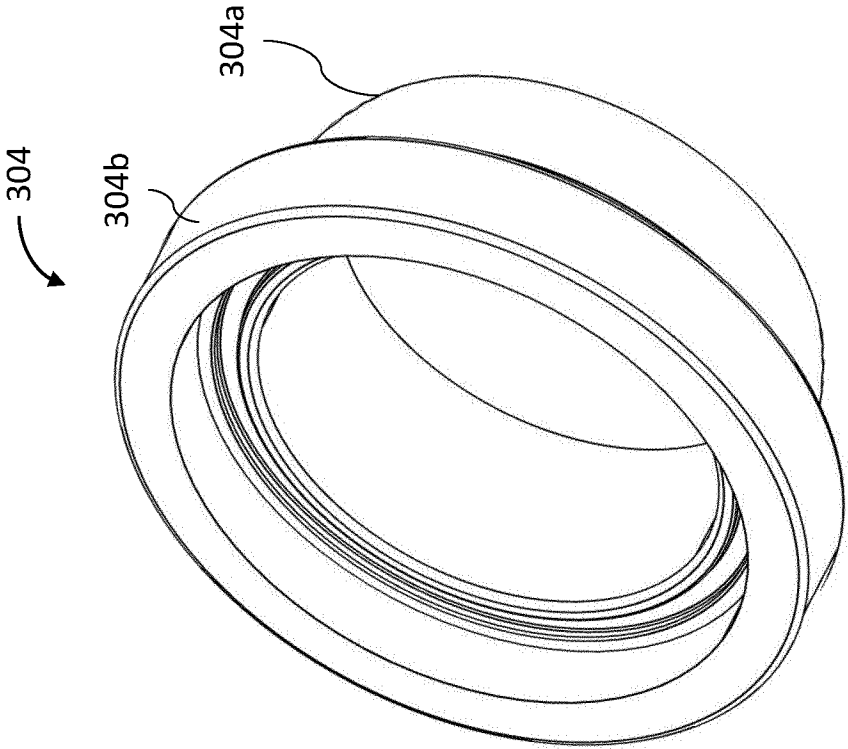


FIG. 5A

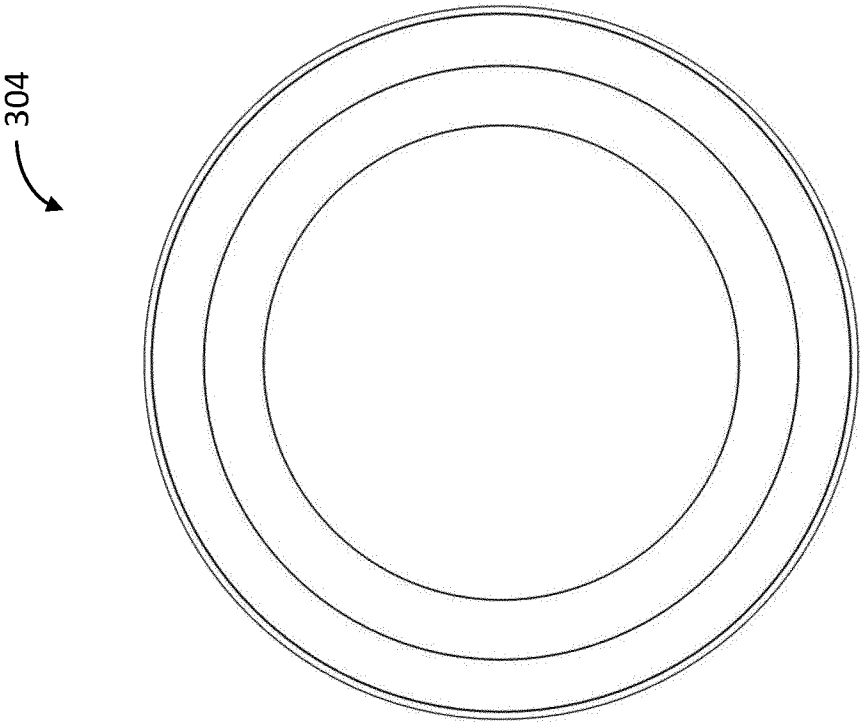


FIG. 5D

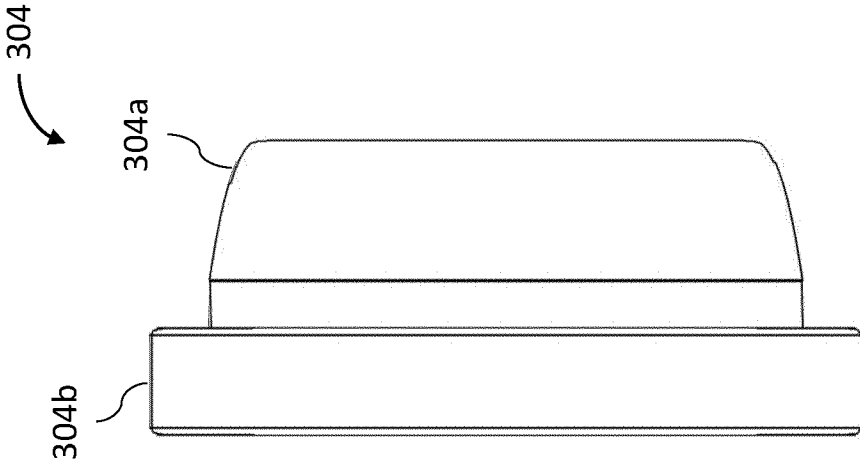
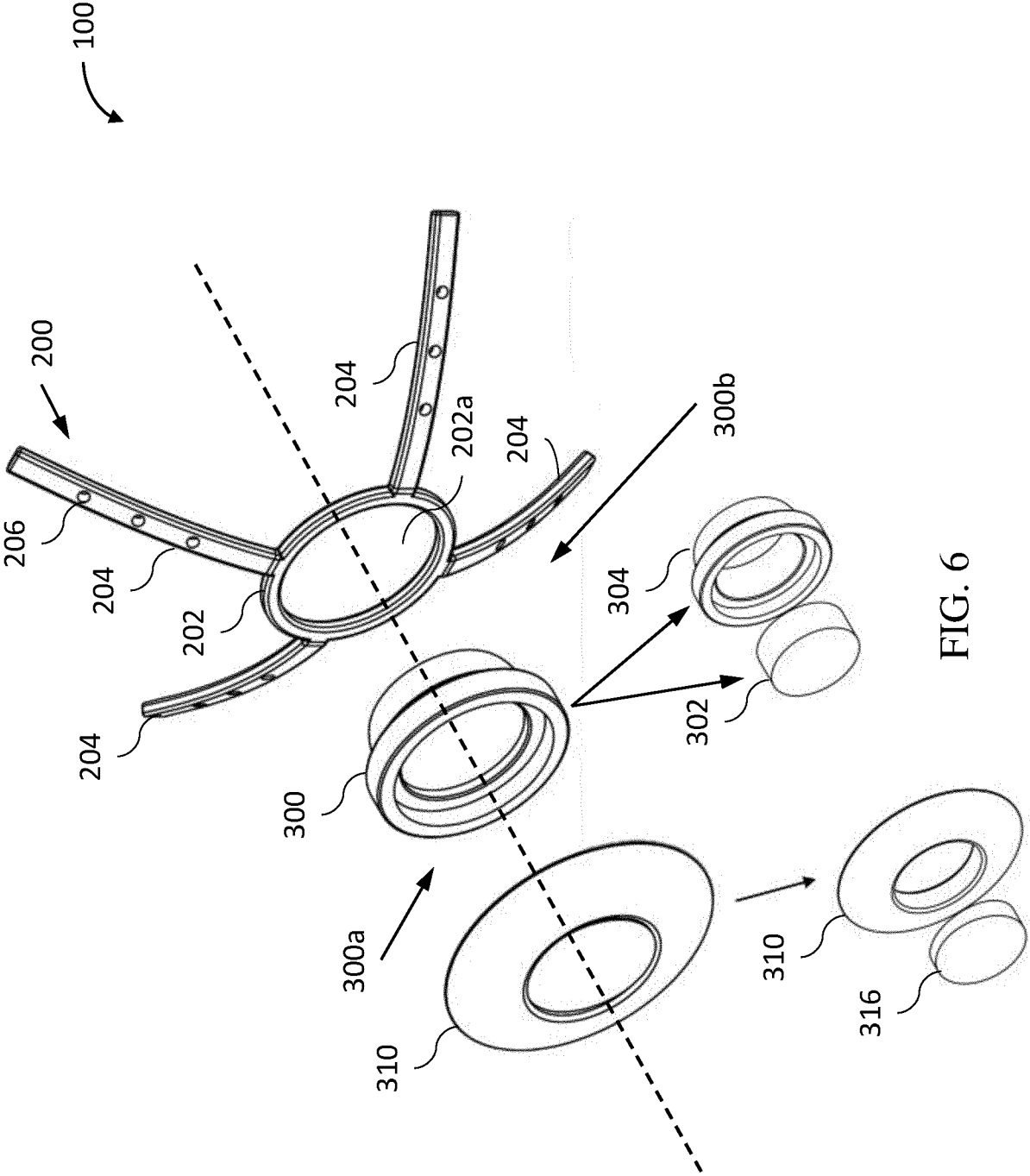


FIG. 5C



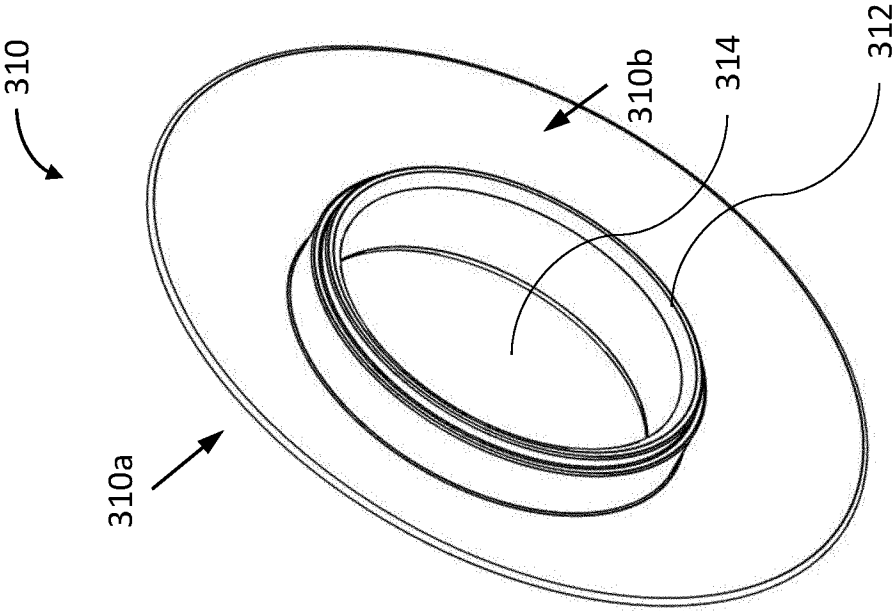


FIG. 7B

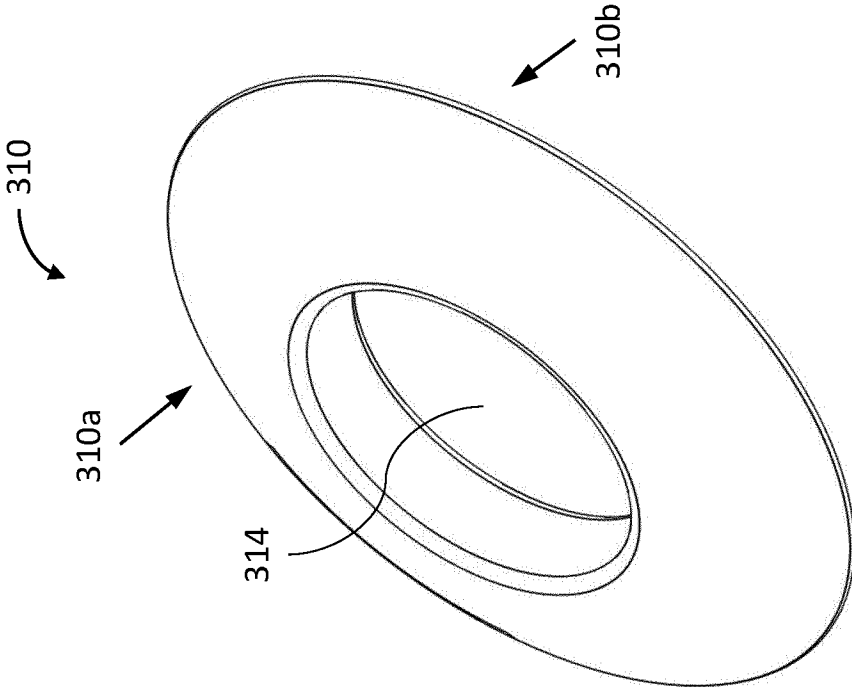


FIG. 7A

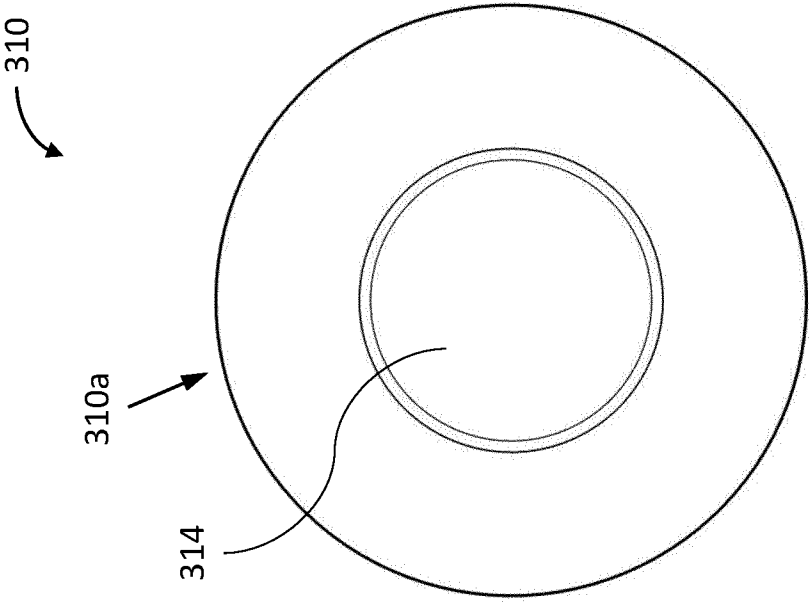


FIG. 7D

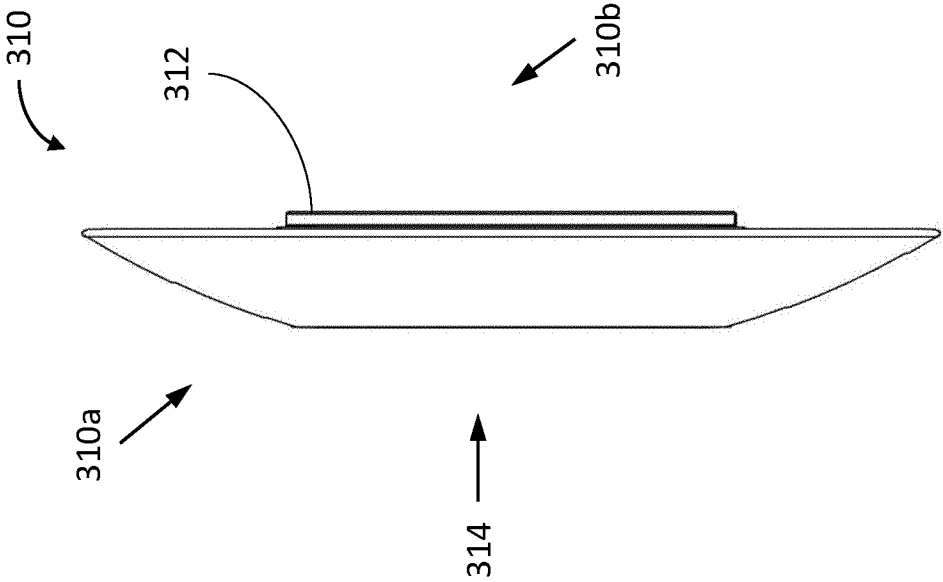


FIG. 7C

316

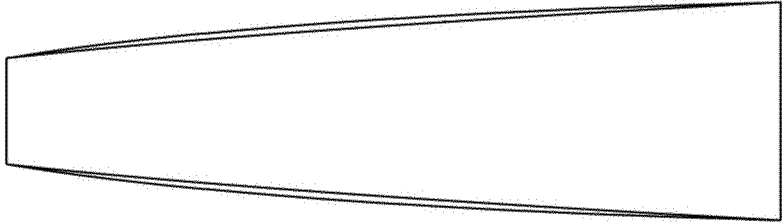


FIG. 8B

316

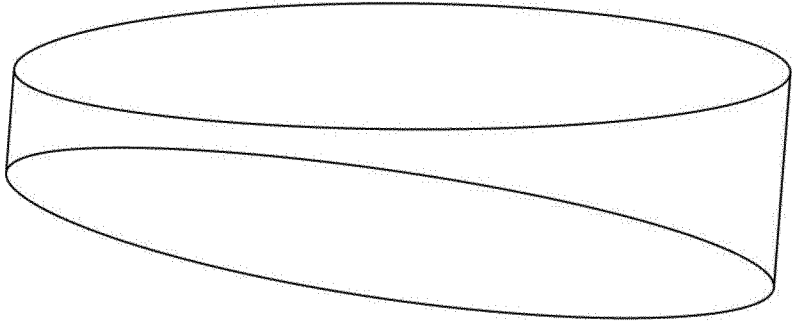


FIG. 8A

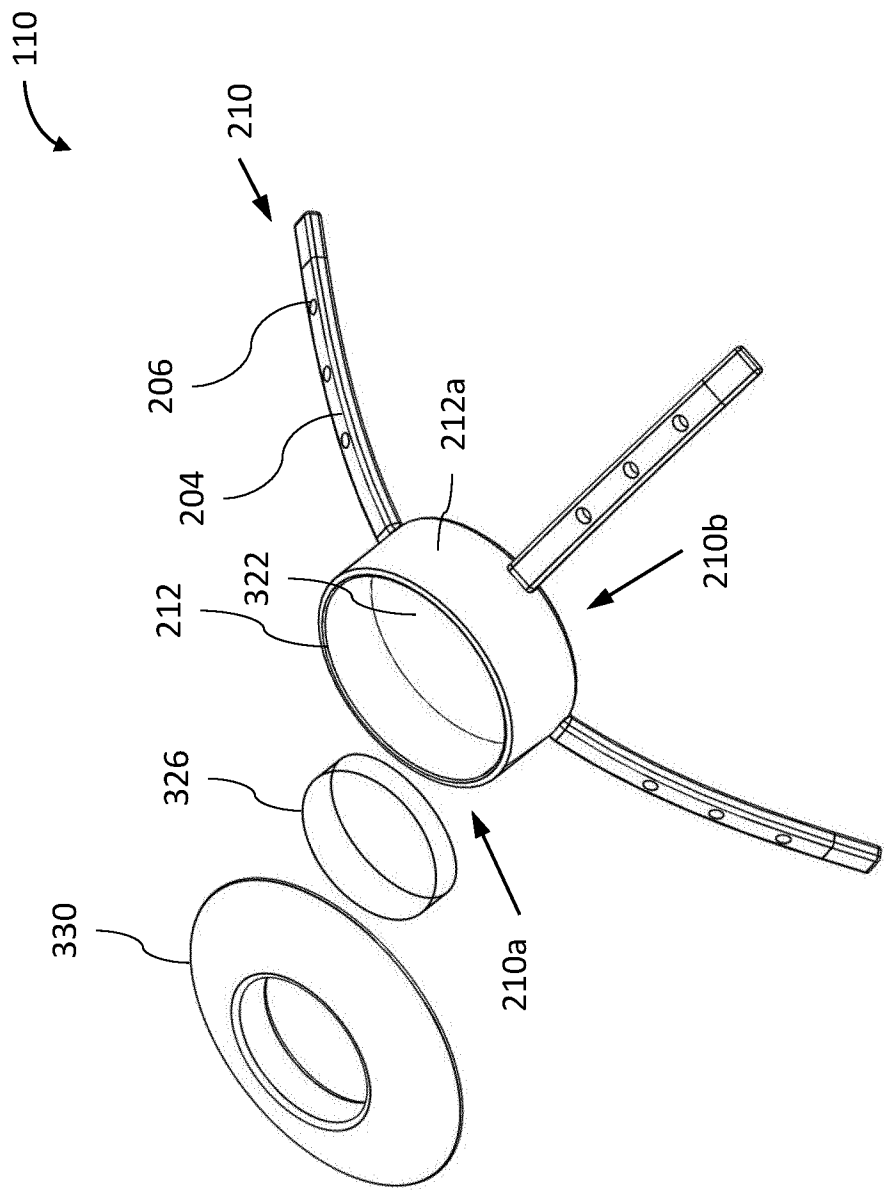
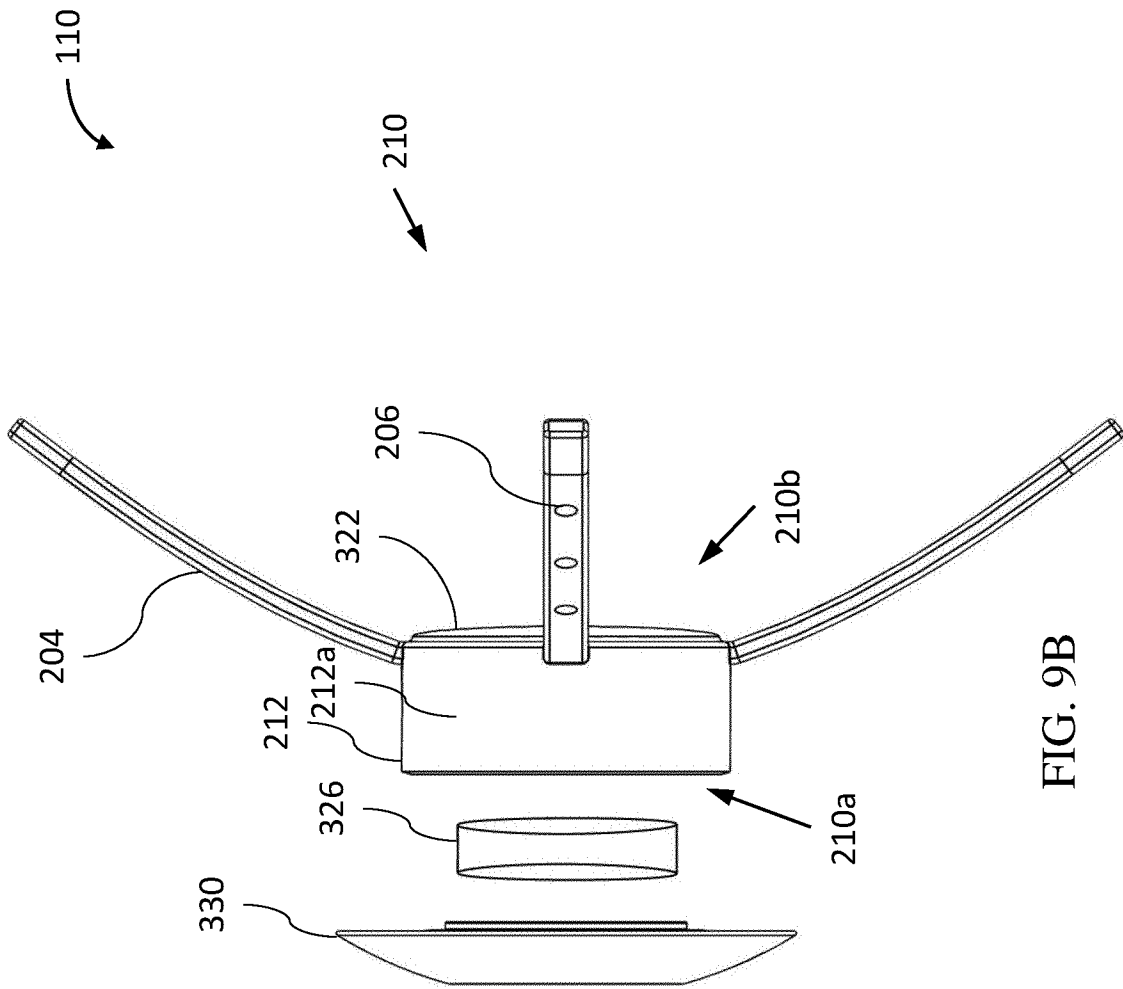


FIG. 9A



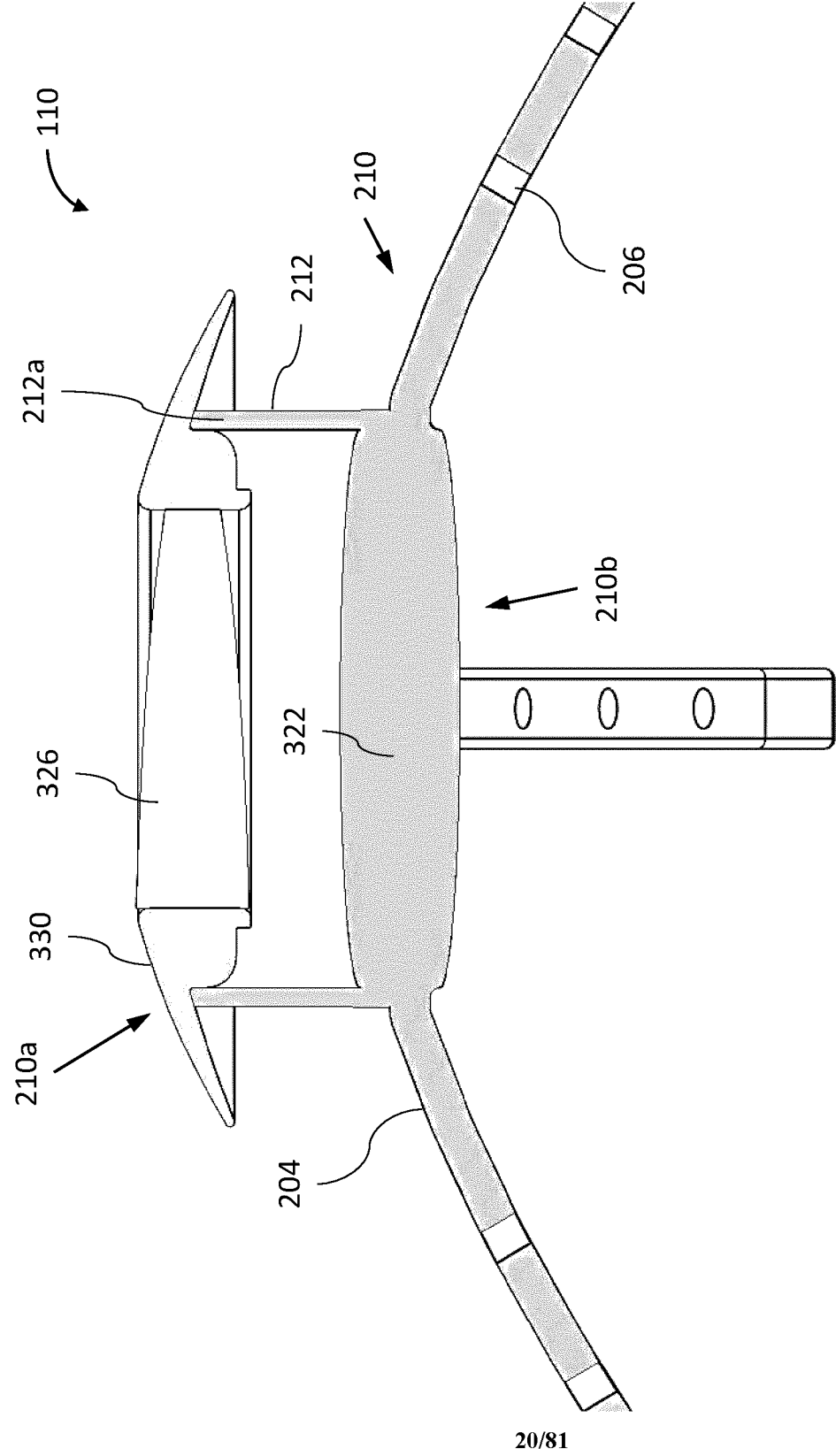


FIG. 9C

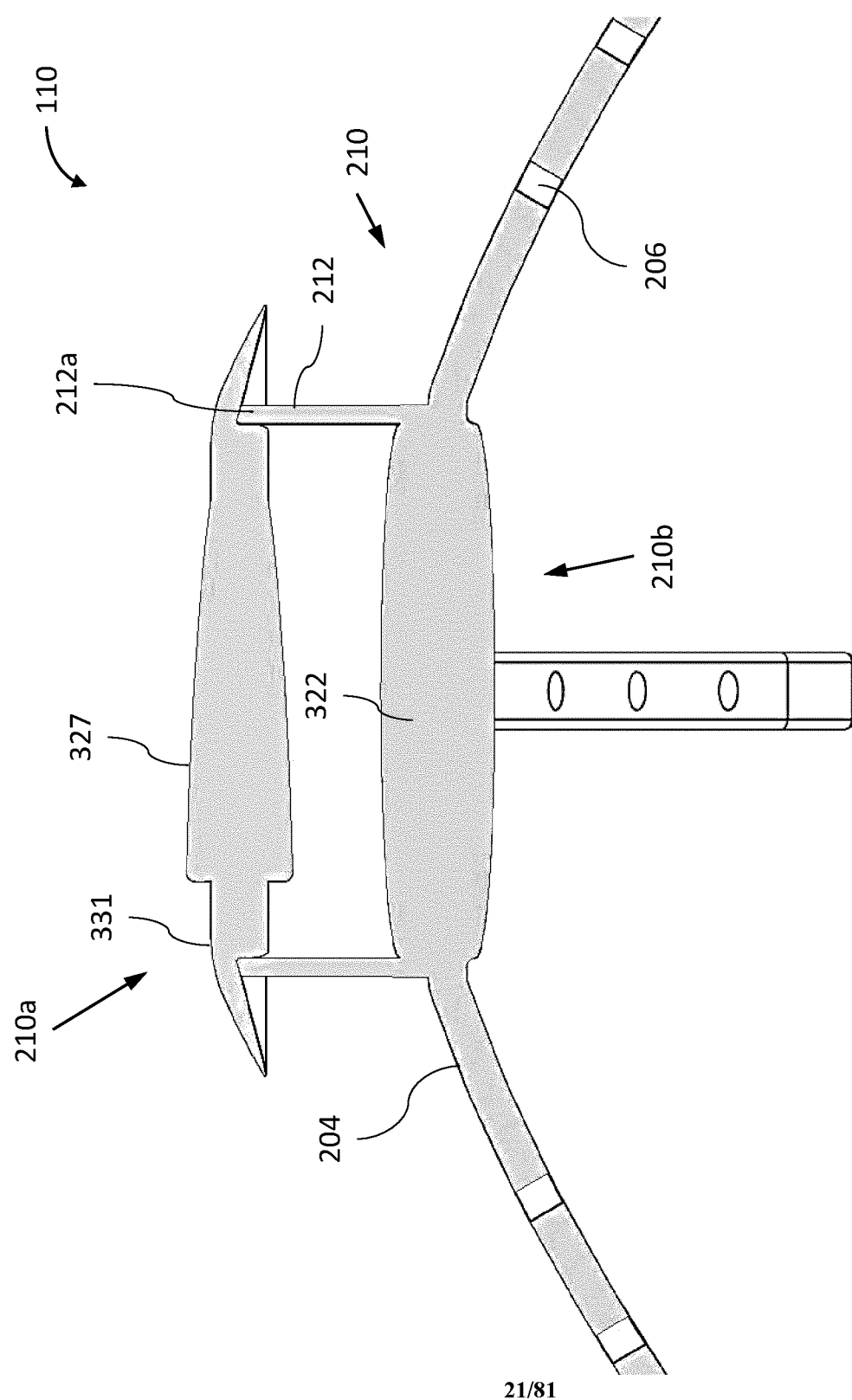


FIG. 9D

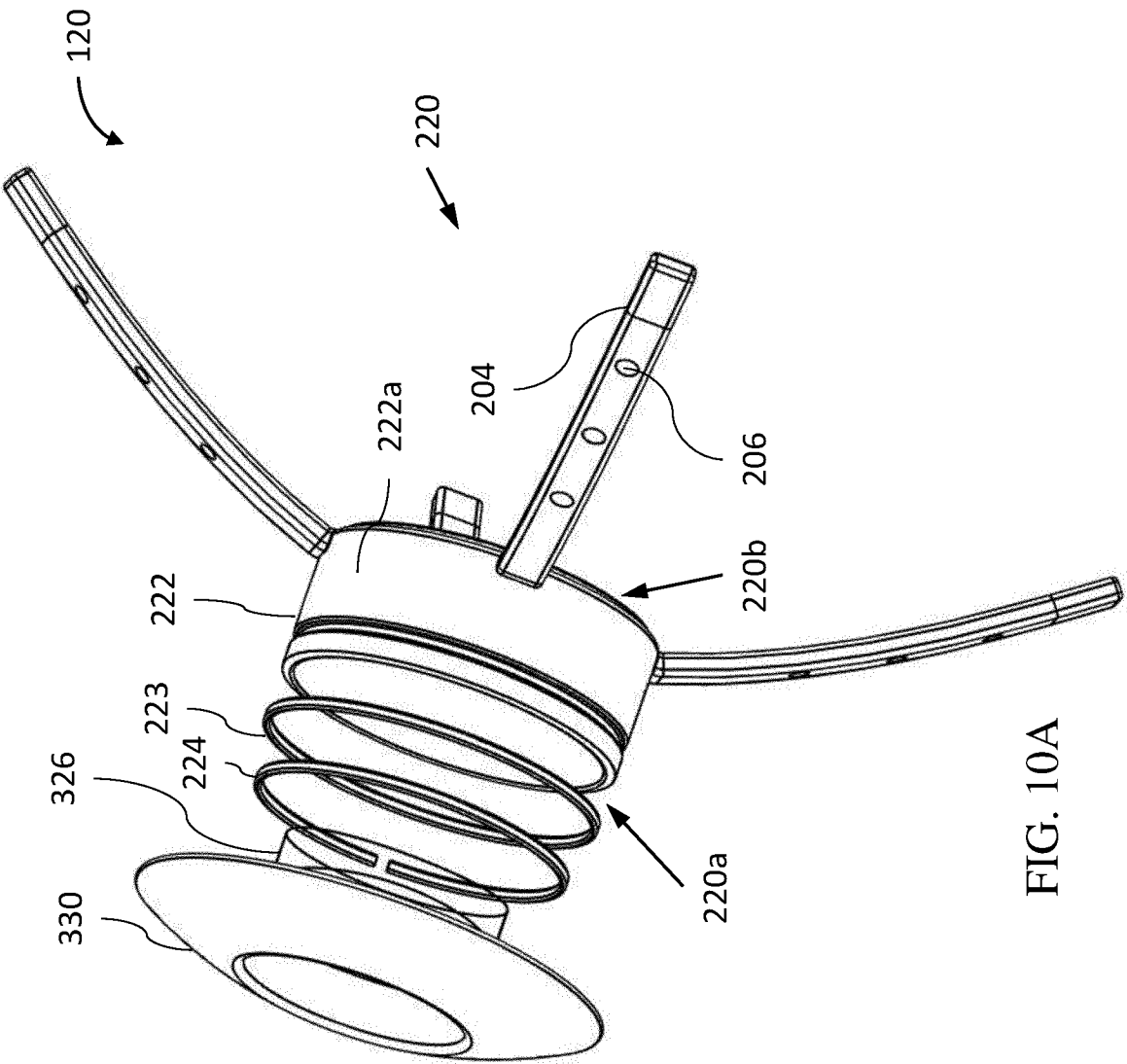


FIG. 10A

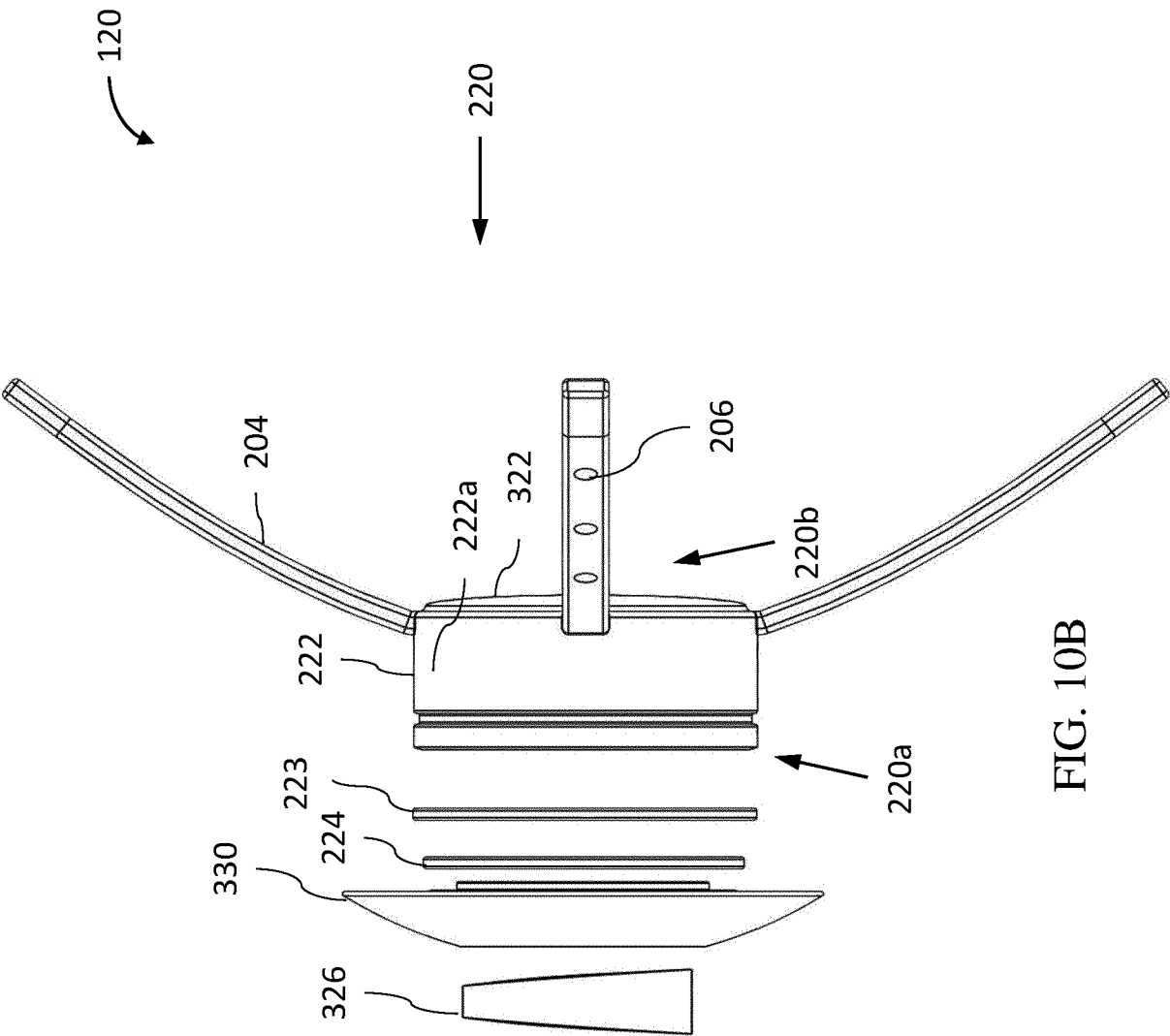


FIG. 10B

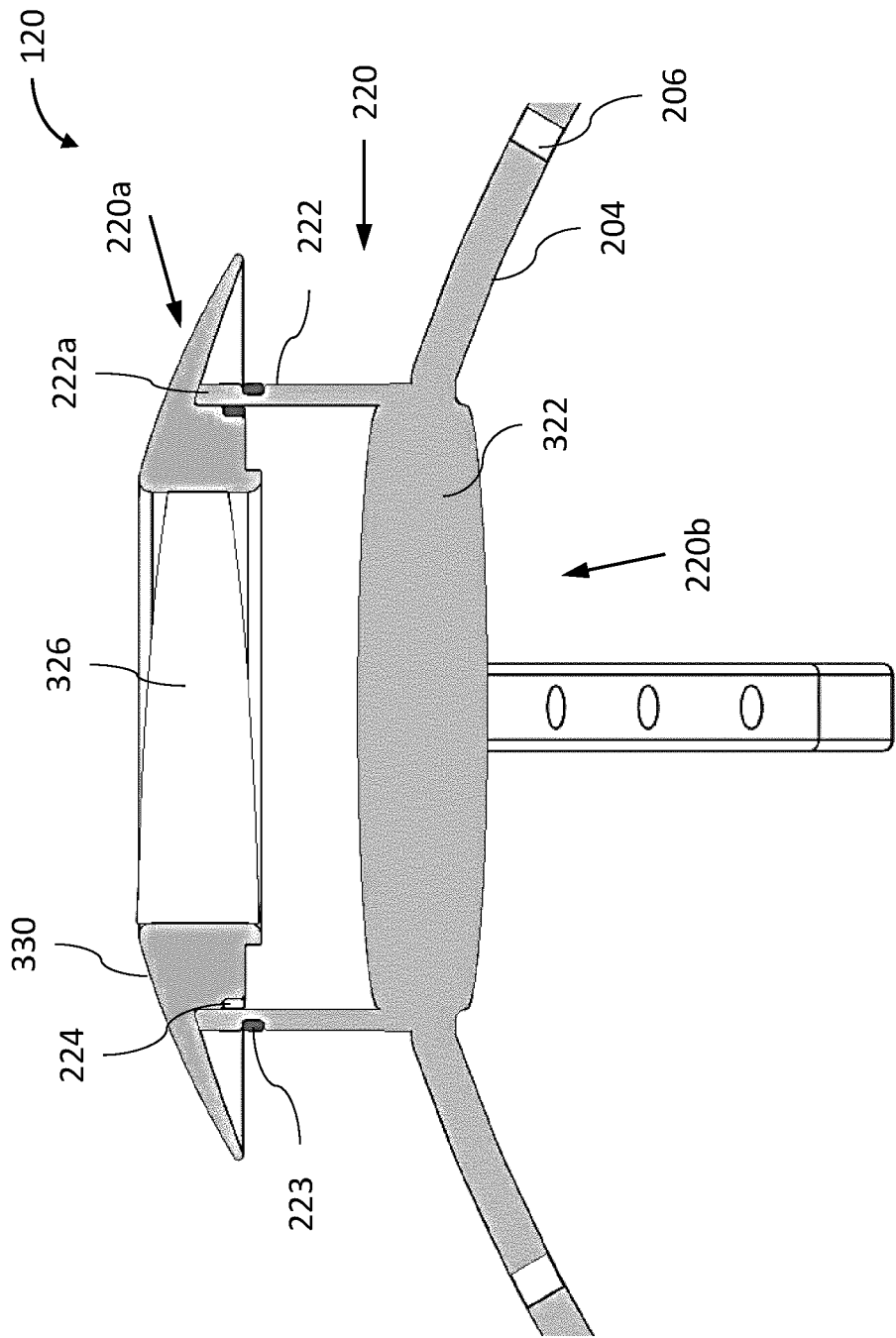
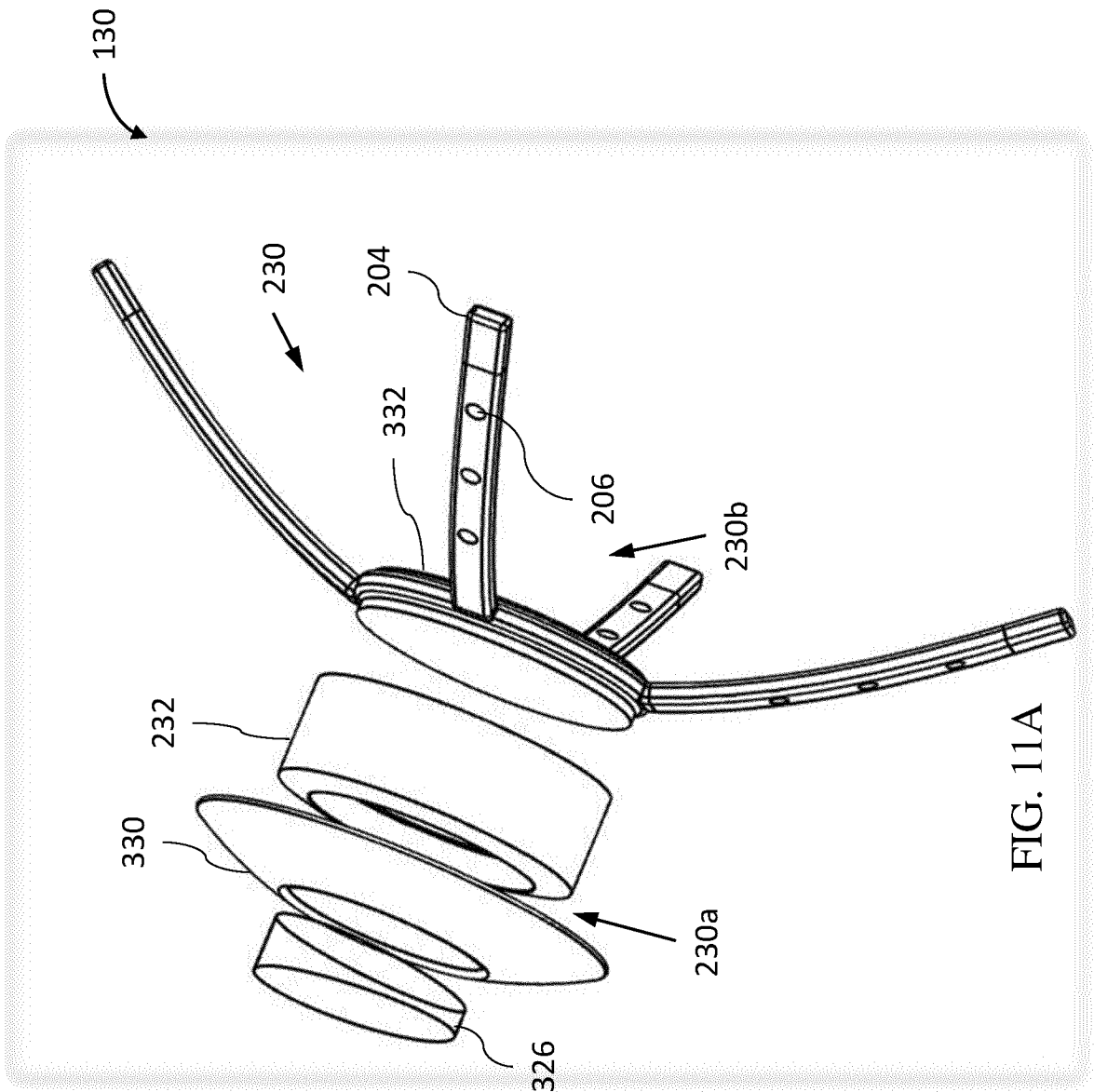
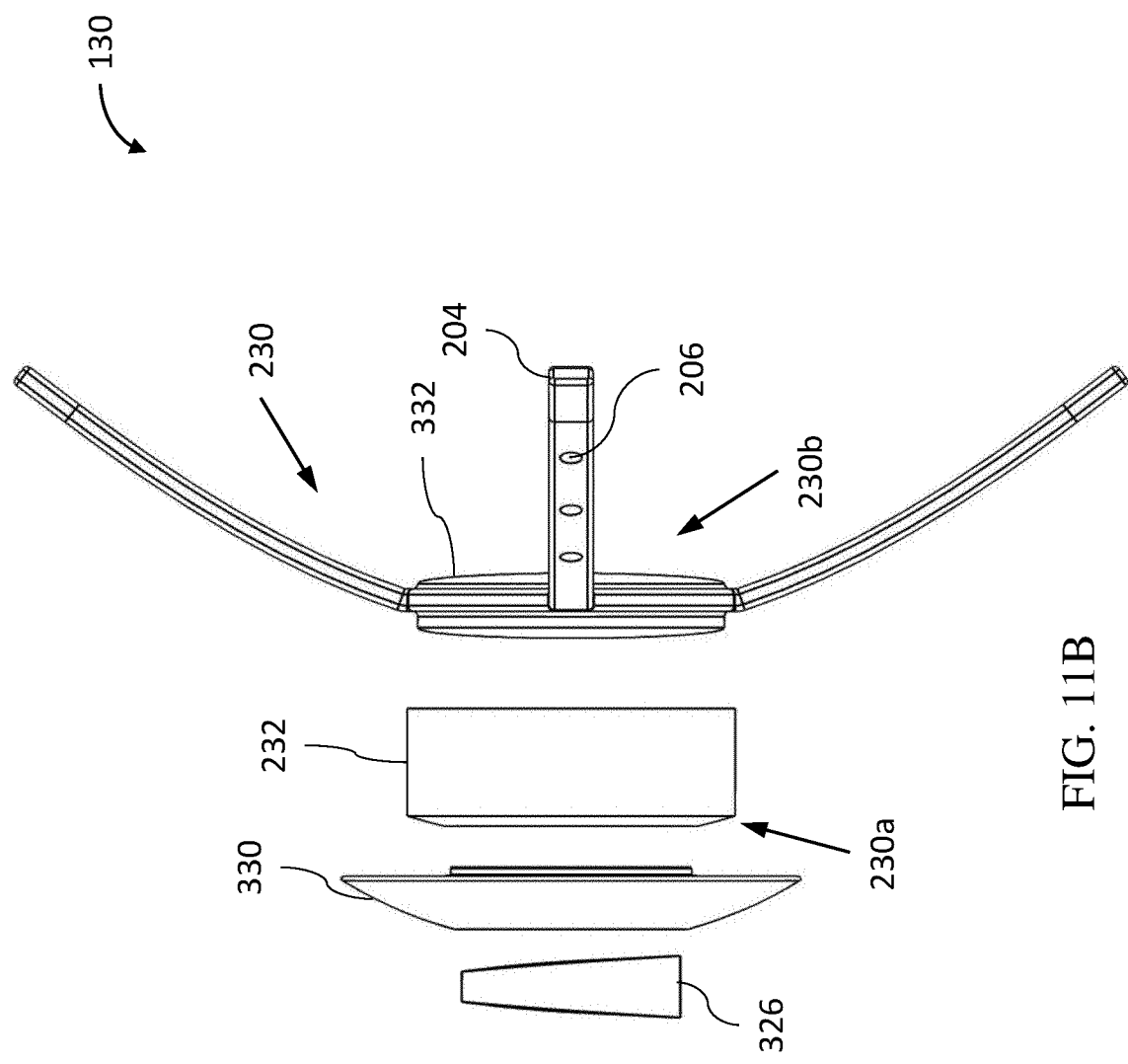


FIG. 10C





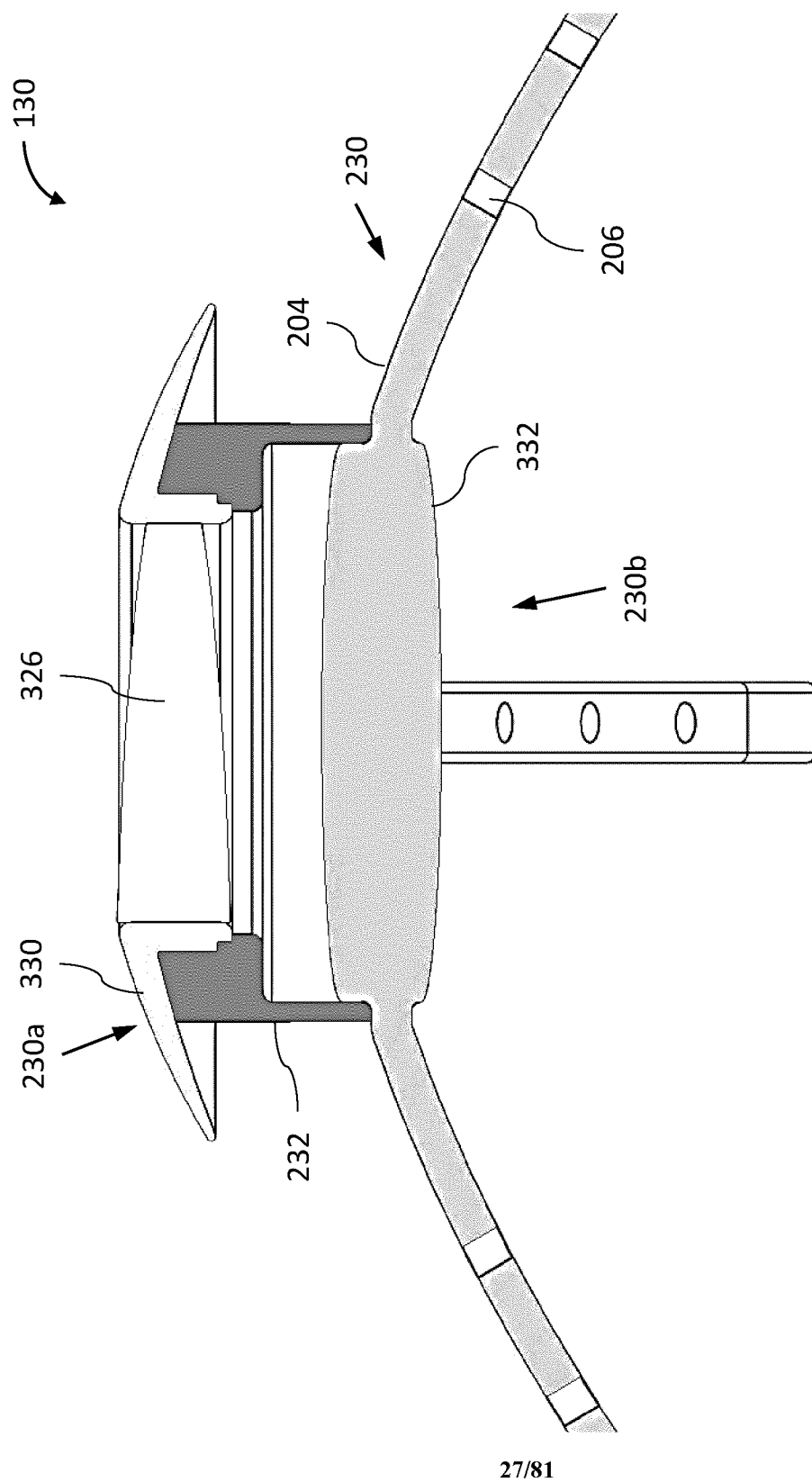


FIG. 11C

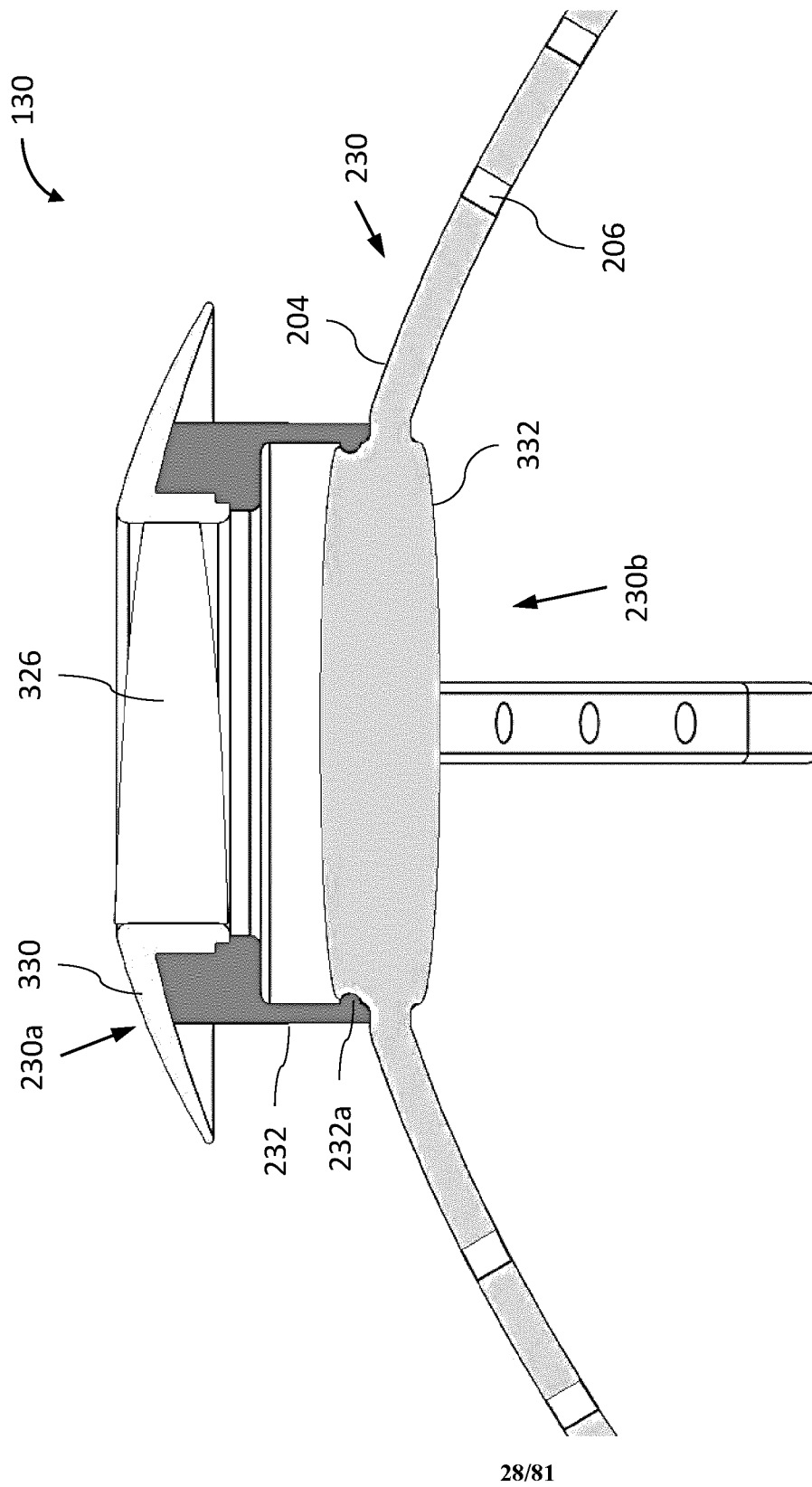


FIG. 11D

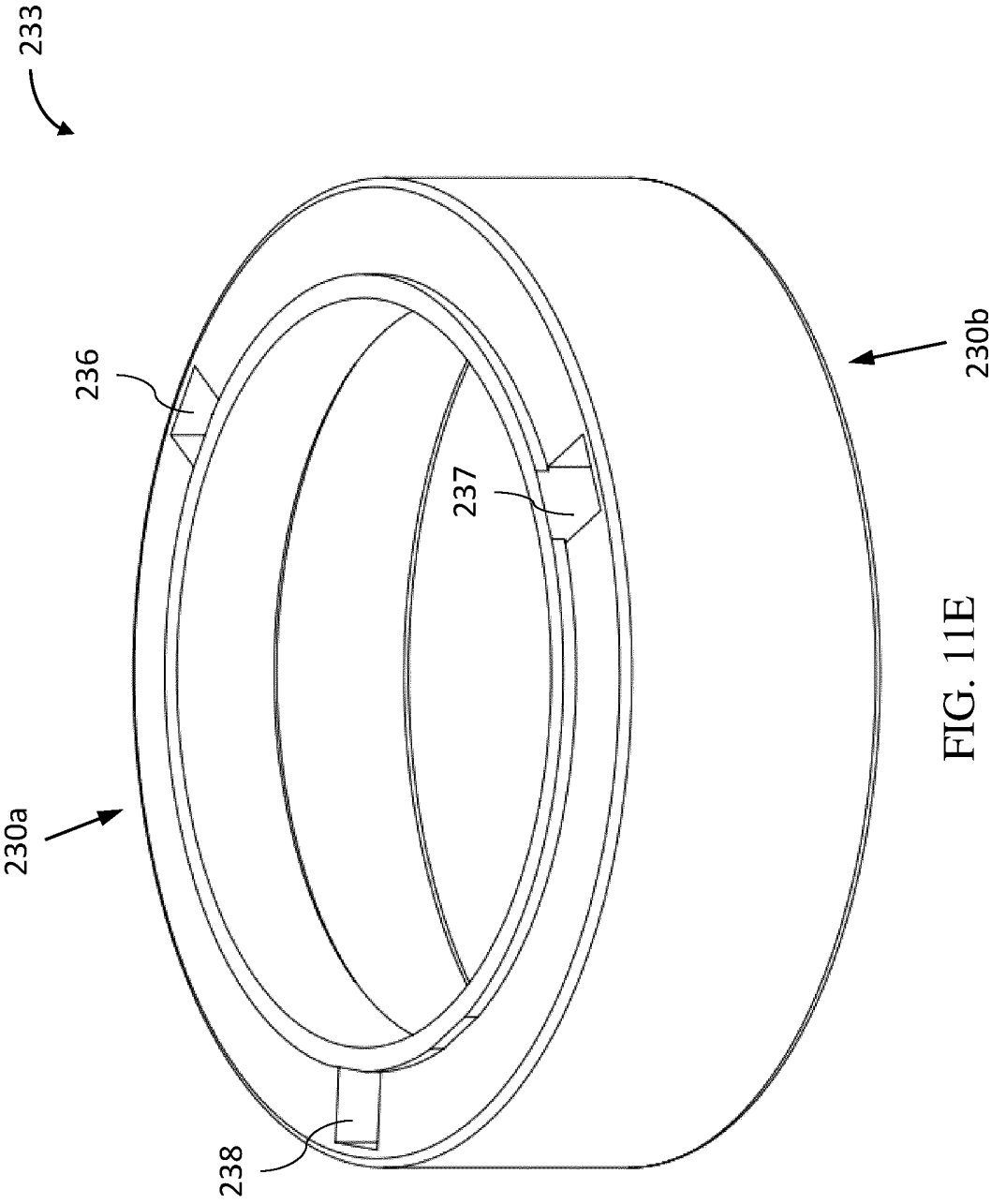


FIG. 11E

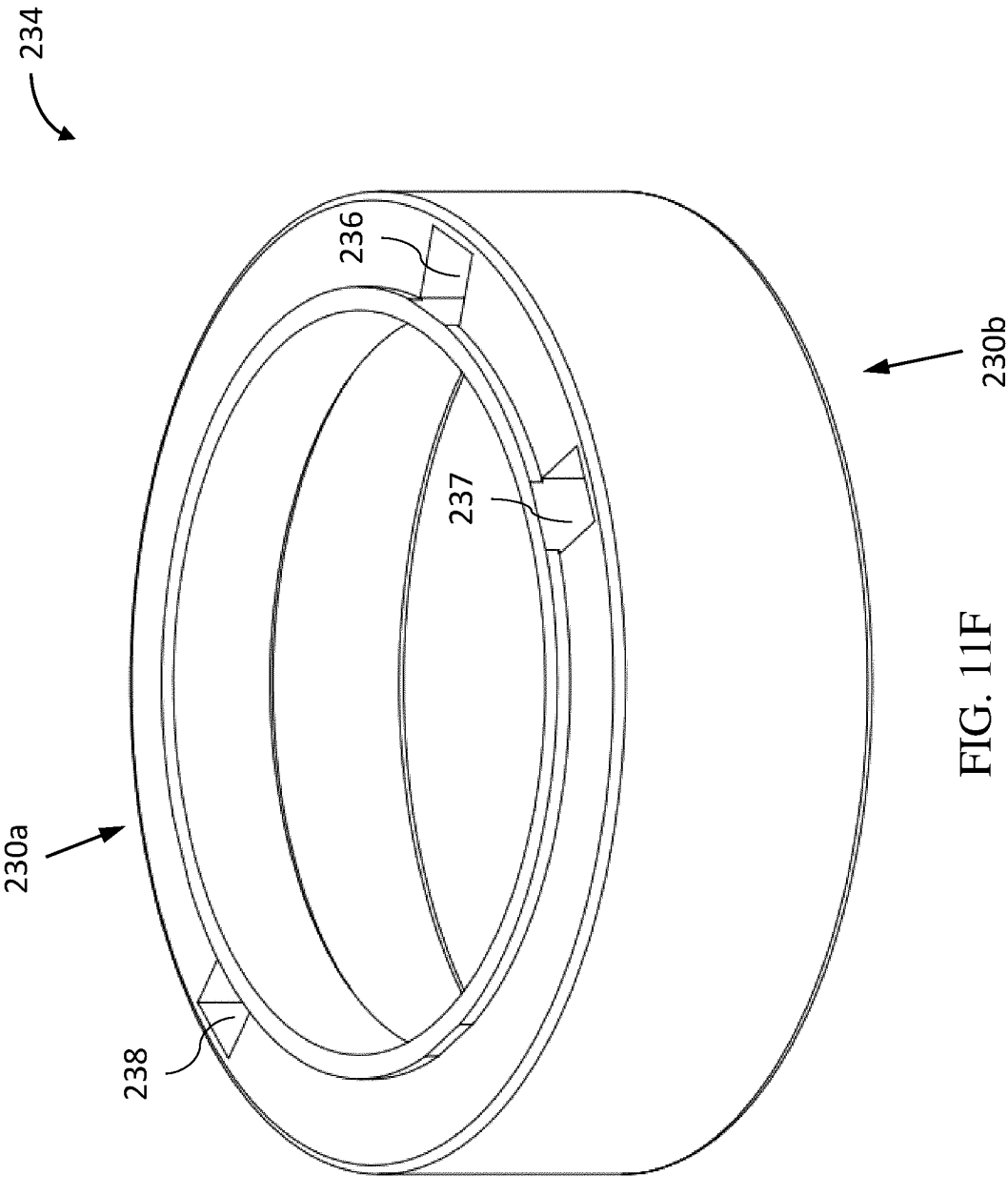


FIG. 11F

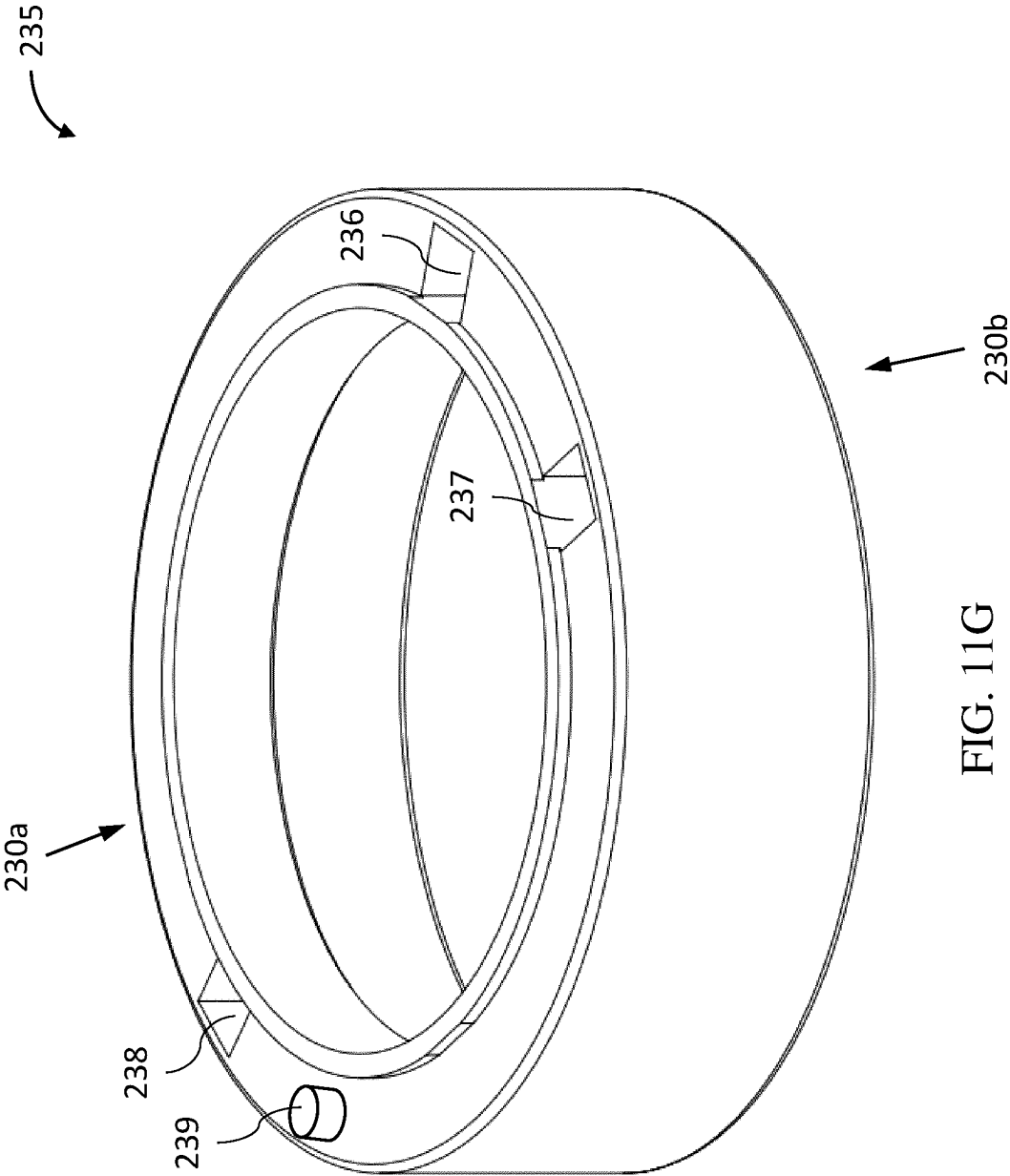


FIG. 11G

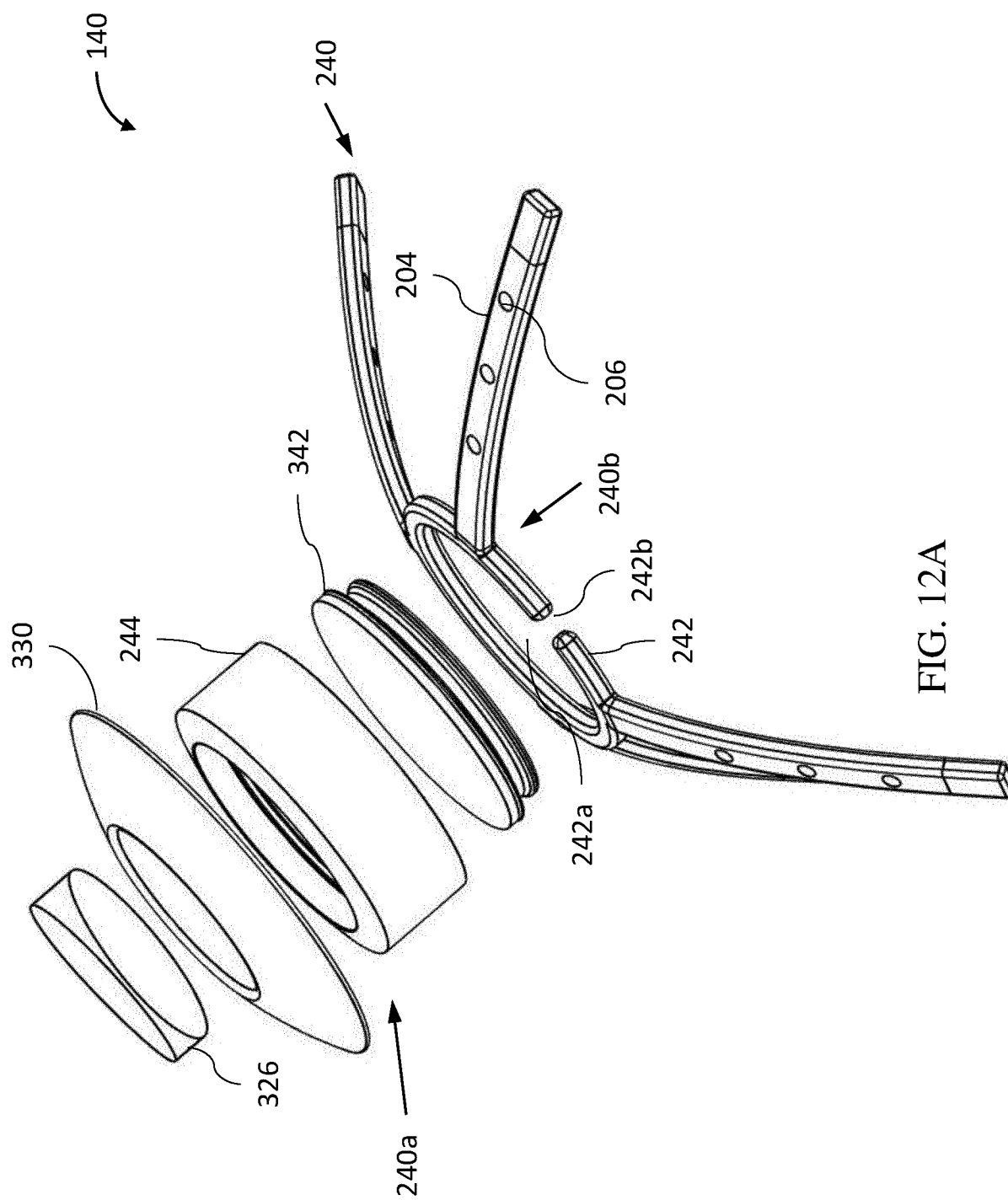


FIG. 12A

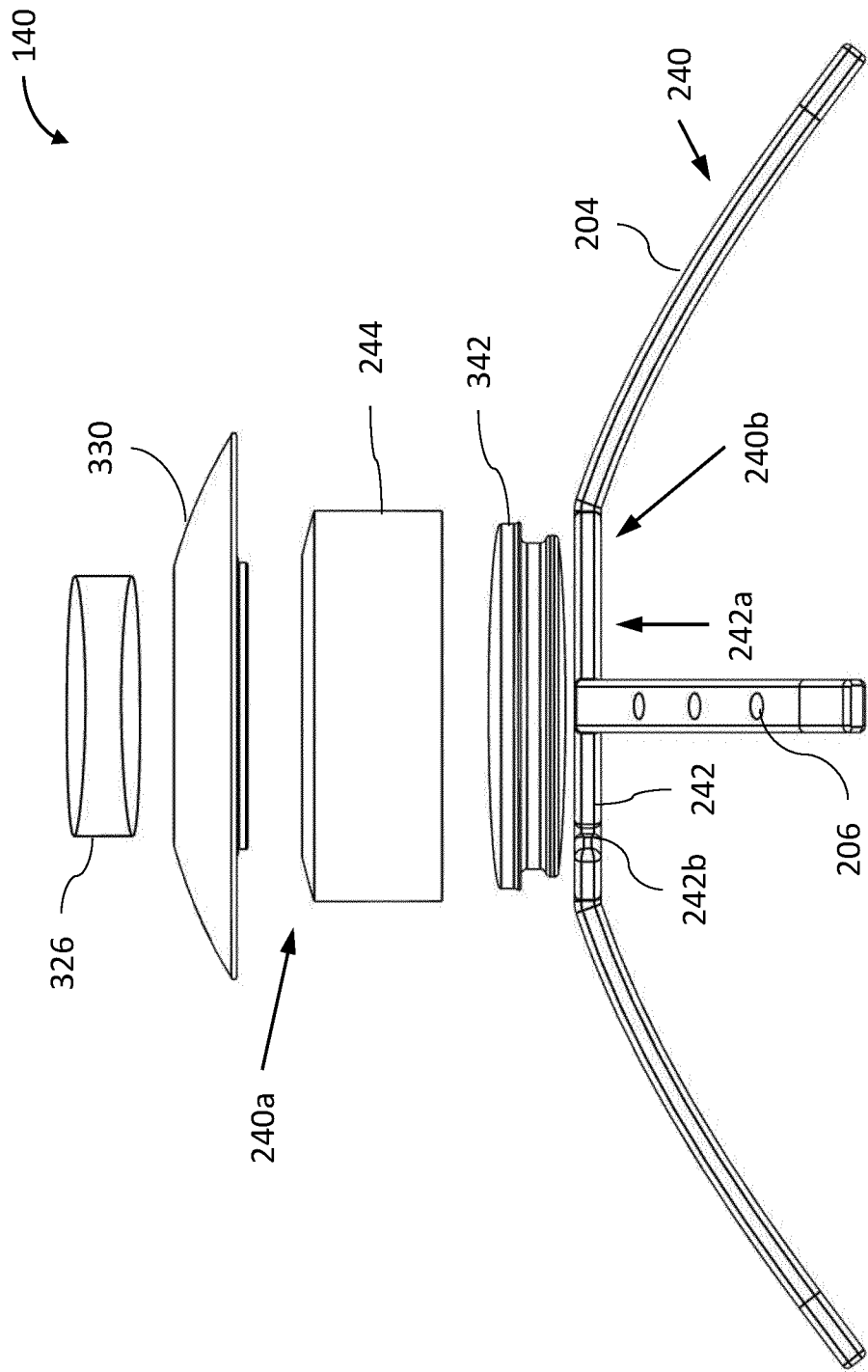


FIG. 12B

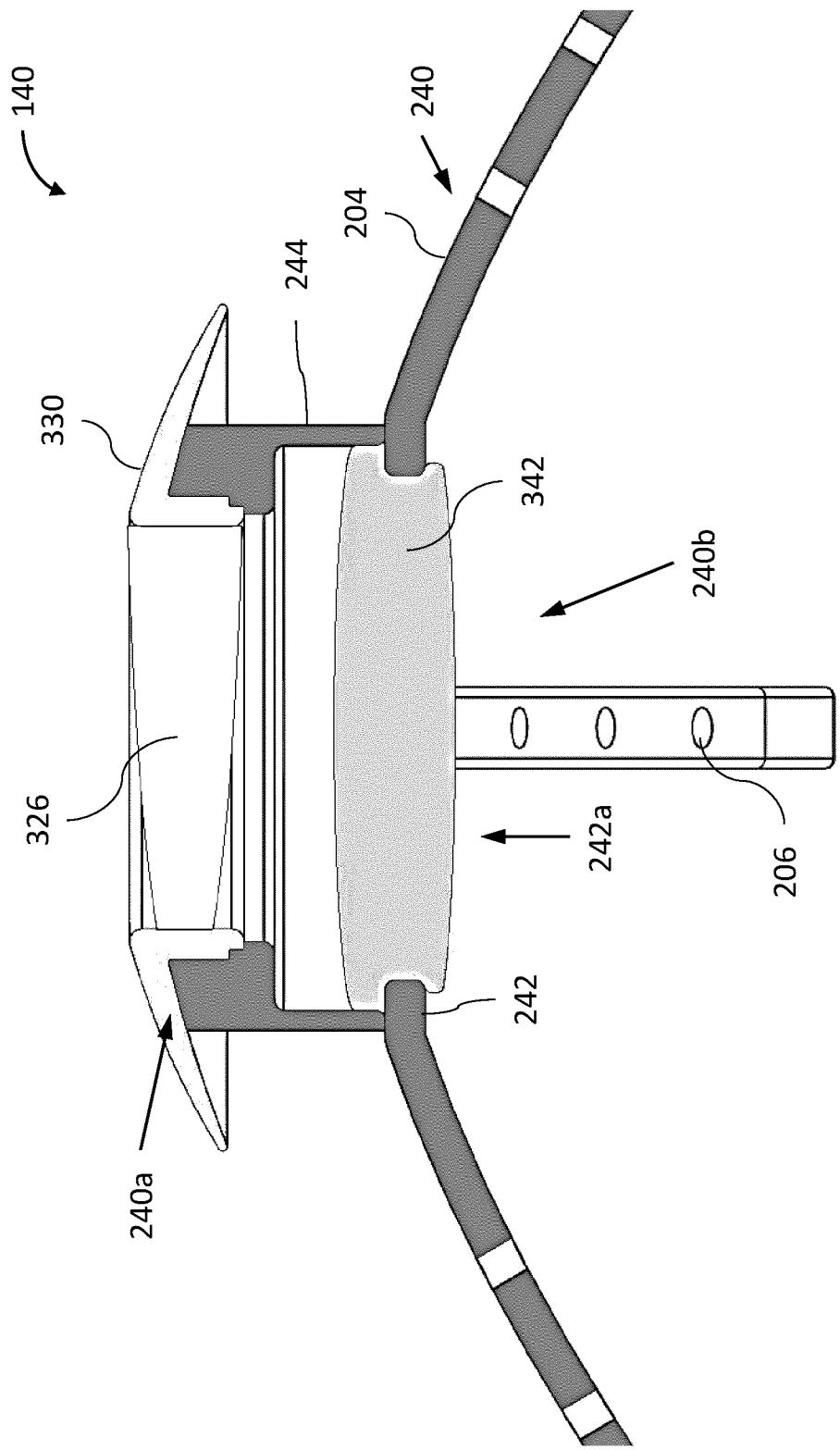


FIG. 12C

1300

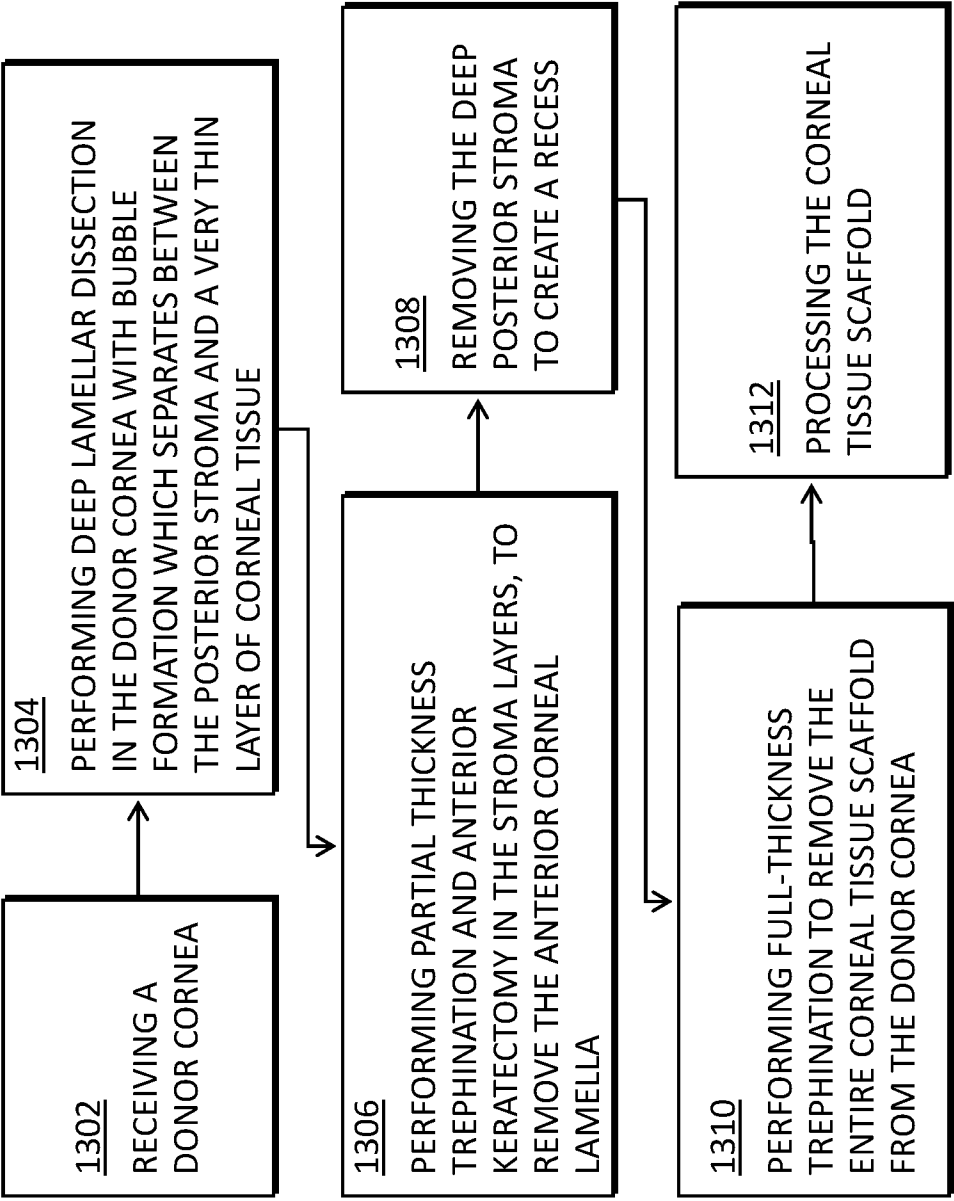


FIG. 13A

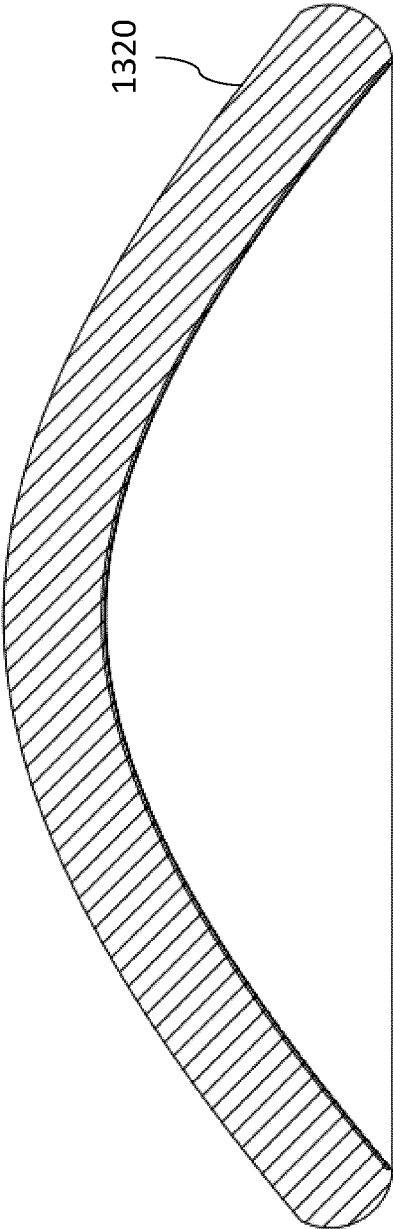


FIG. 13B

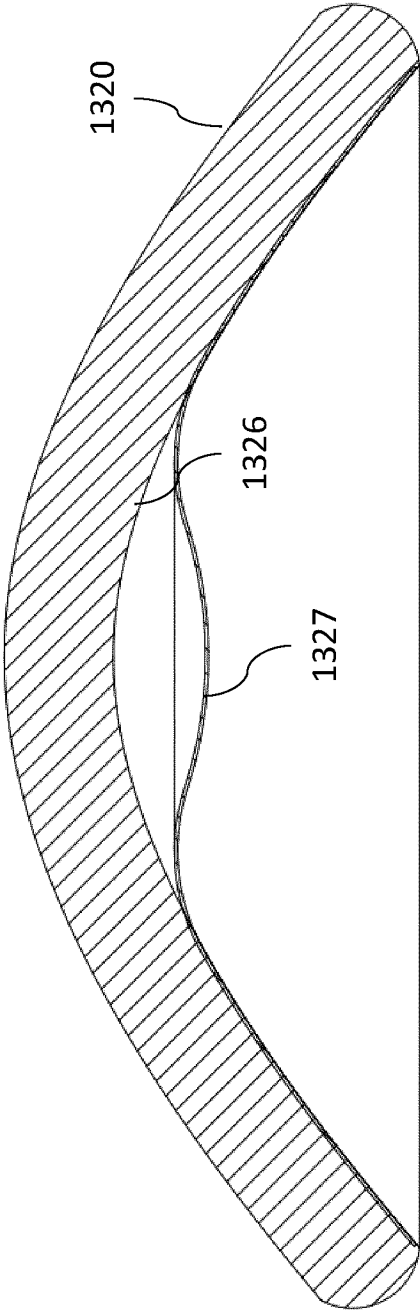


FIG. 13C

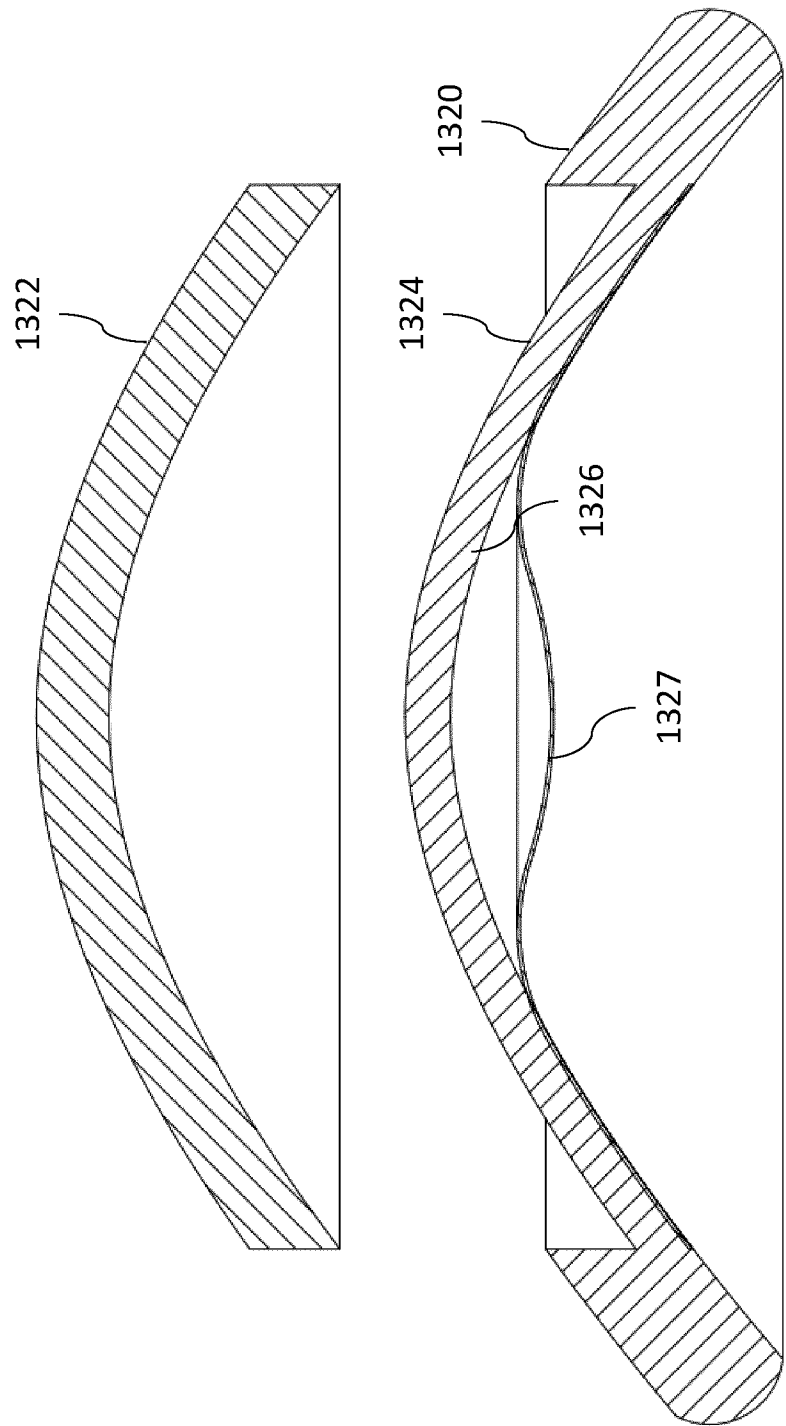


FIG. 13D

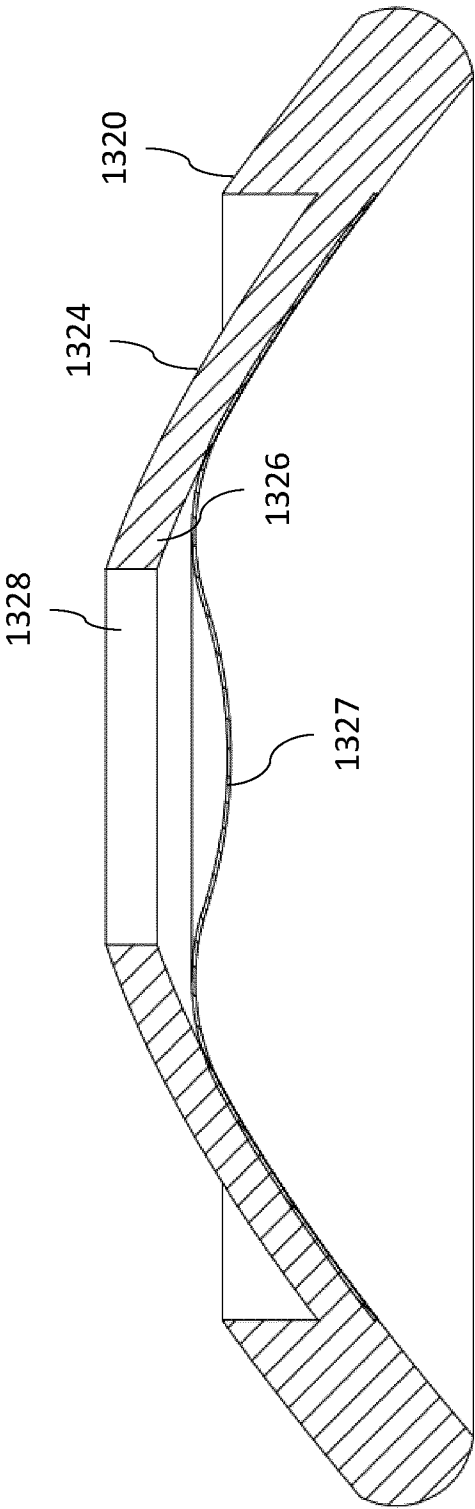


FIG. 13E

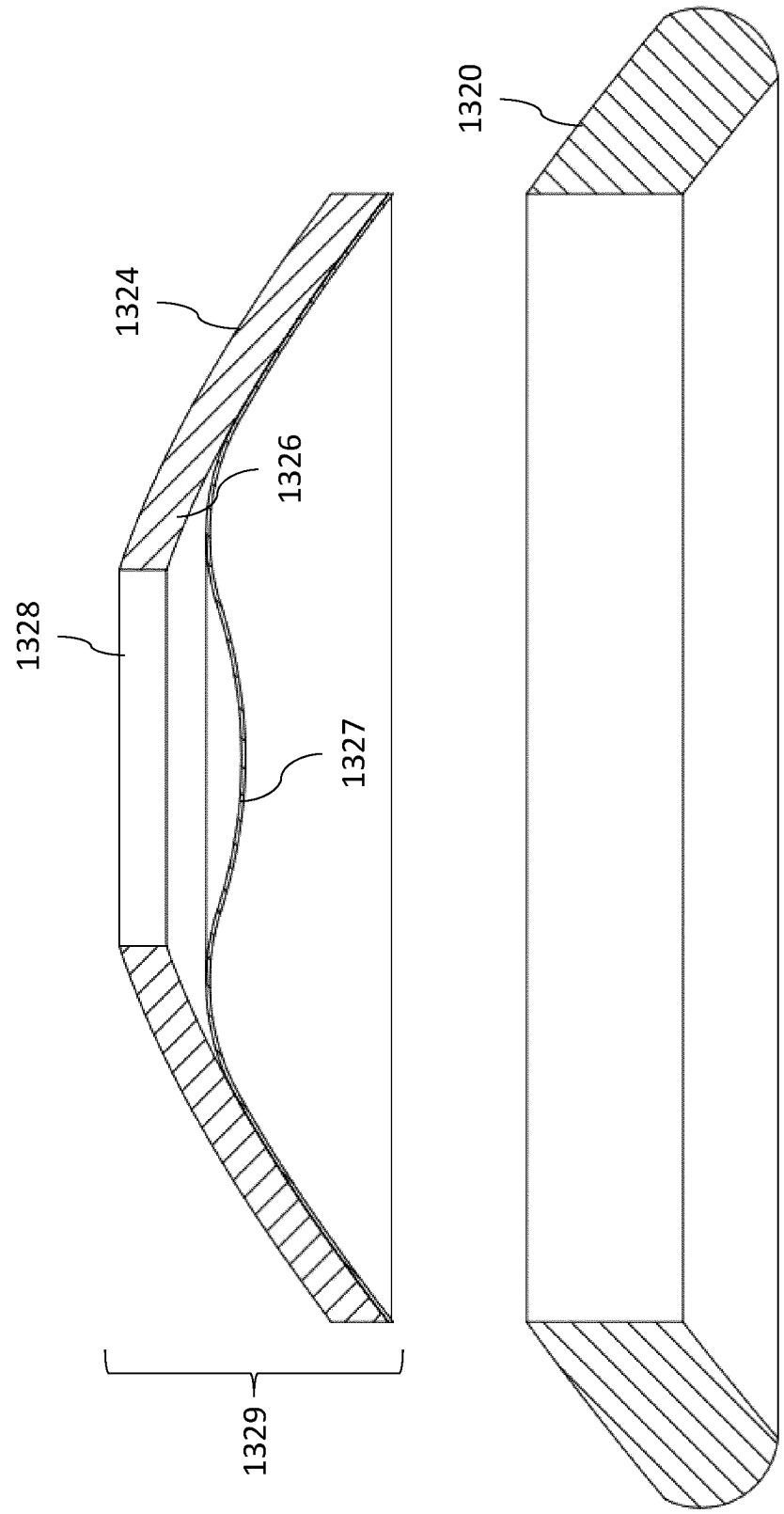


FIG. 13F

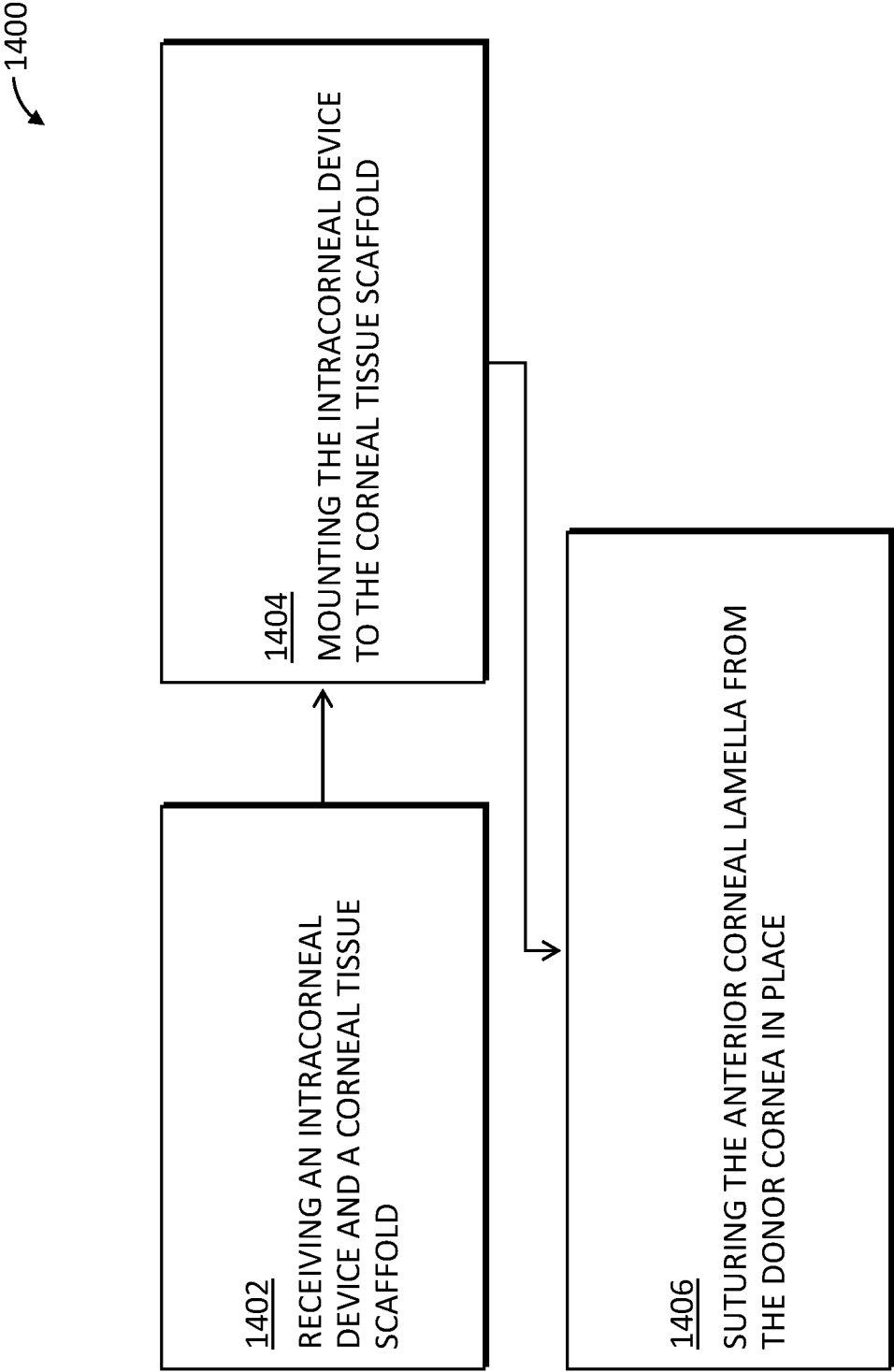


FIG. 14A

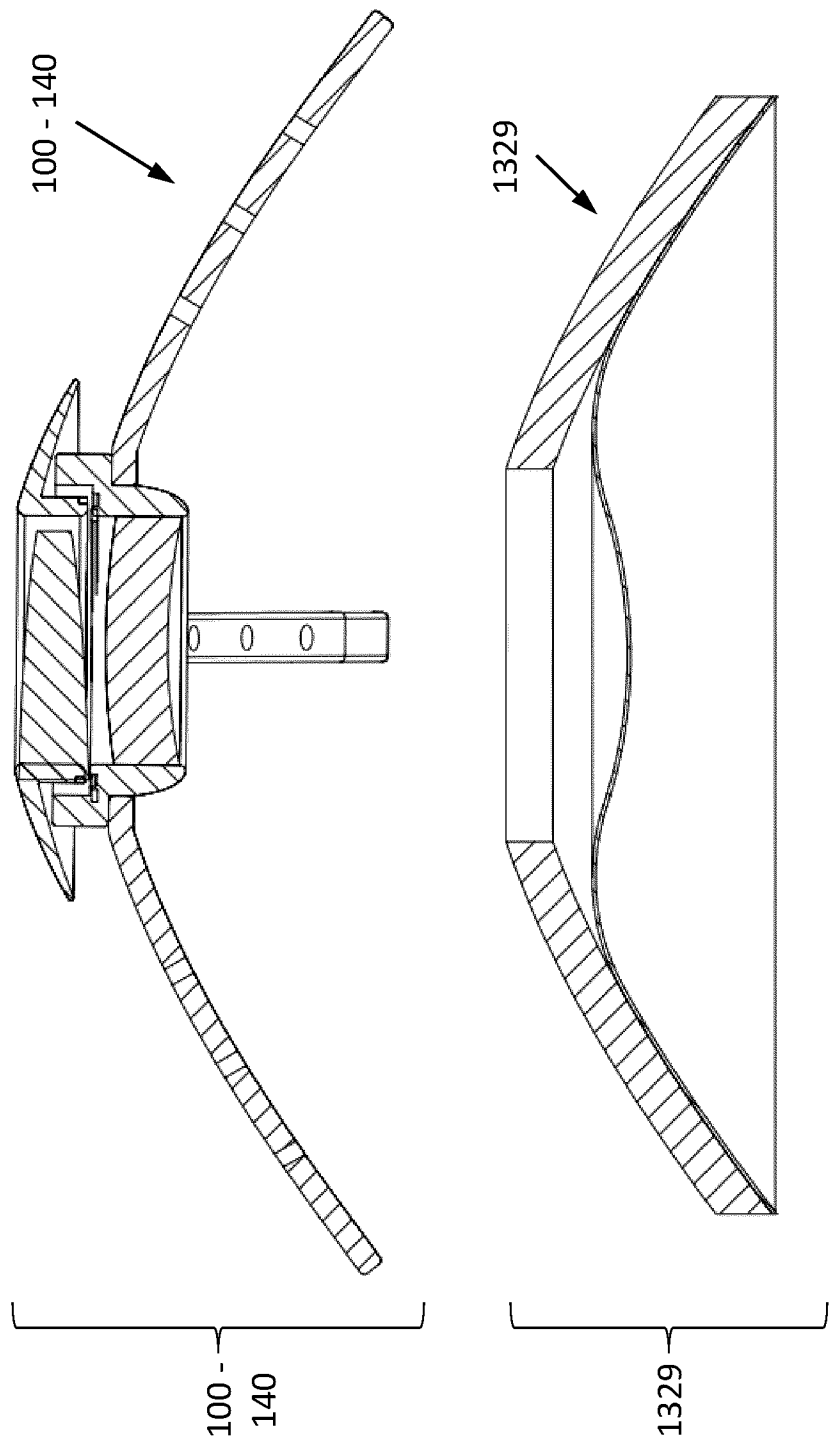


FIG. 14B

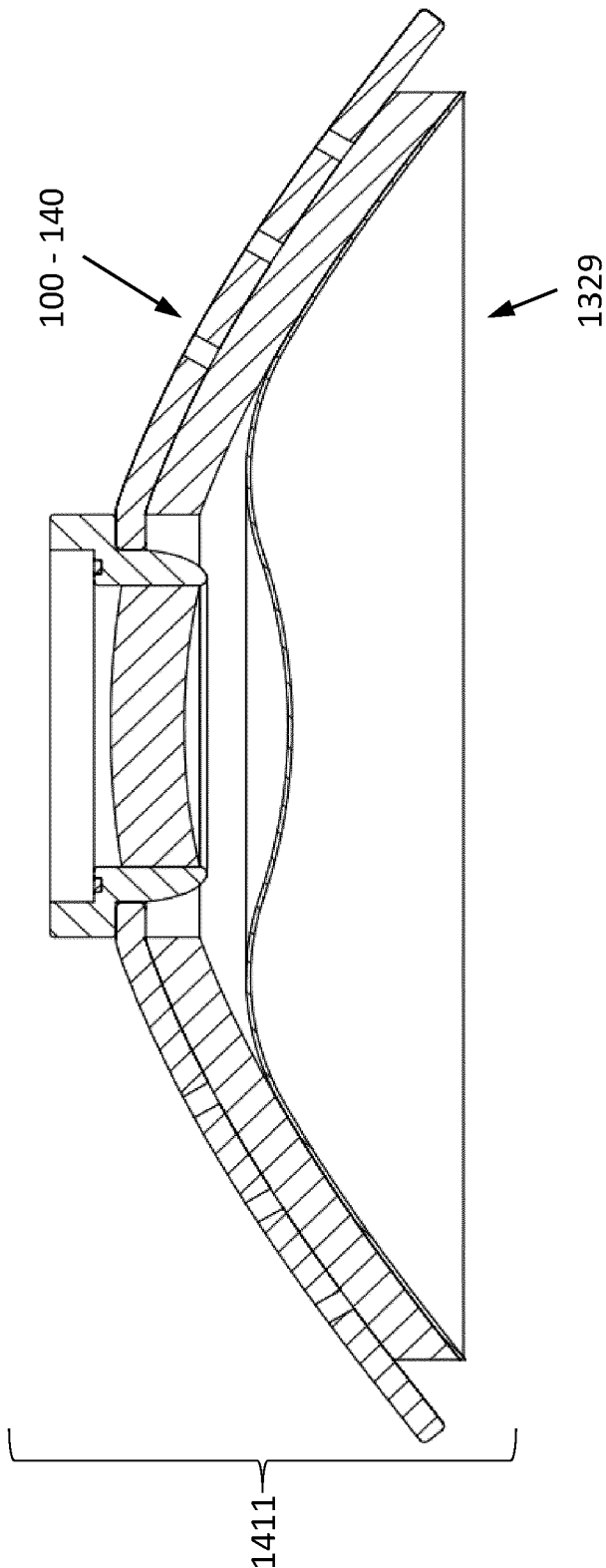


FIG. 14C

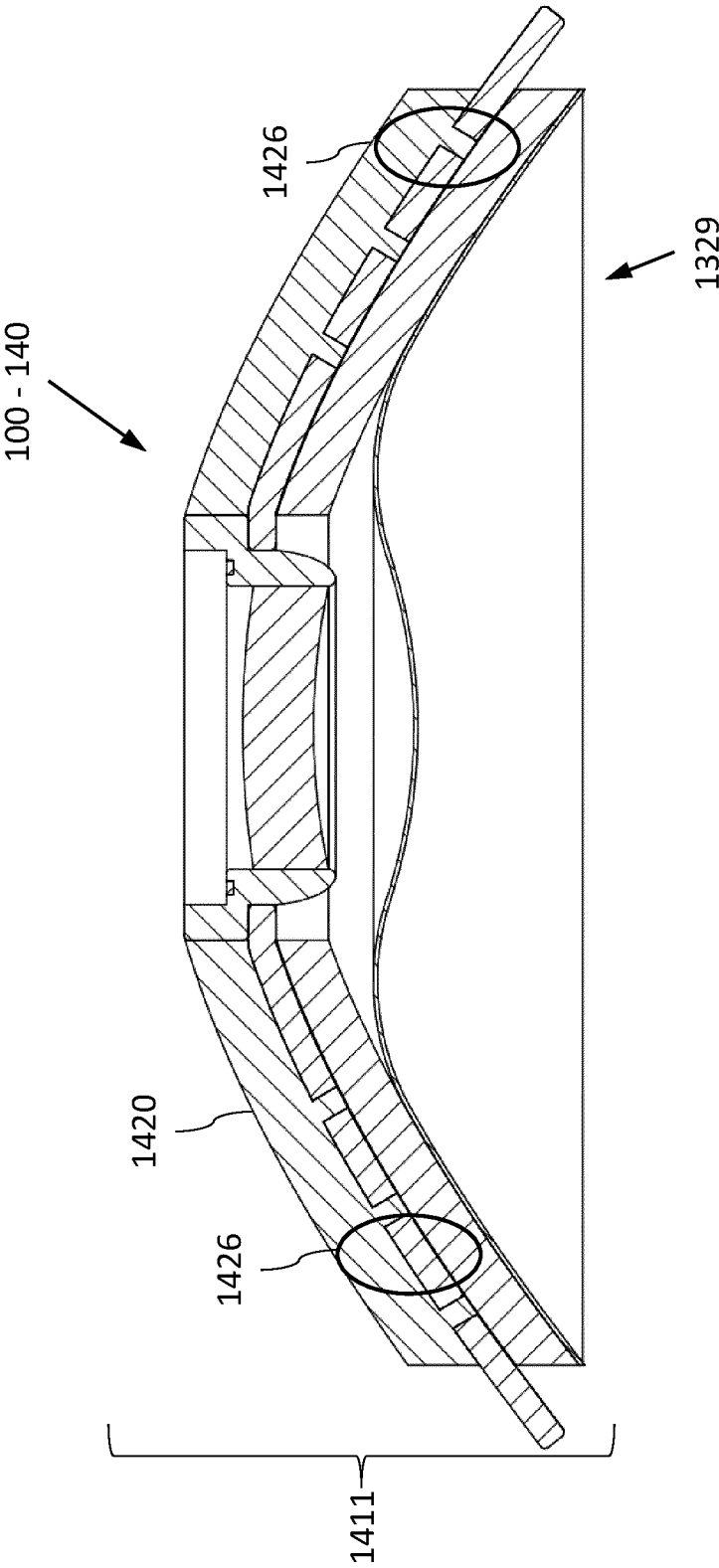


FIG. 14D

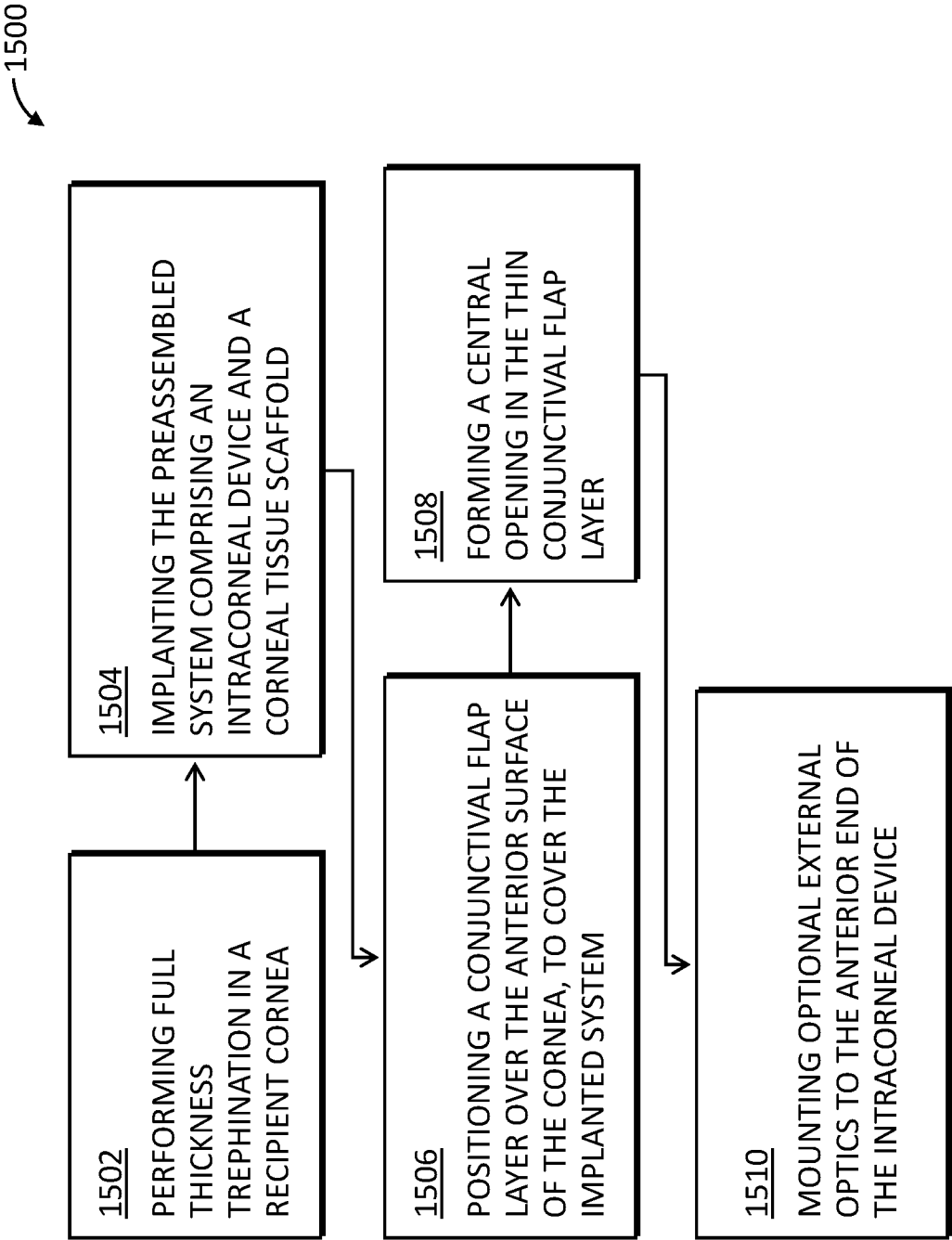


FIG. 15A

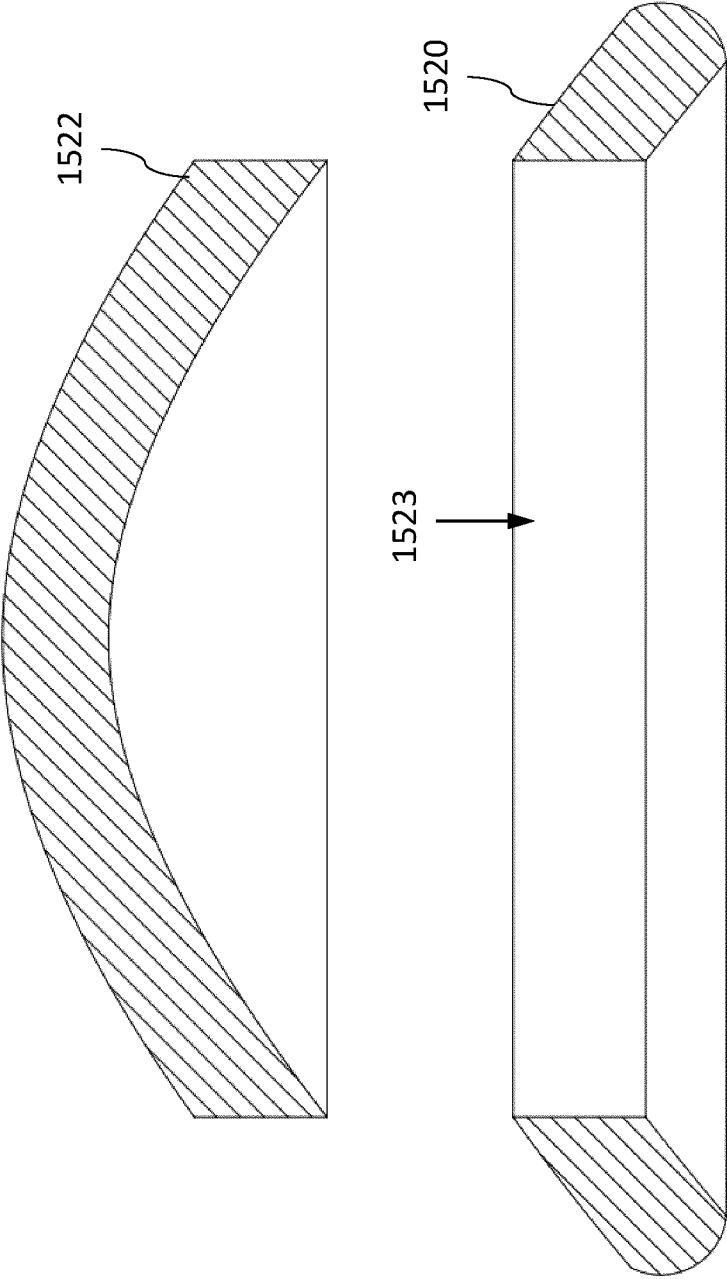


FIG. 15B

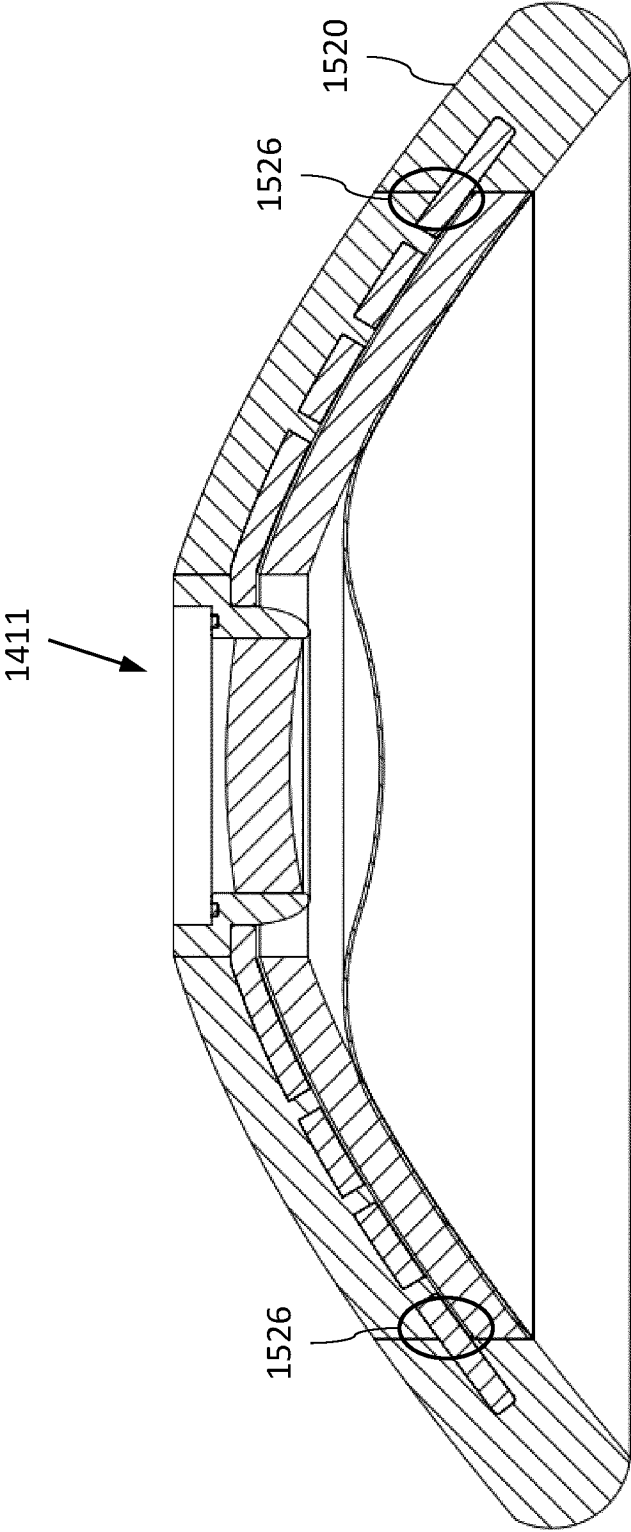


FIG. 15C

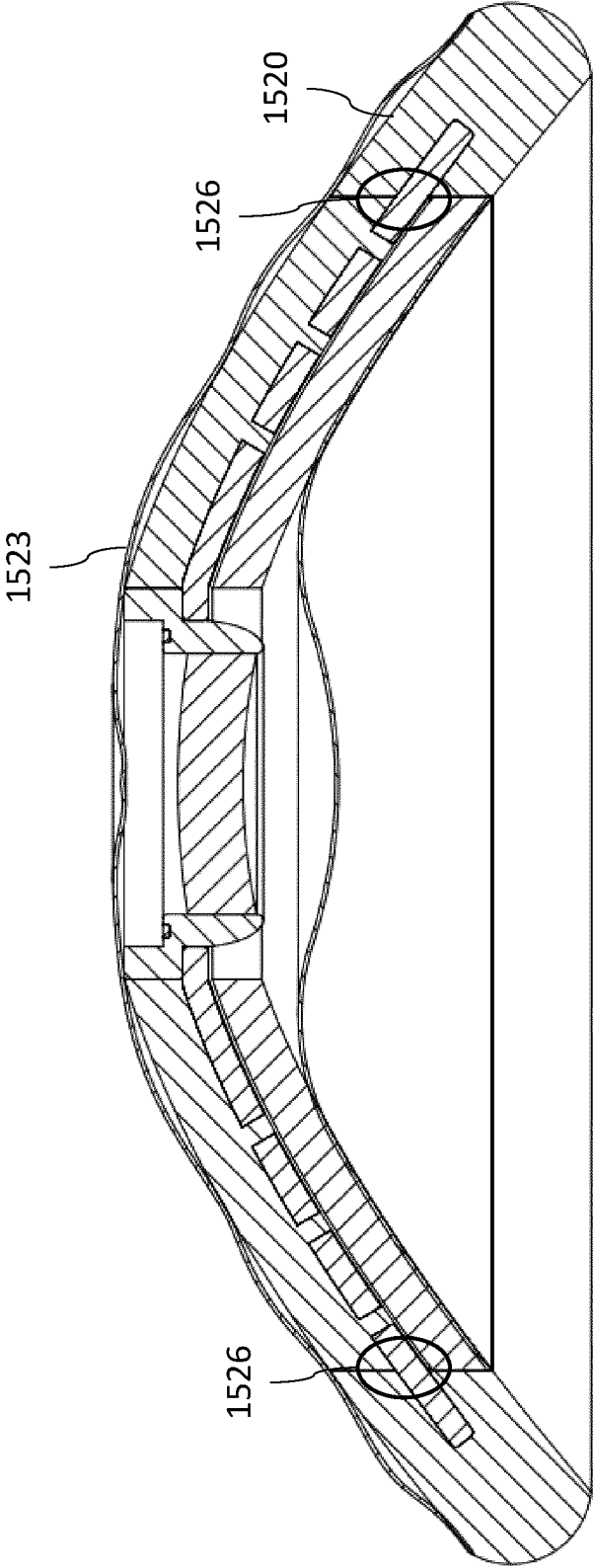


FIG. 15D

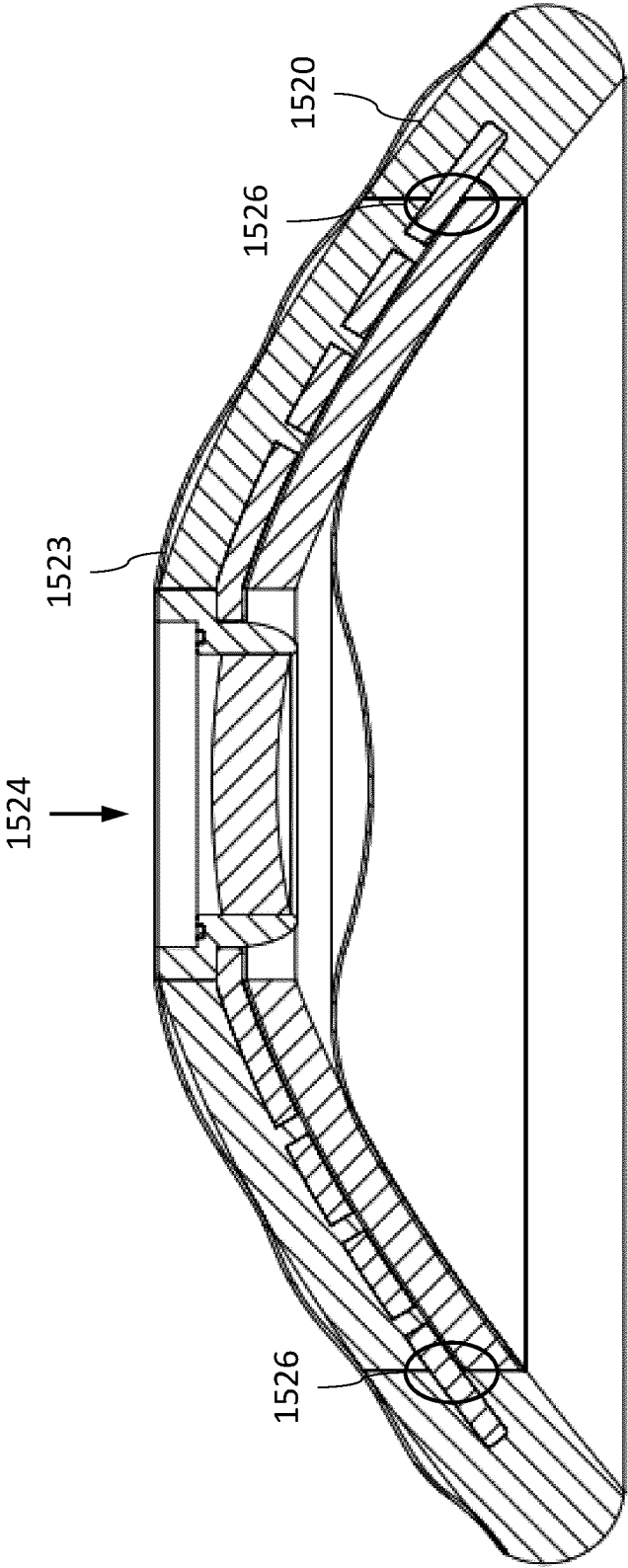


FIG. 15E

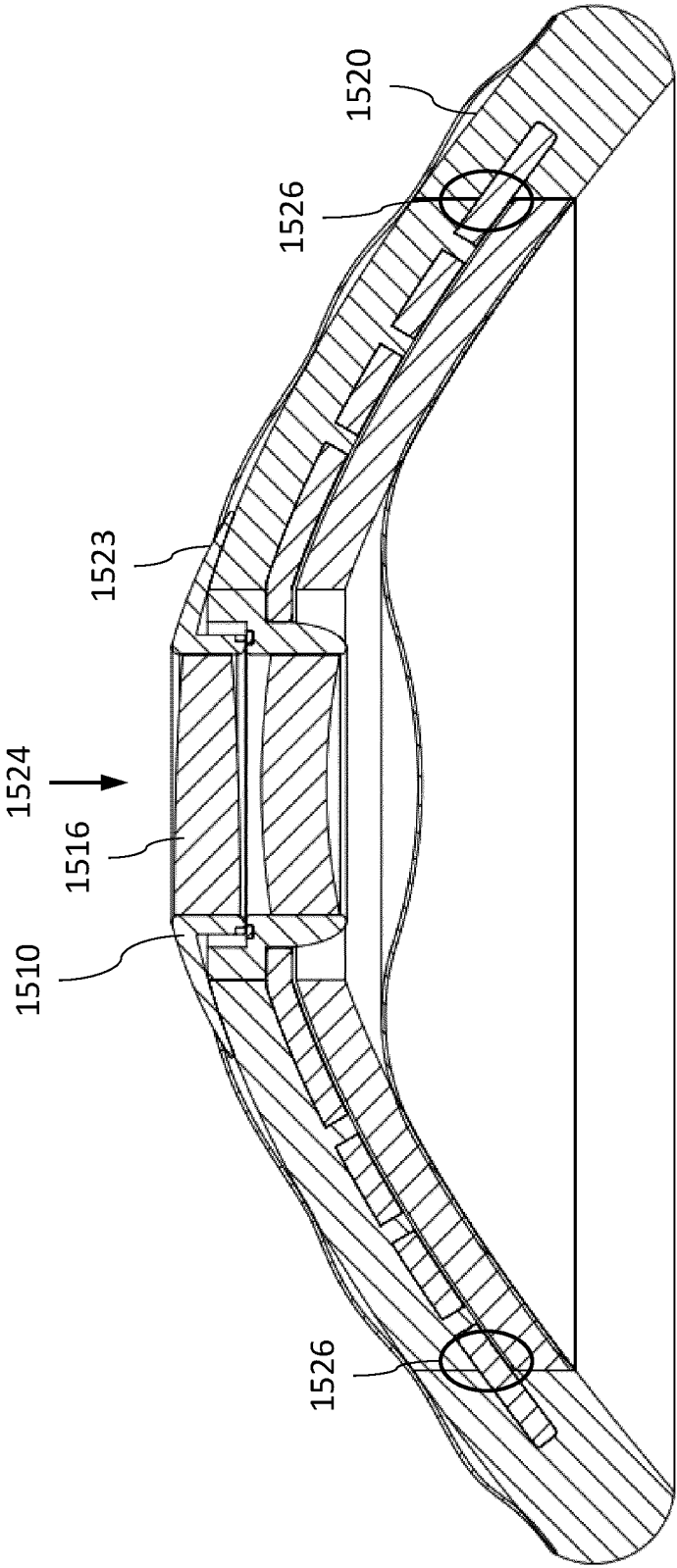


FIG. 15F

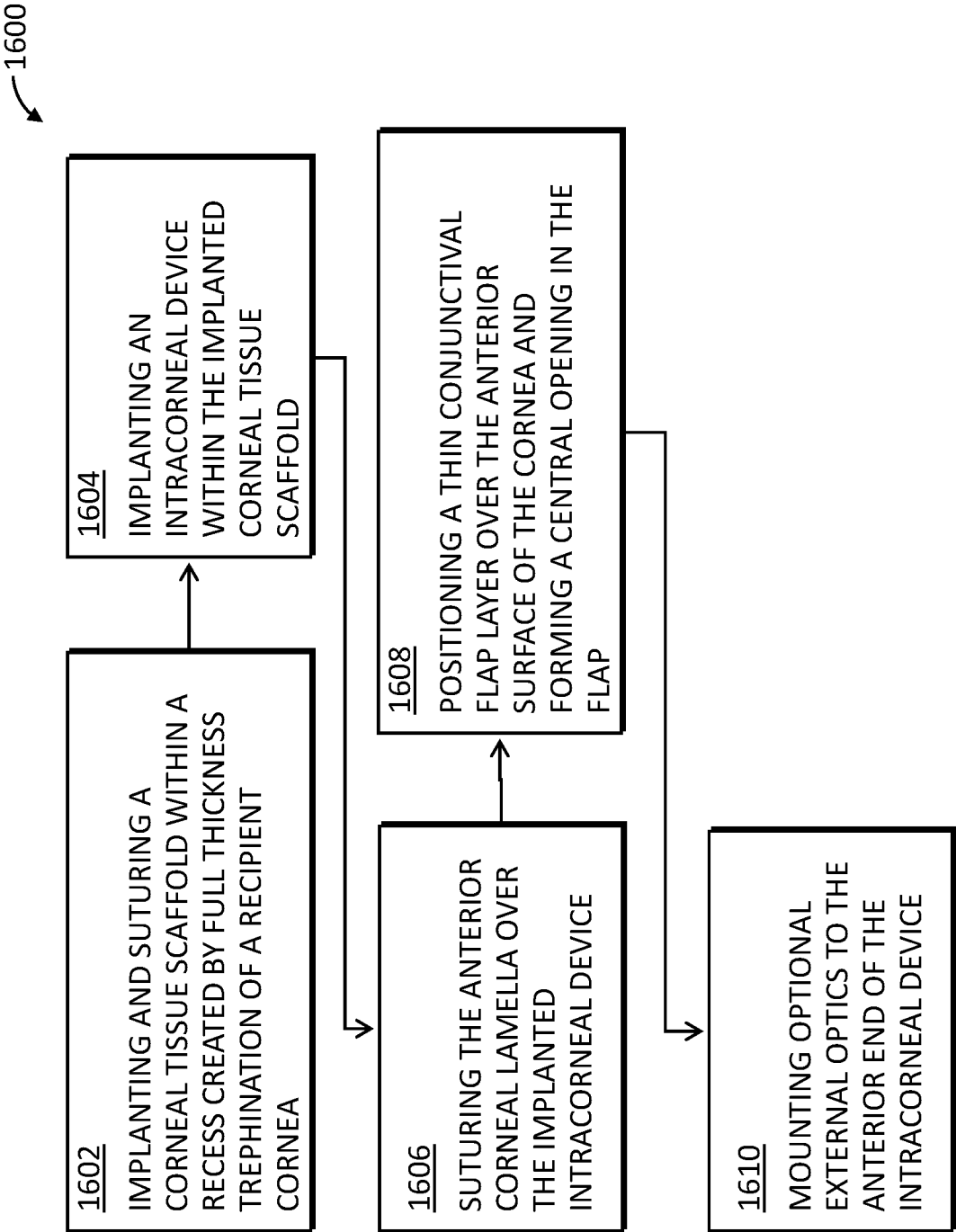


FIG. 16A

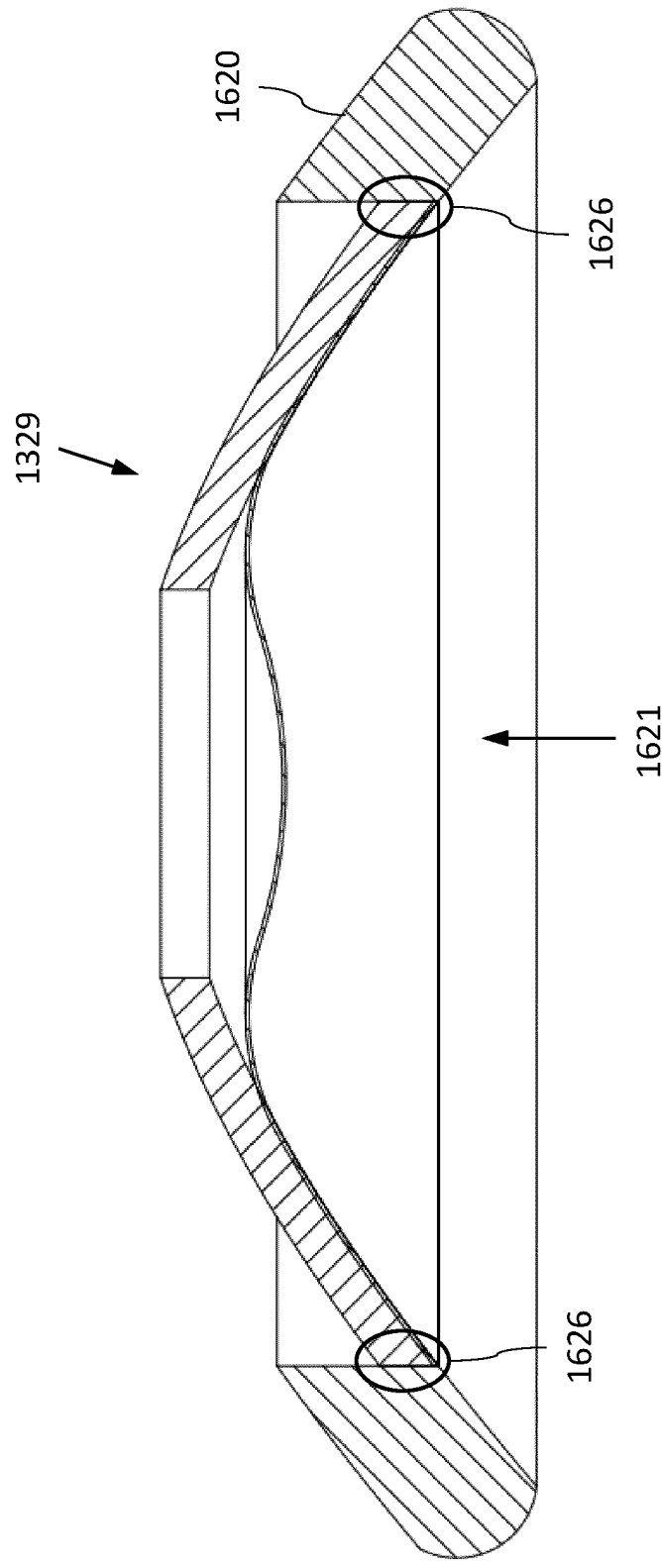


FIG. 16B

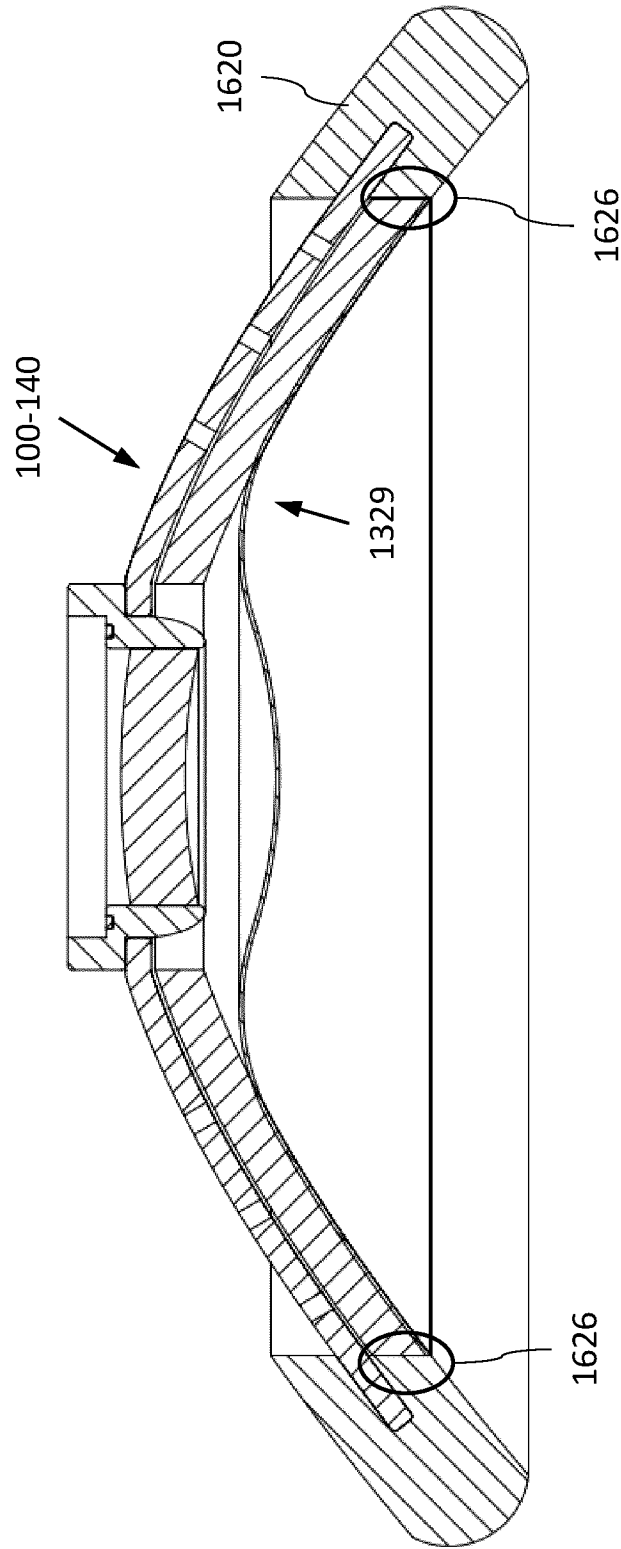


FIG. 16C

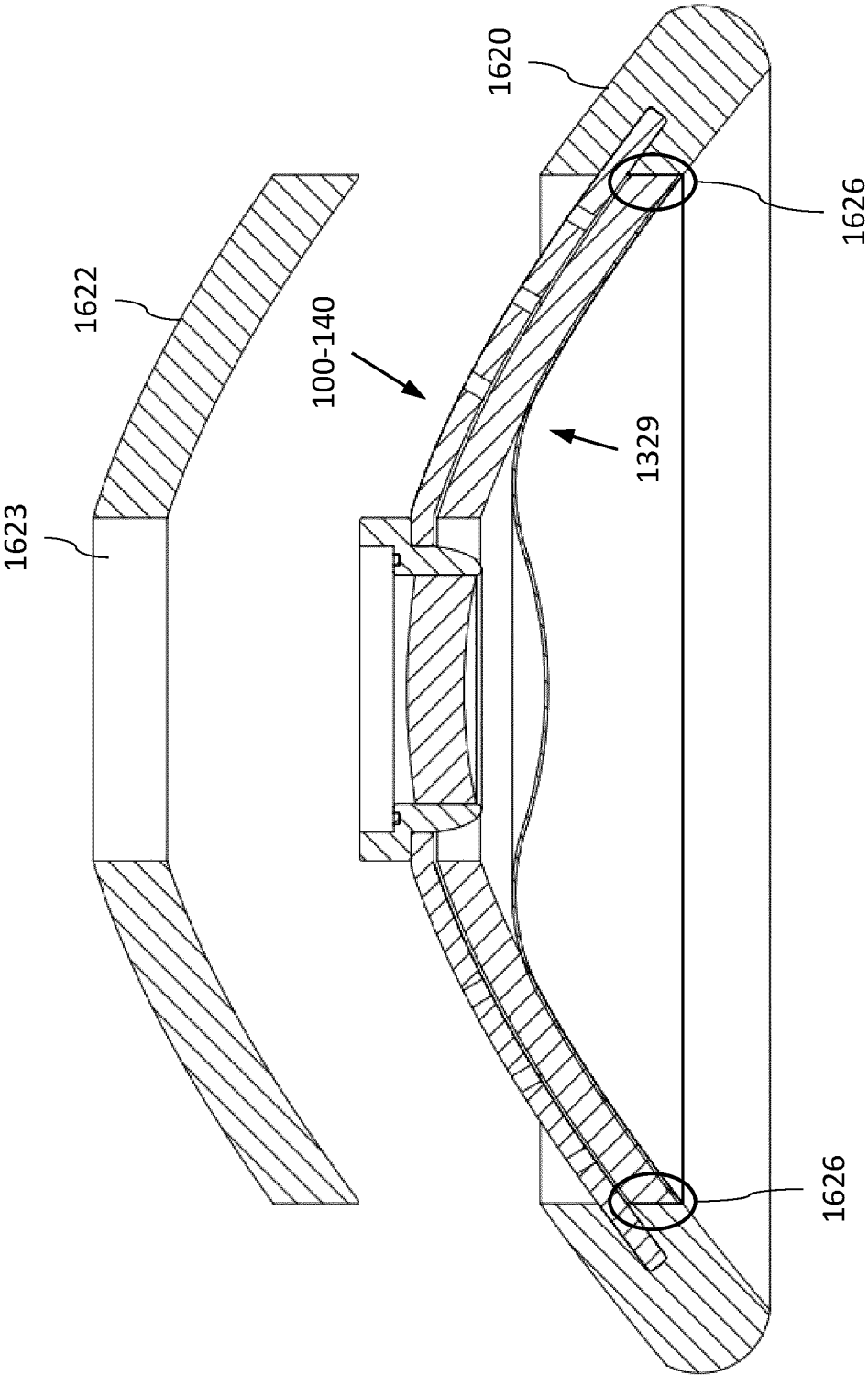


FIG. 16D

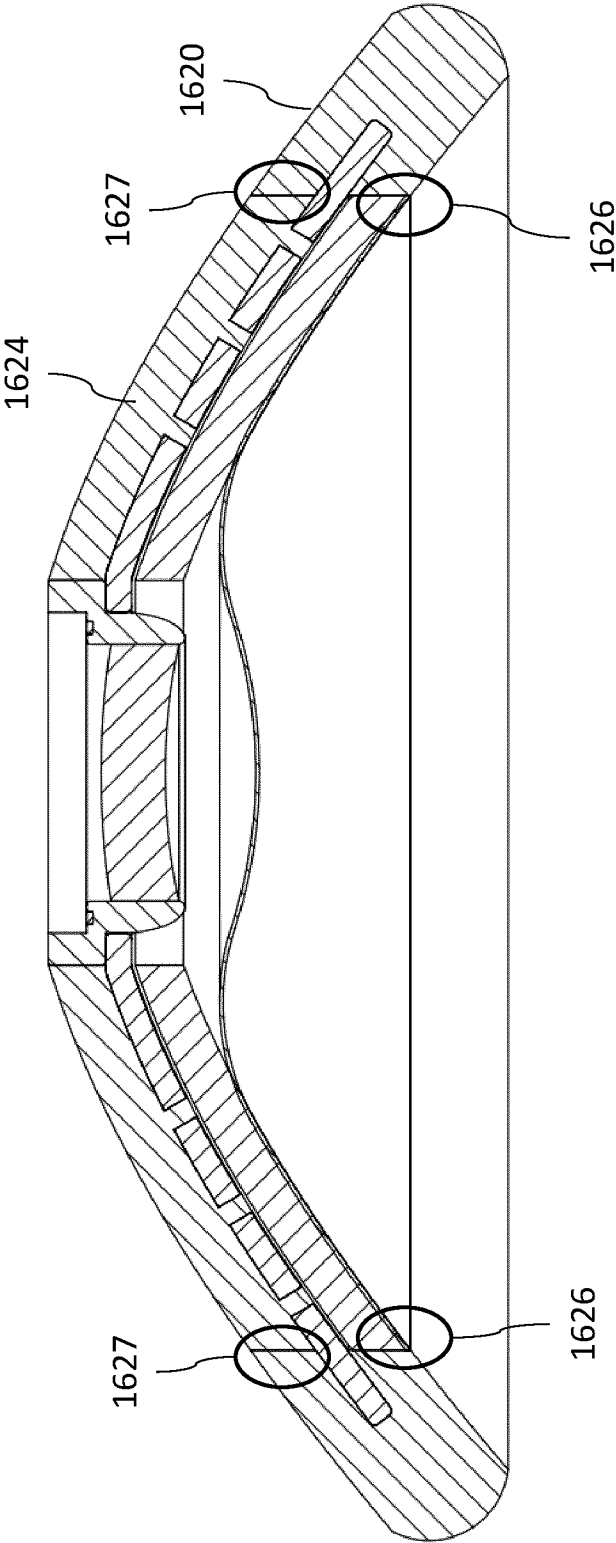


FIG. 16E

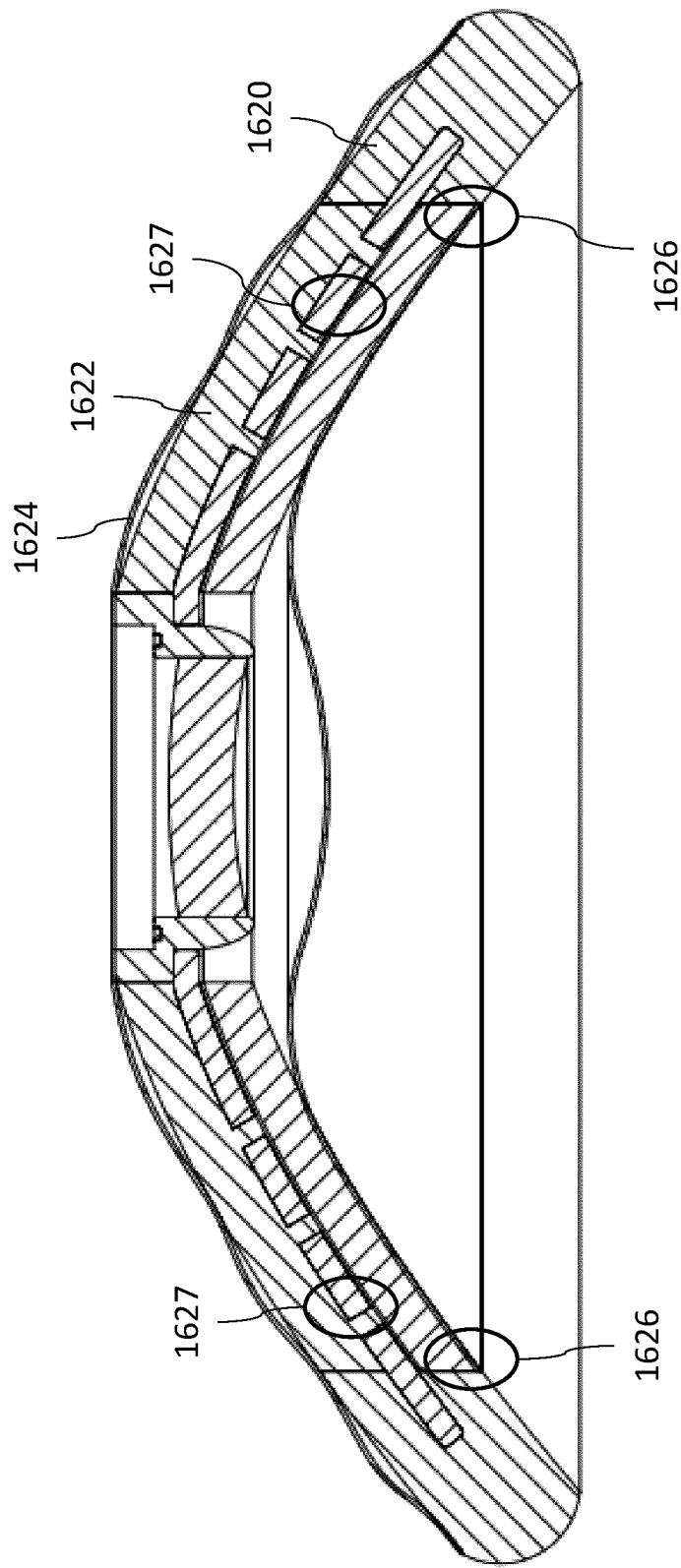


FIG. 16F

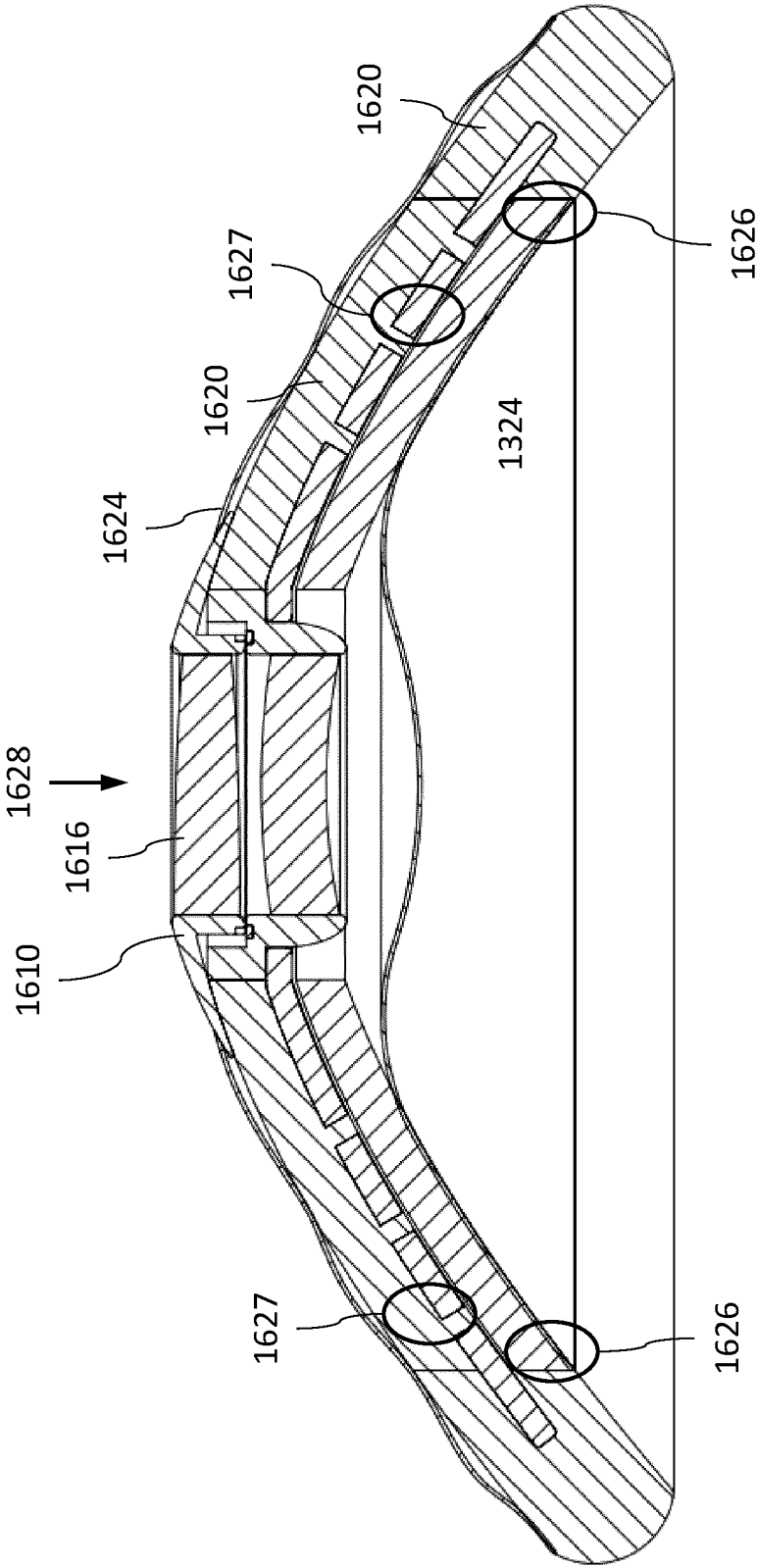


FIG. 16G

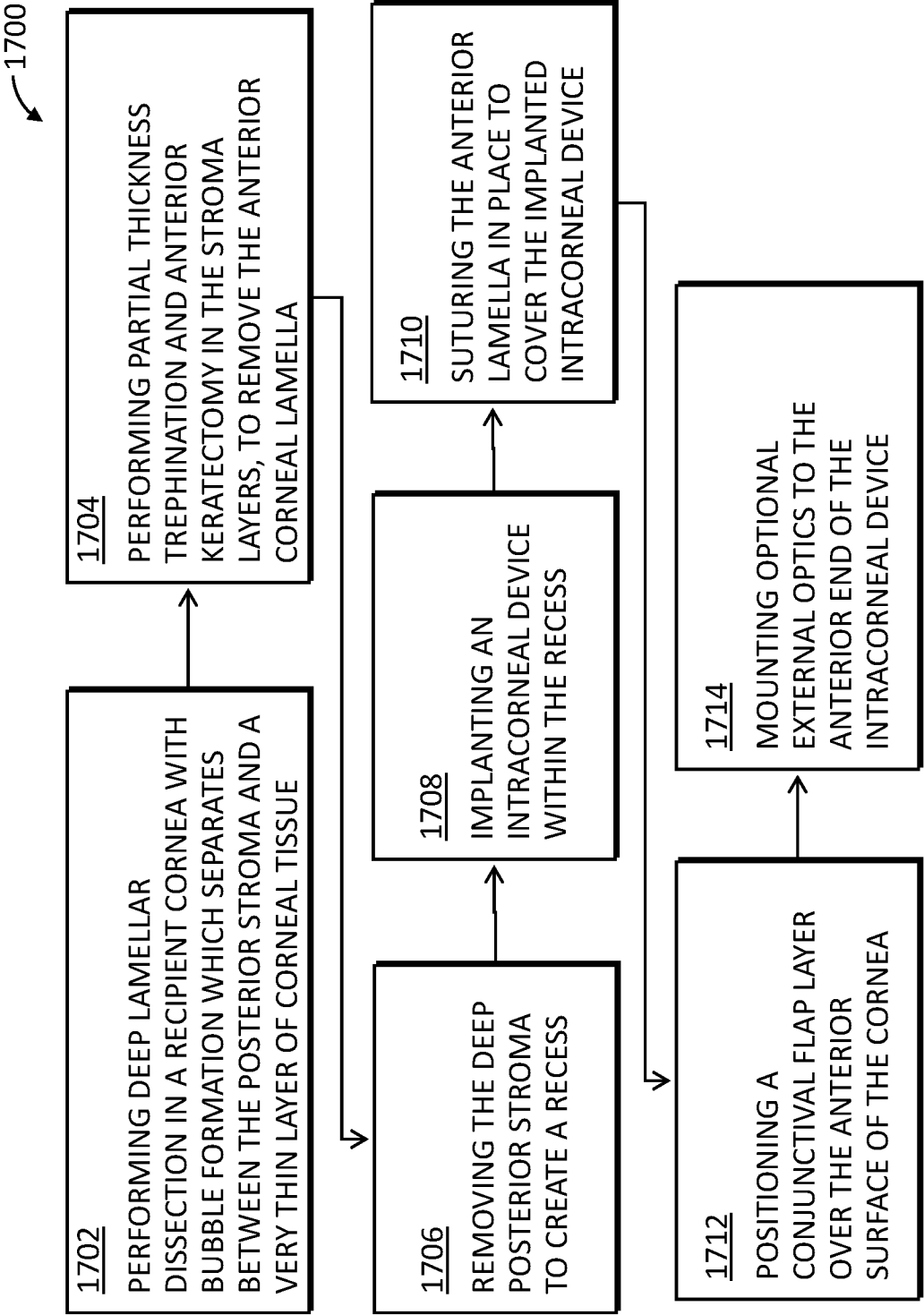


FIG. 17A

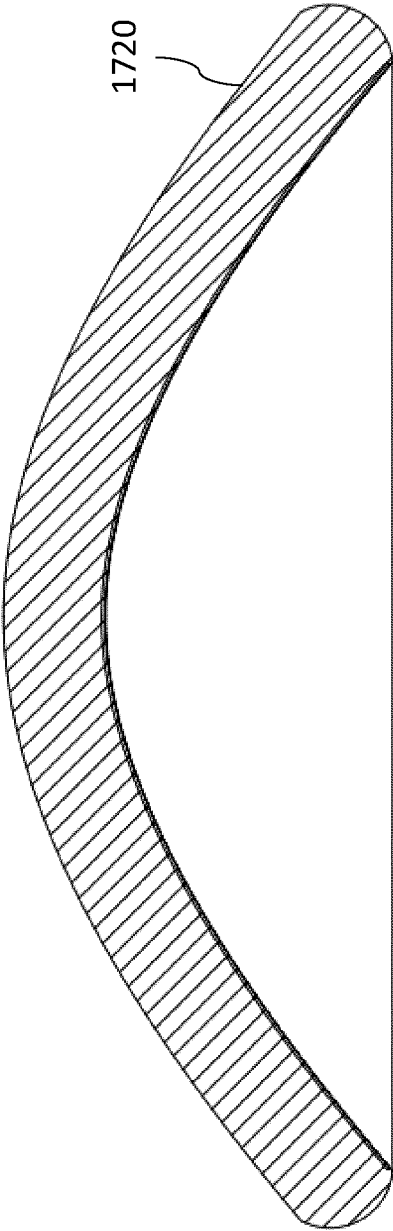


FIG. 17B

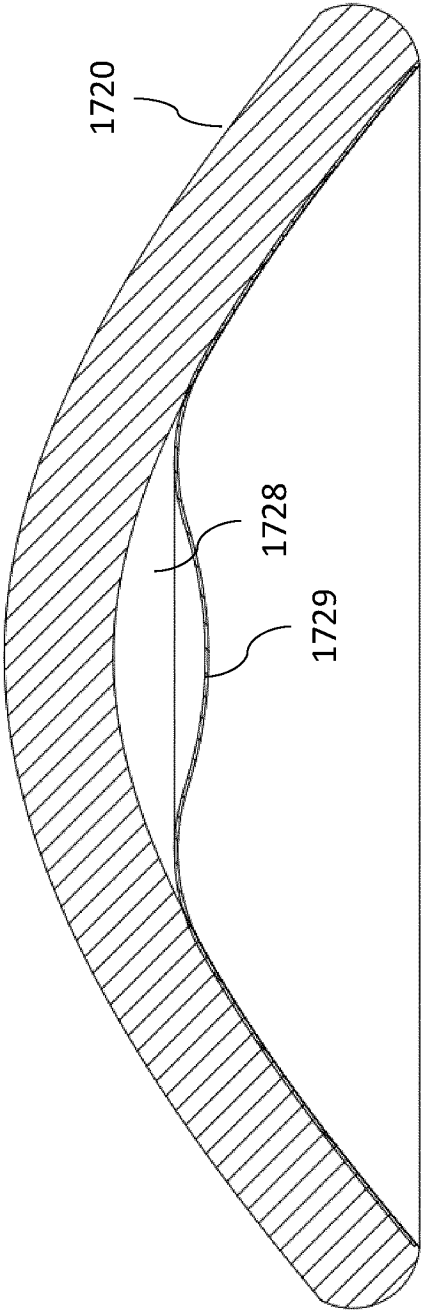


FIG. 17C

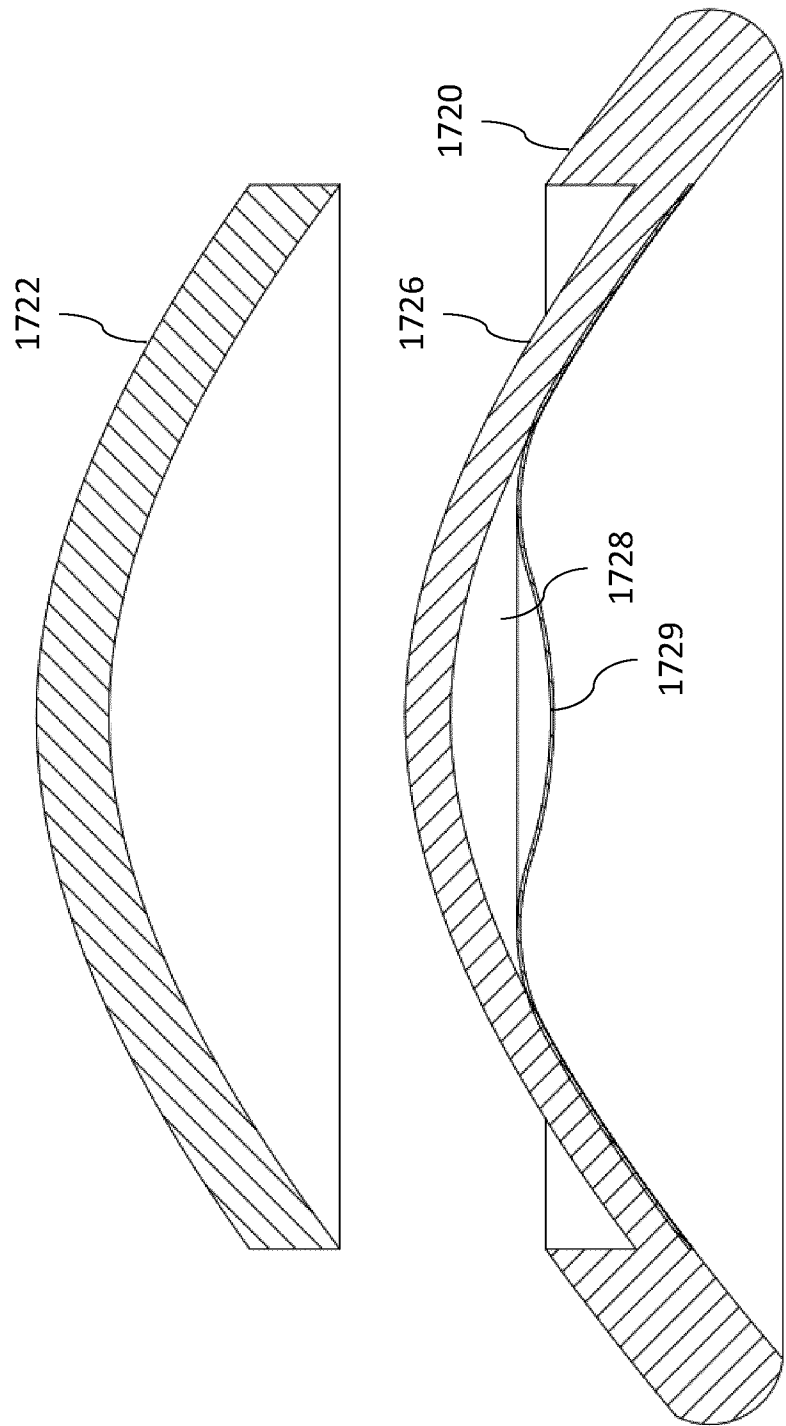


FIG. 17D

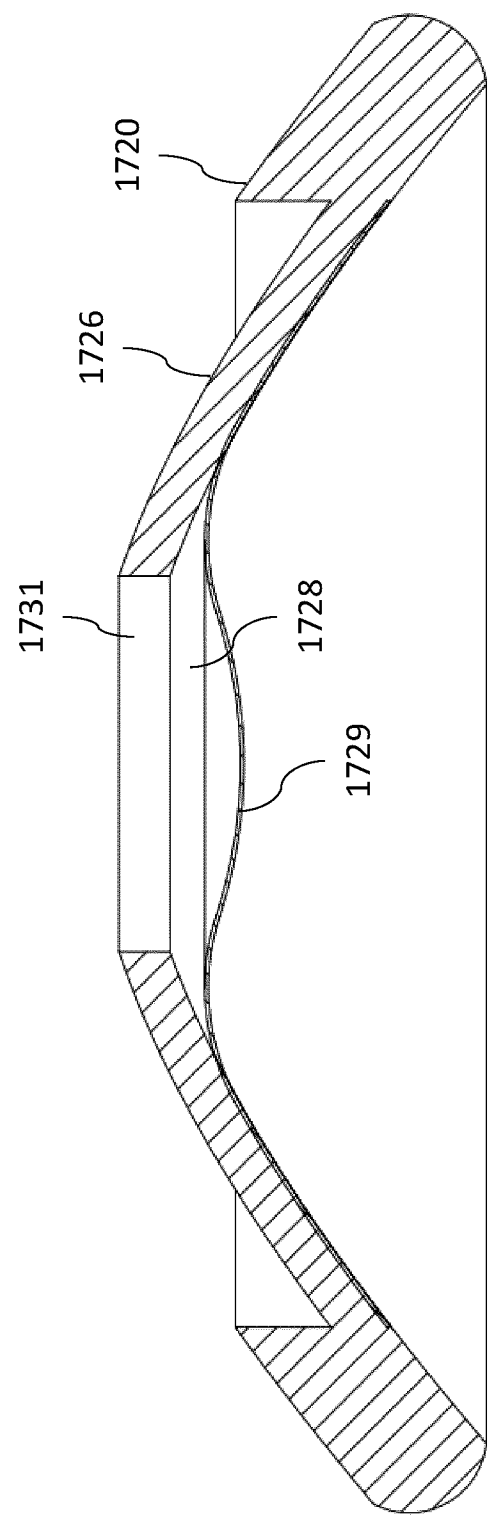


FIG. 17E

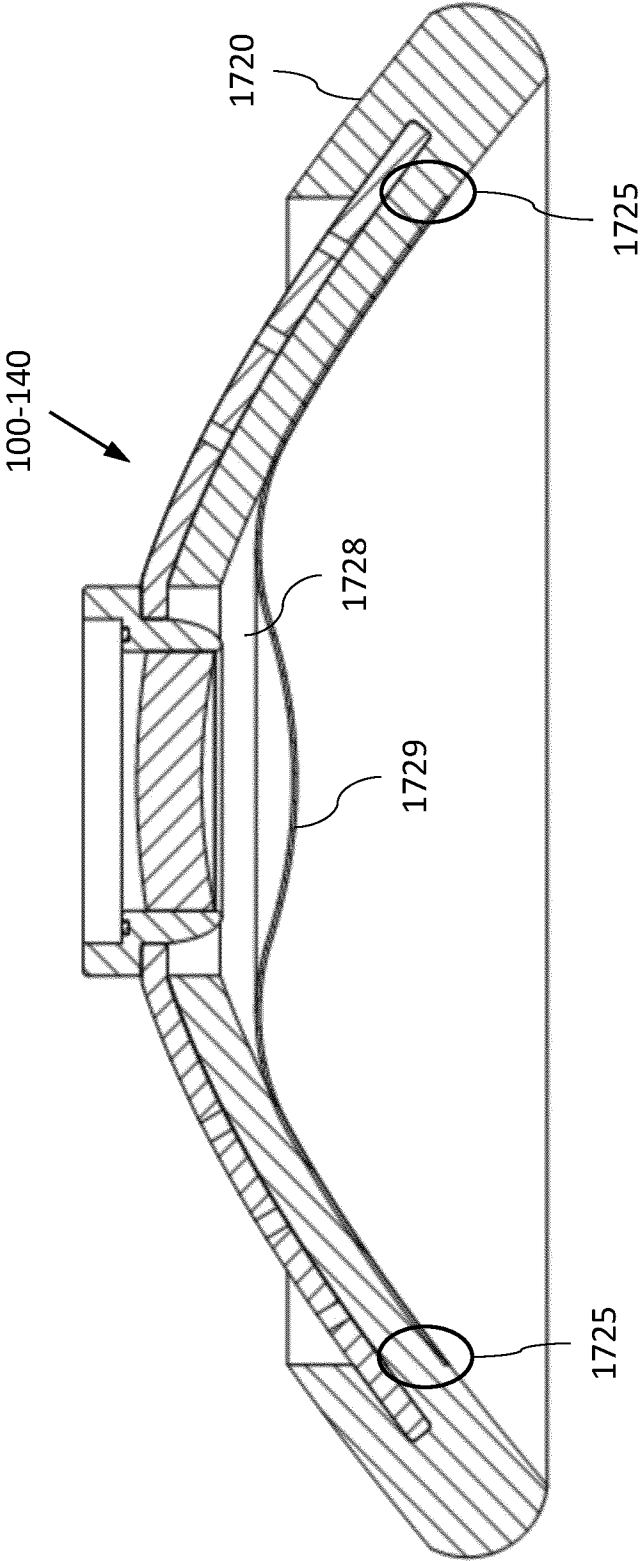


FIG. 17F

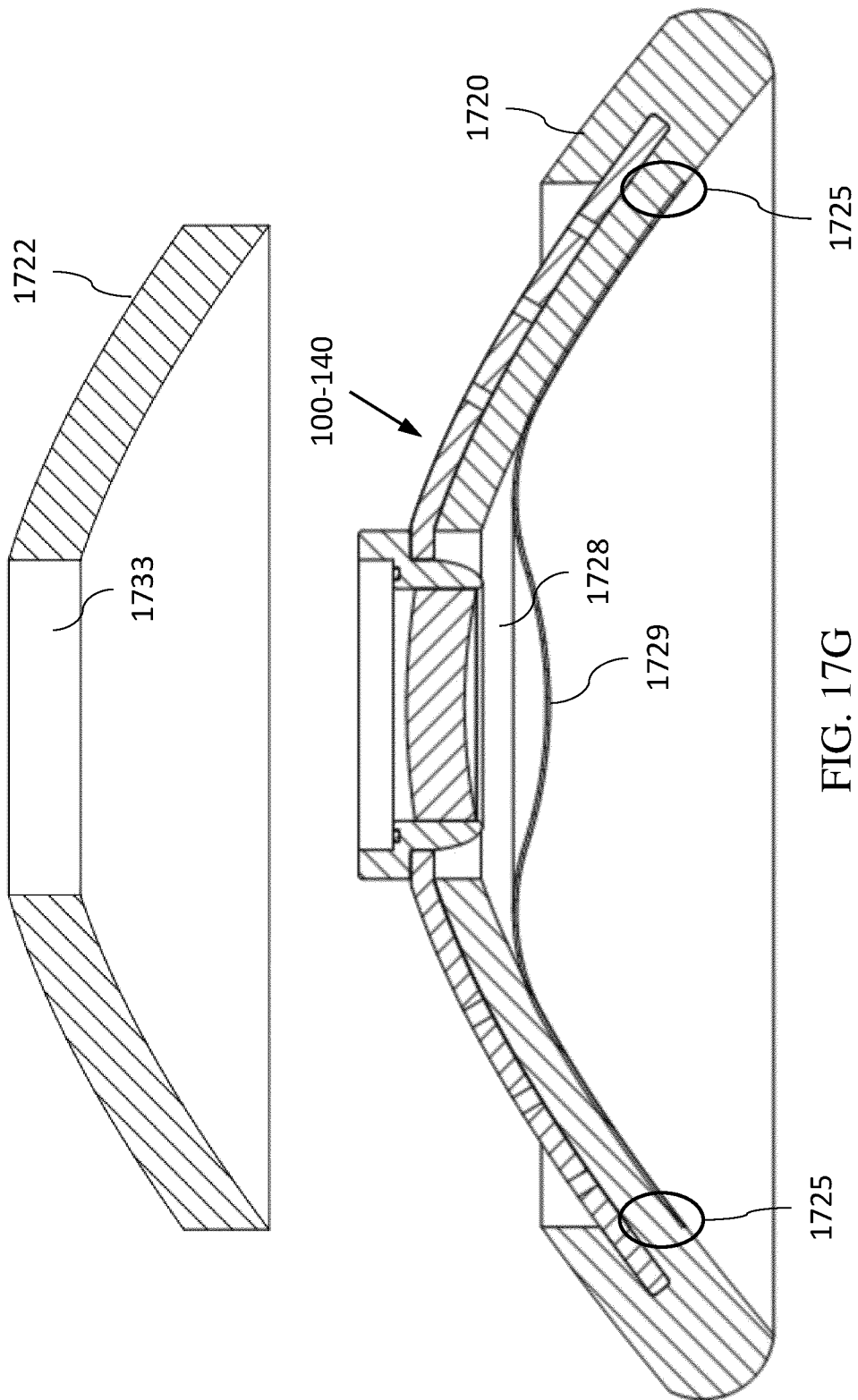


FIG. 17G

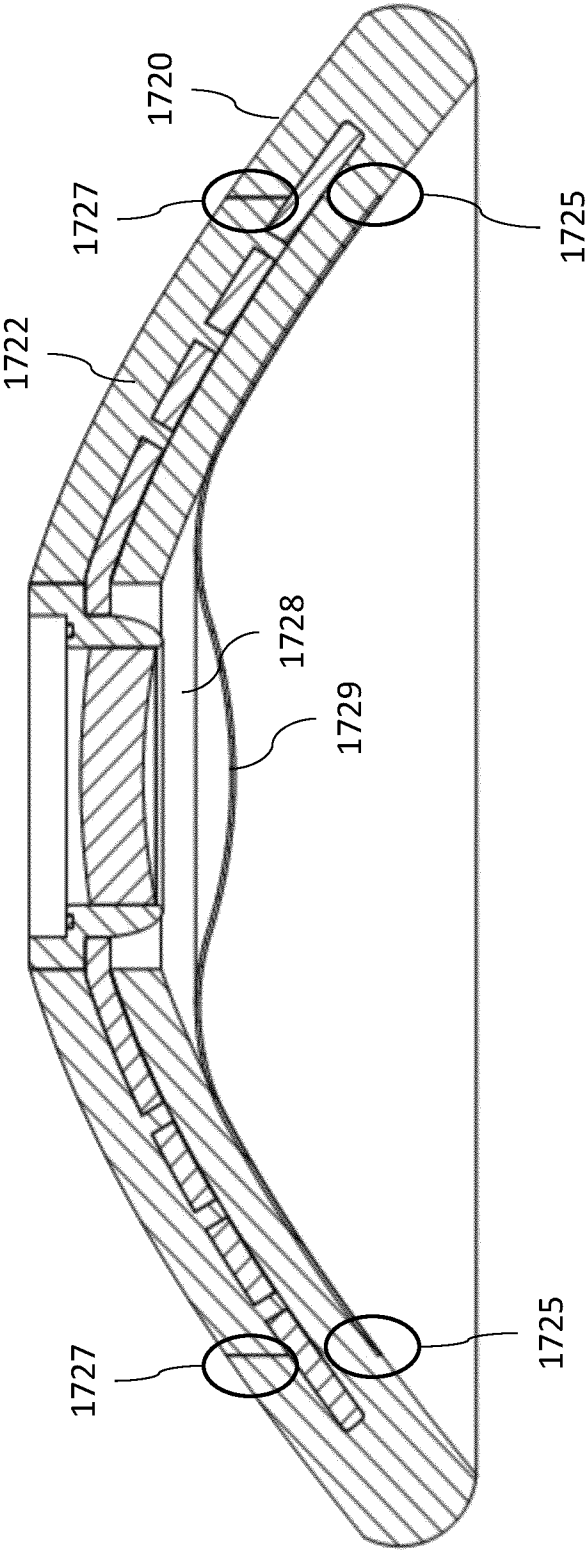


FIG. 17H

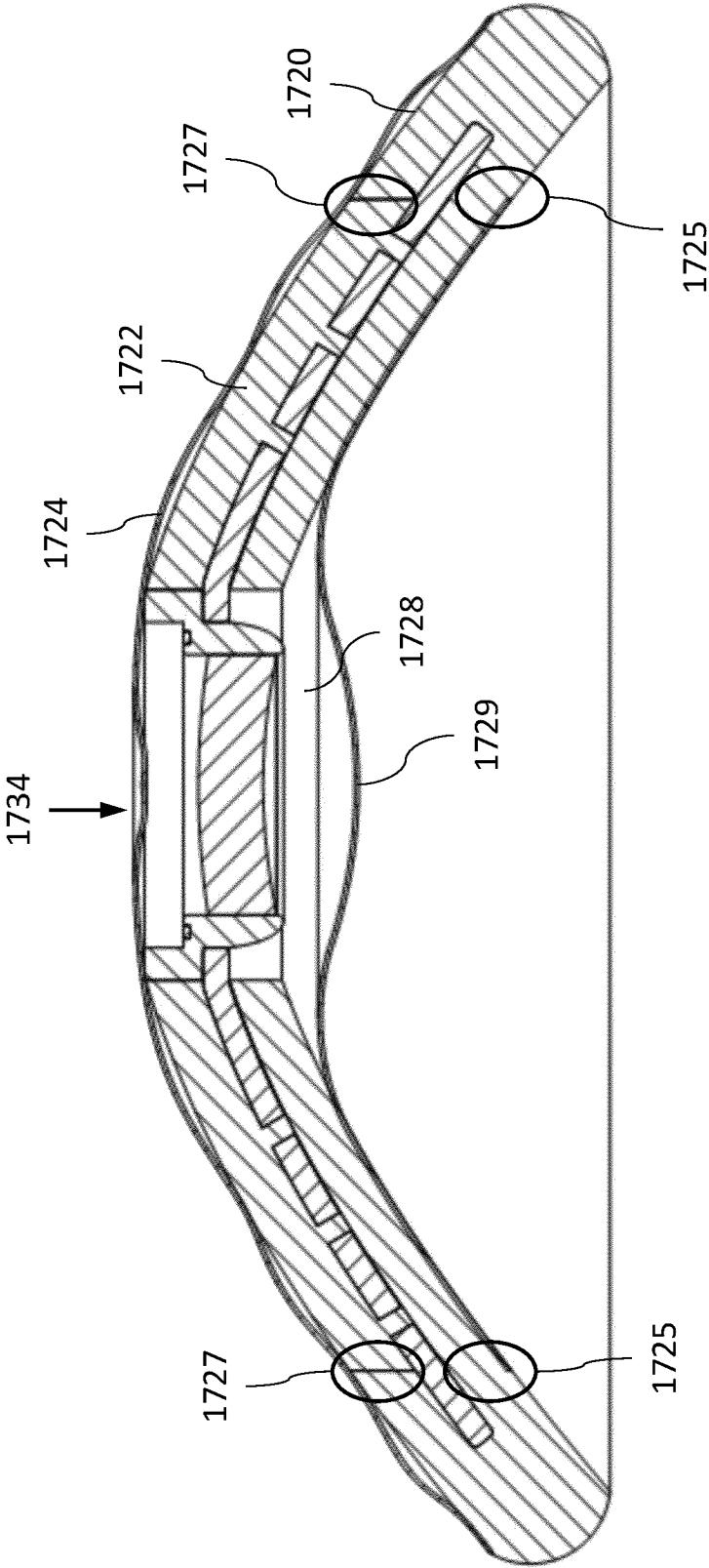


FIG. 17I

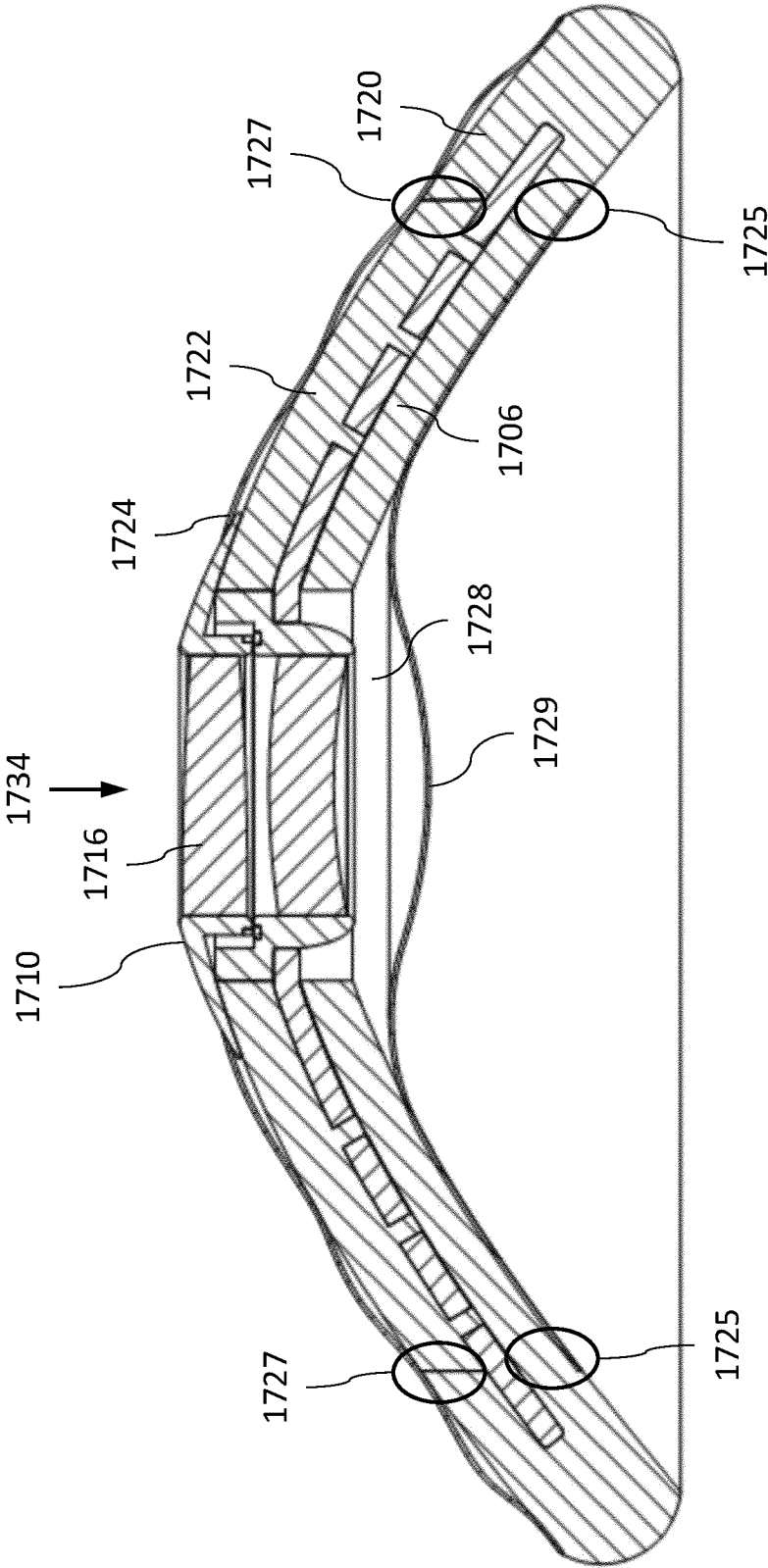


FIG. 17J

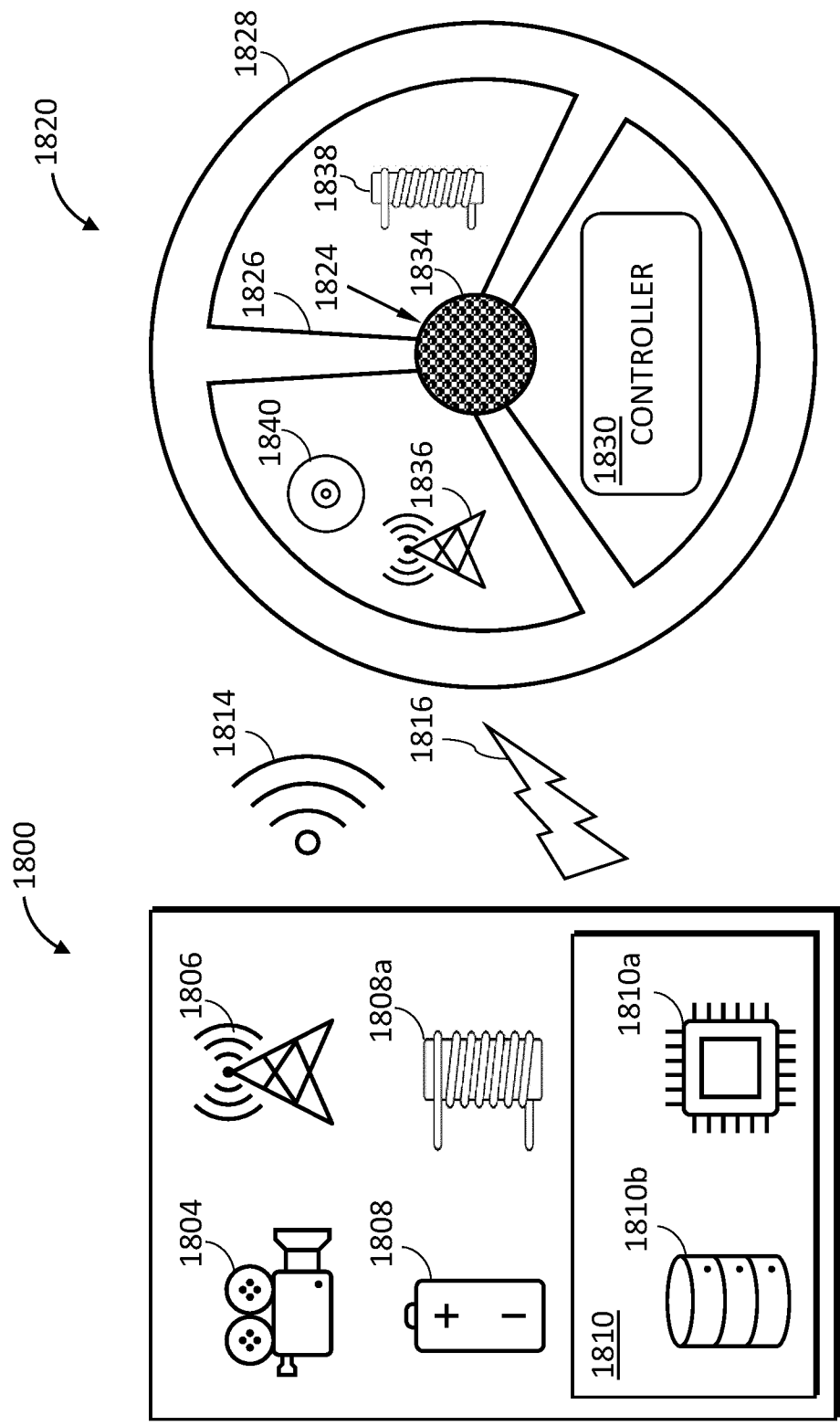


FIG. 18A

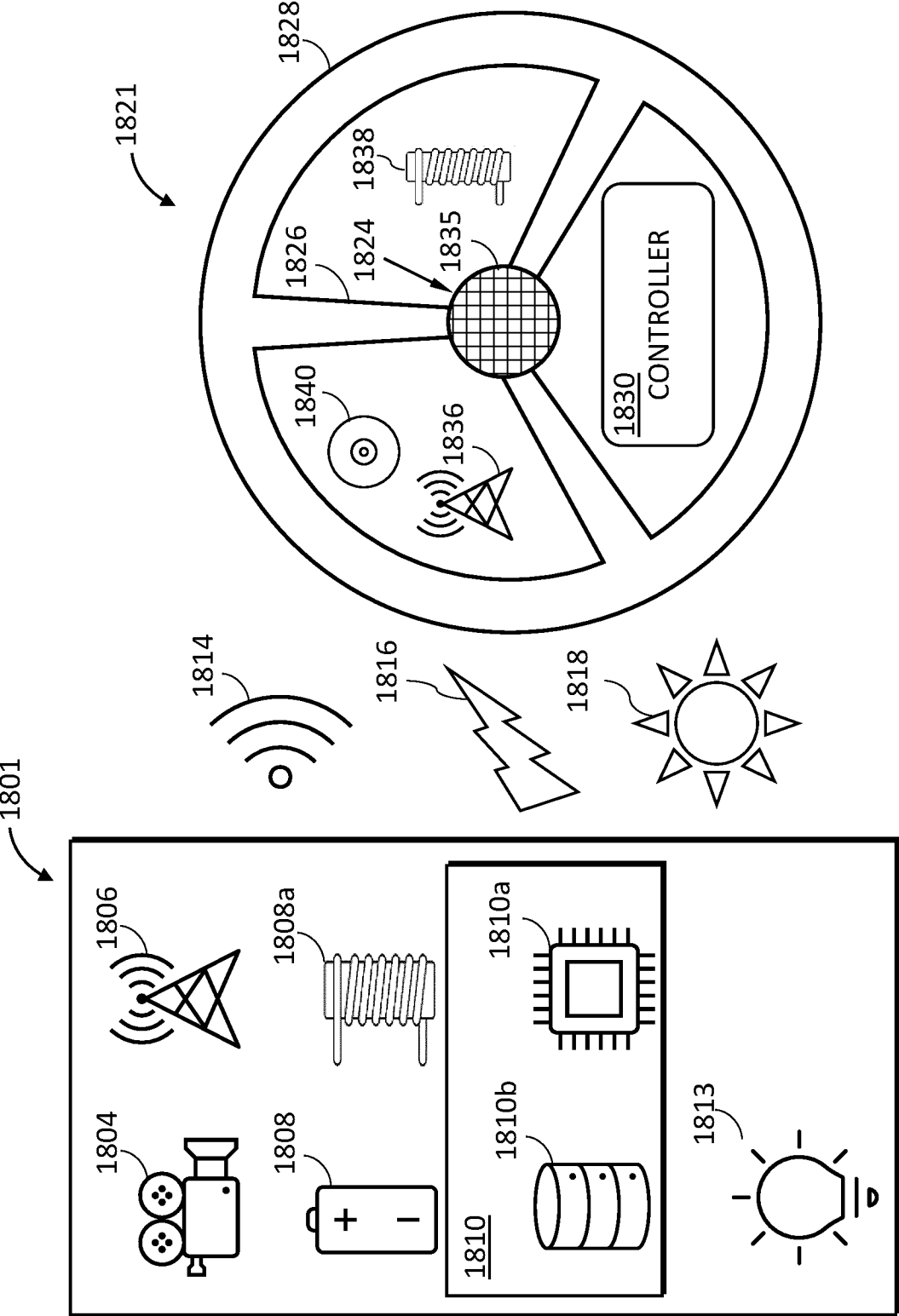


FIG. 18B

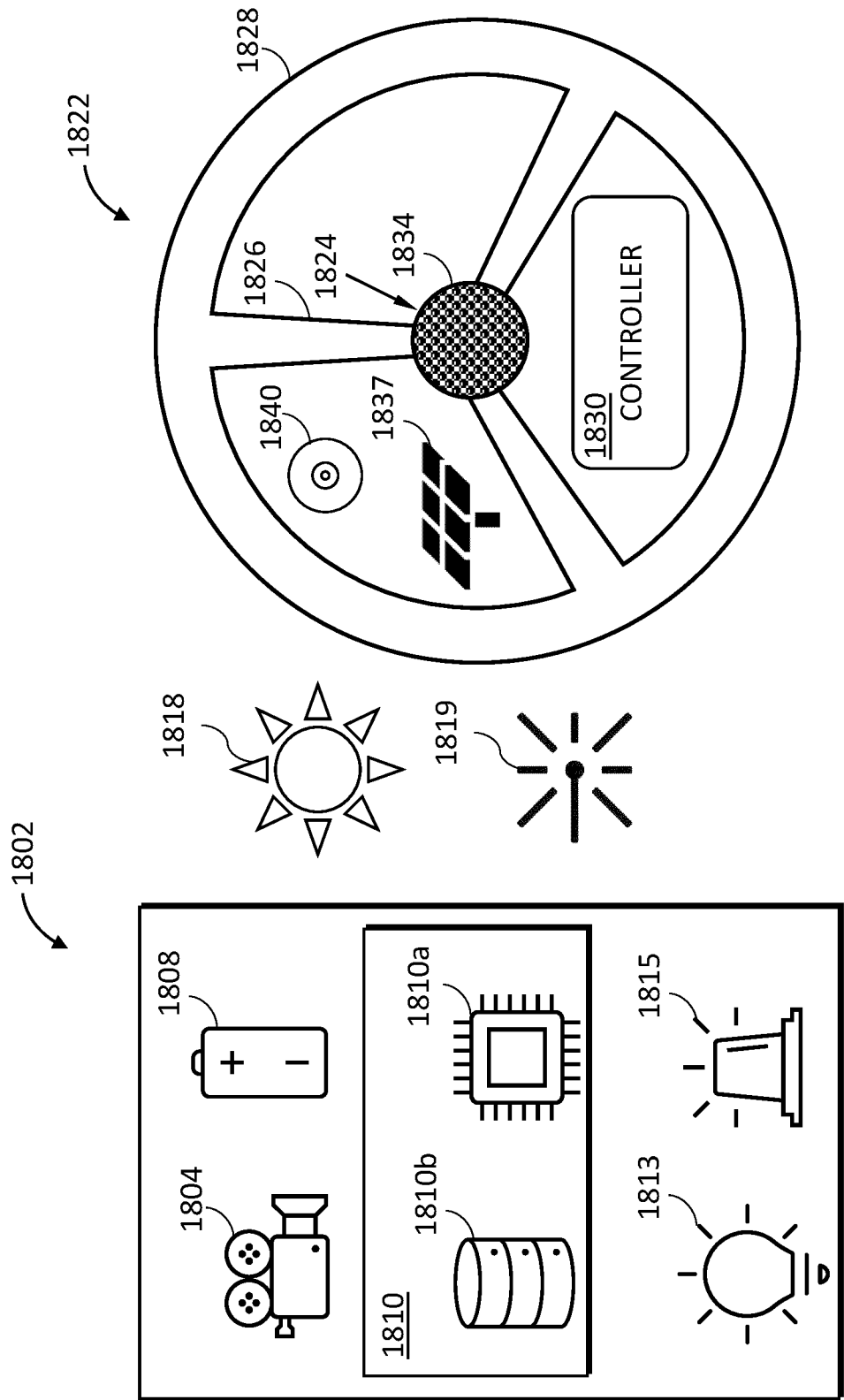


FIG. 18C

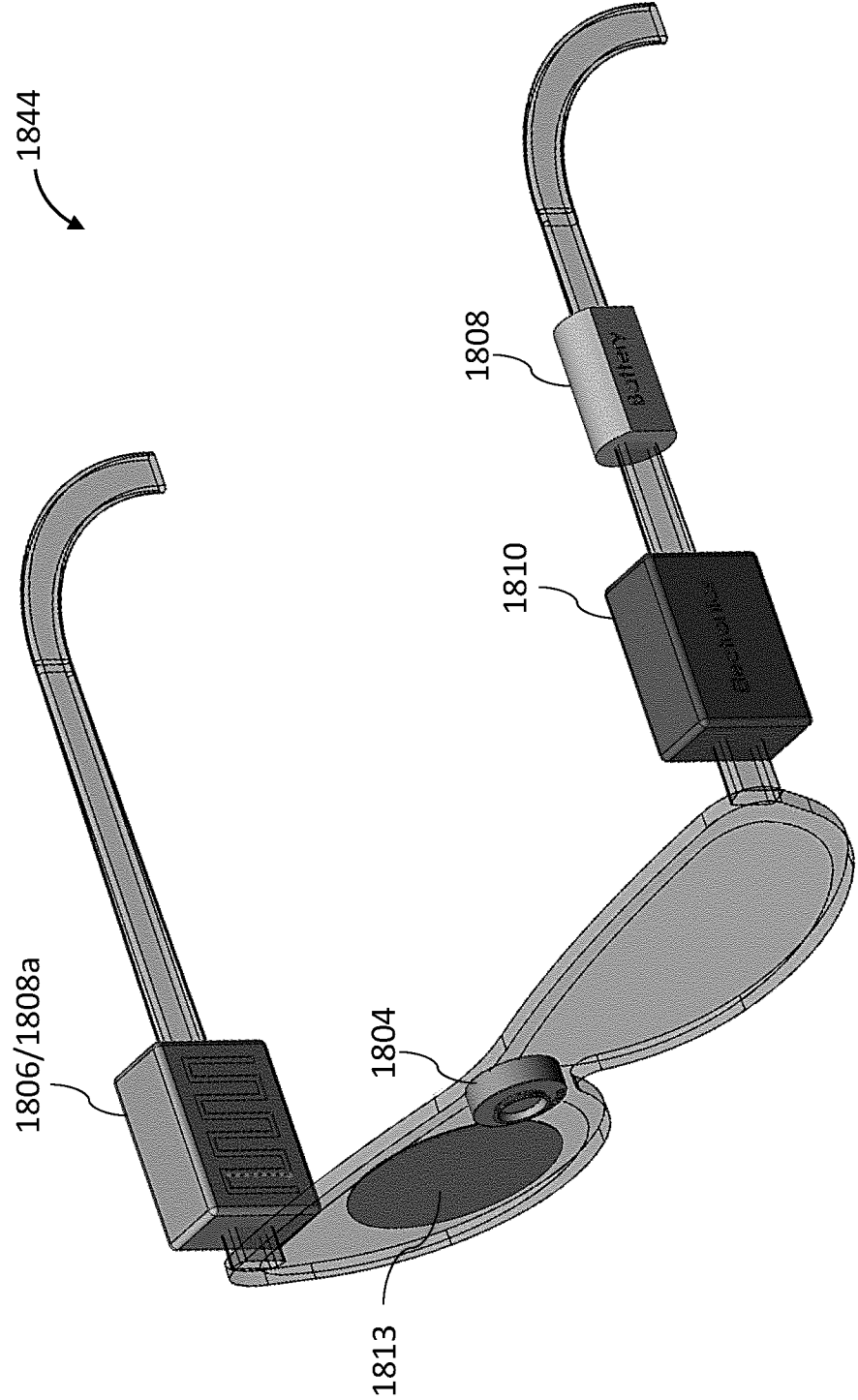


FIG. 18D

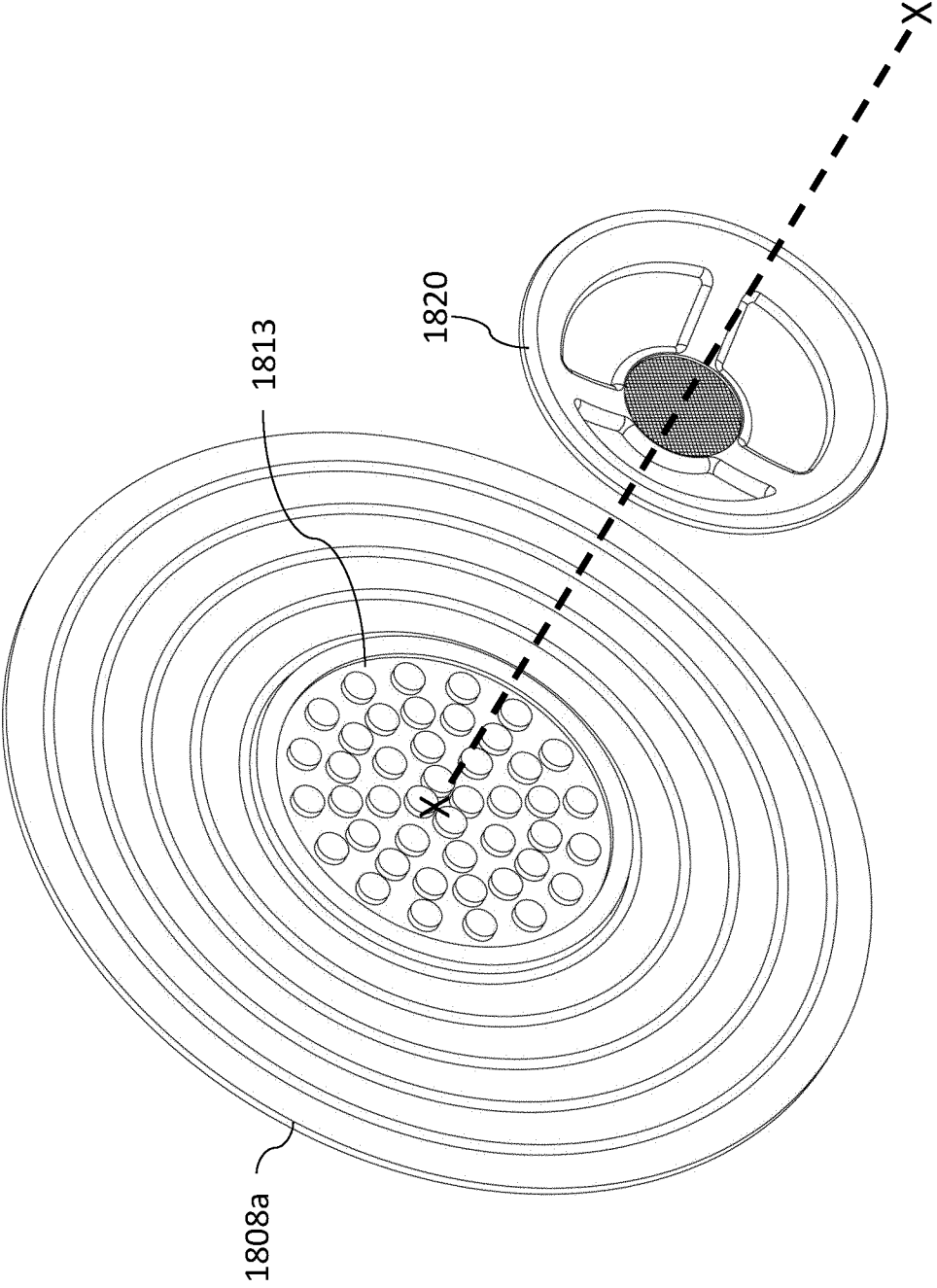


FIG. 18E

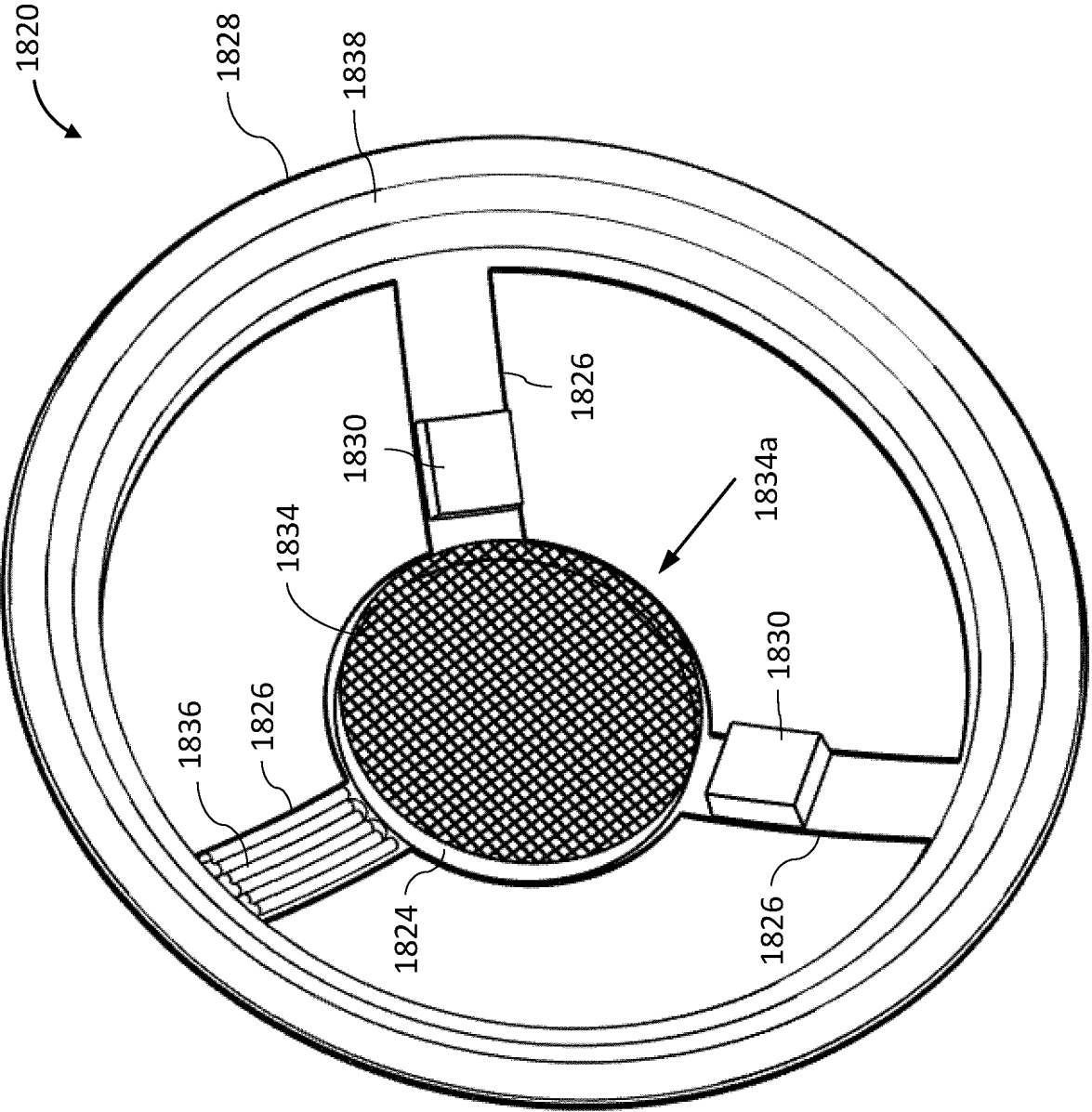


FIG. 19A

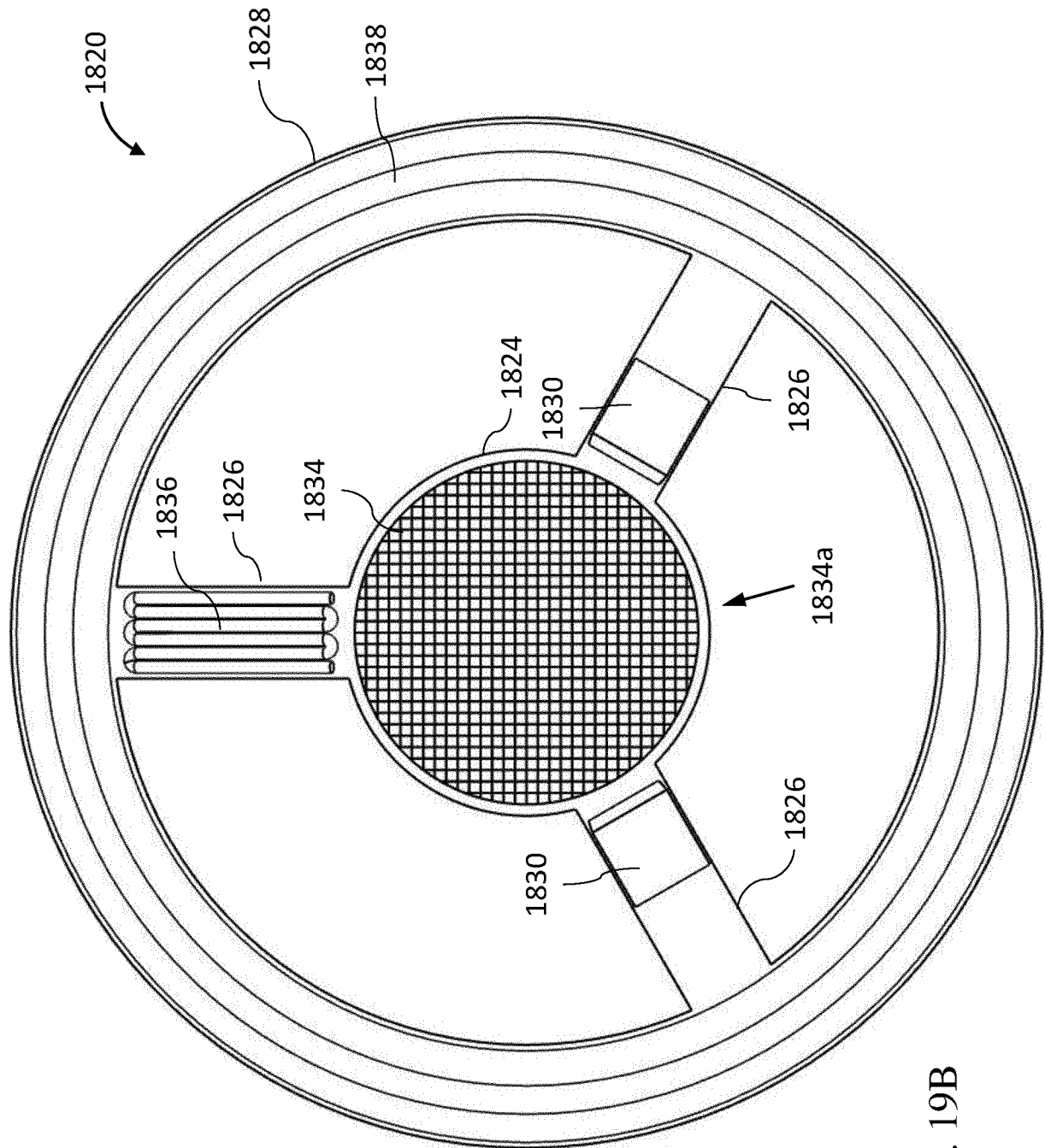


FIG. 19B

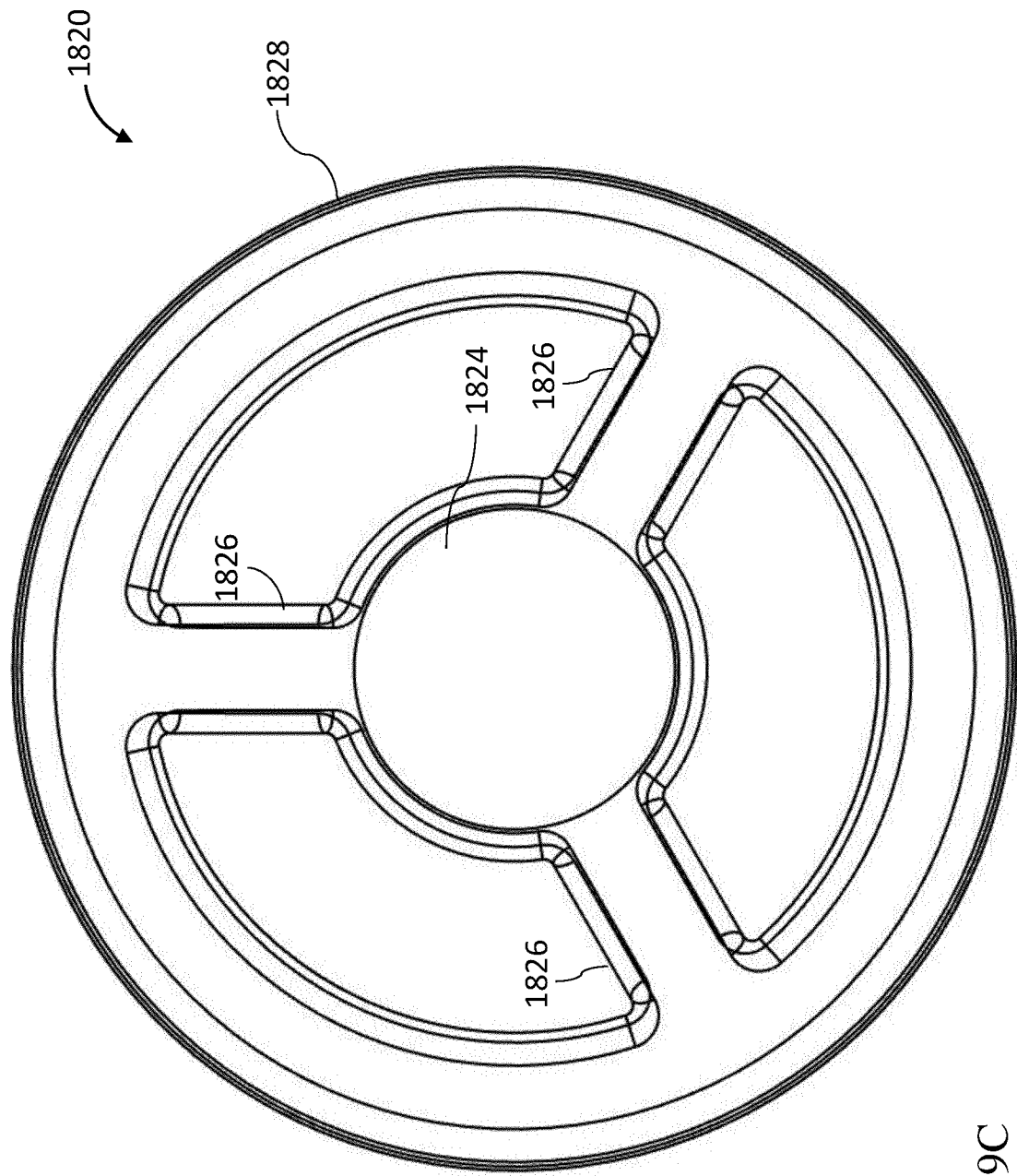


FIG. 19C

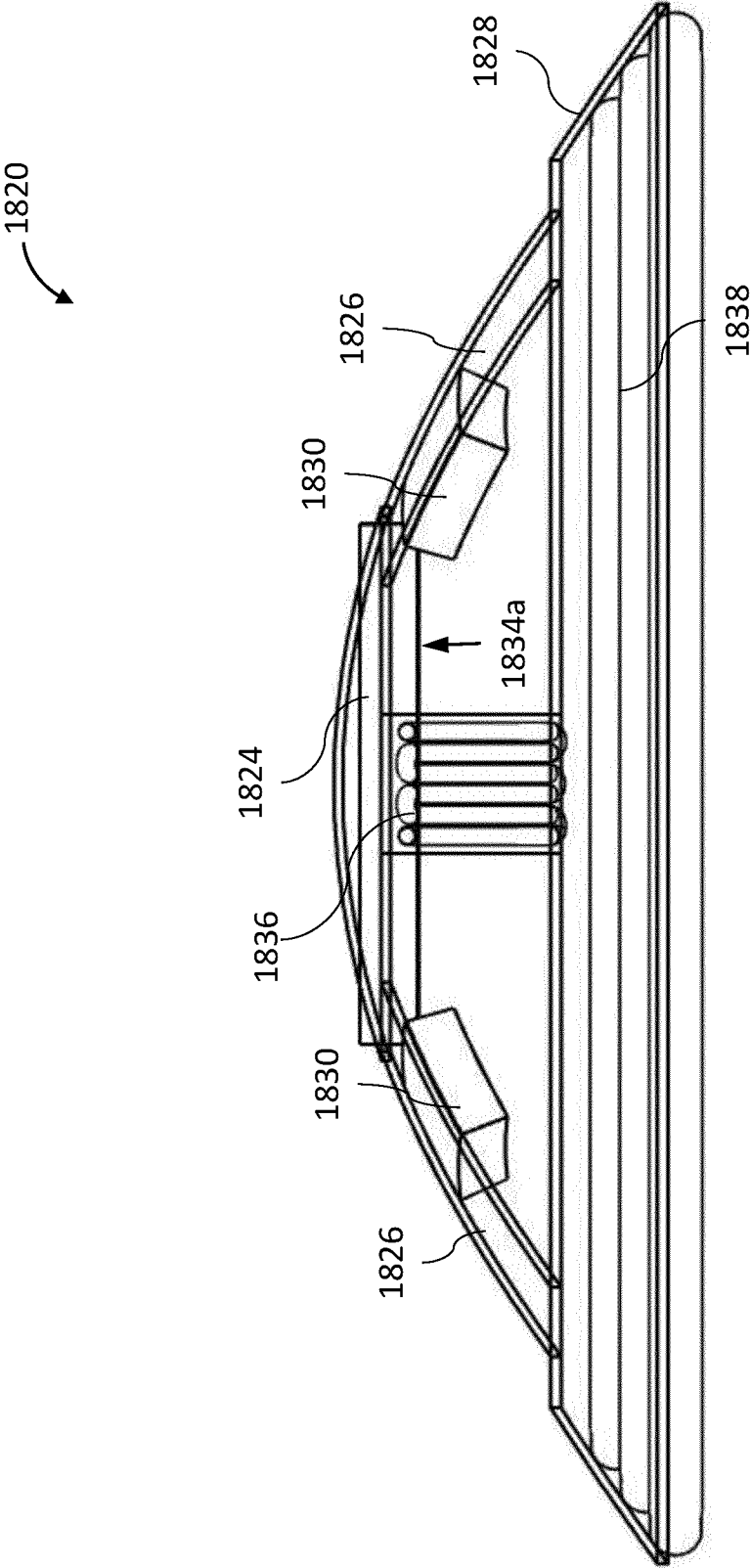


FIG. 19D

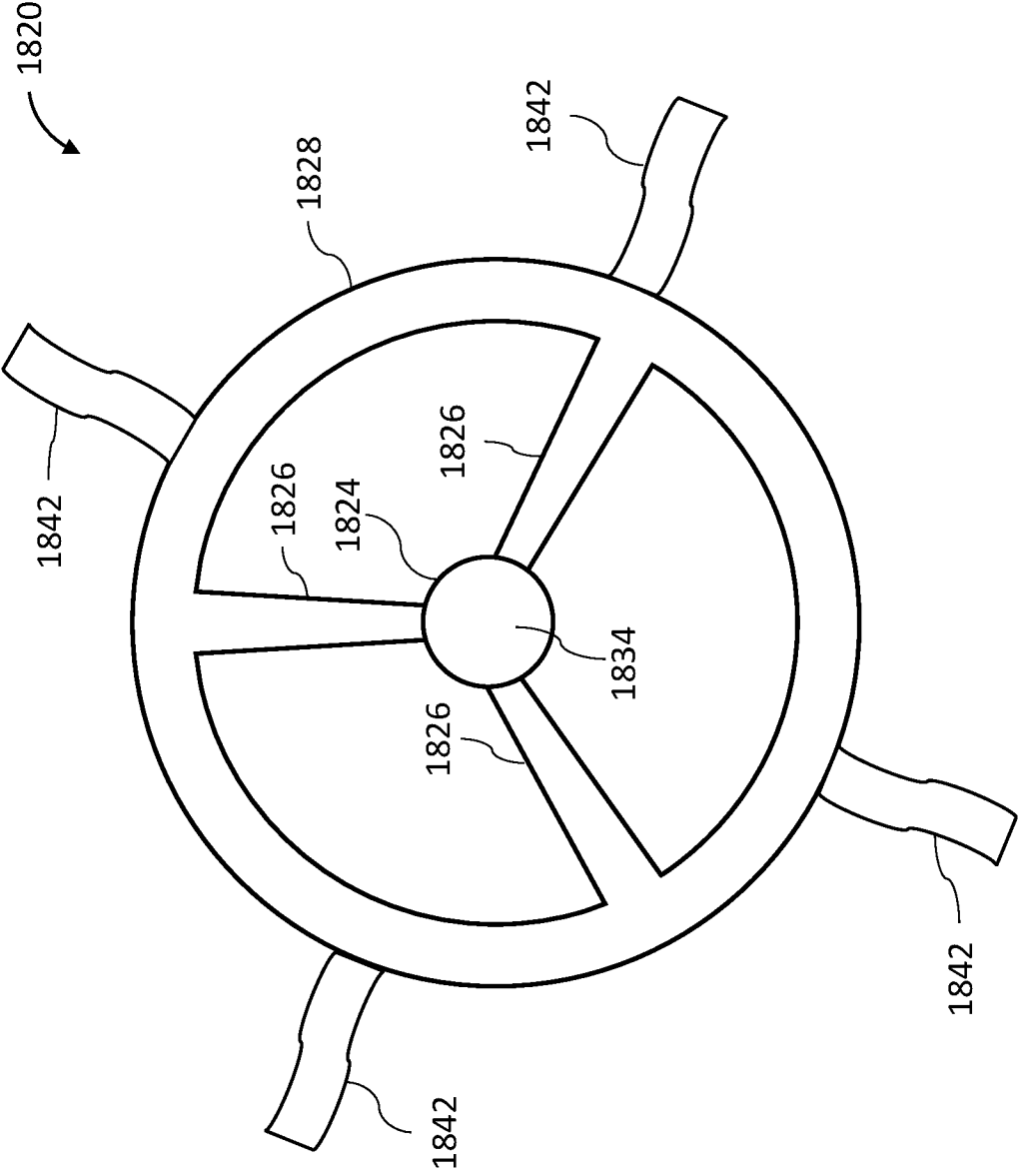


FIG. 20

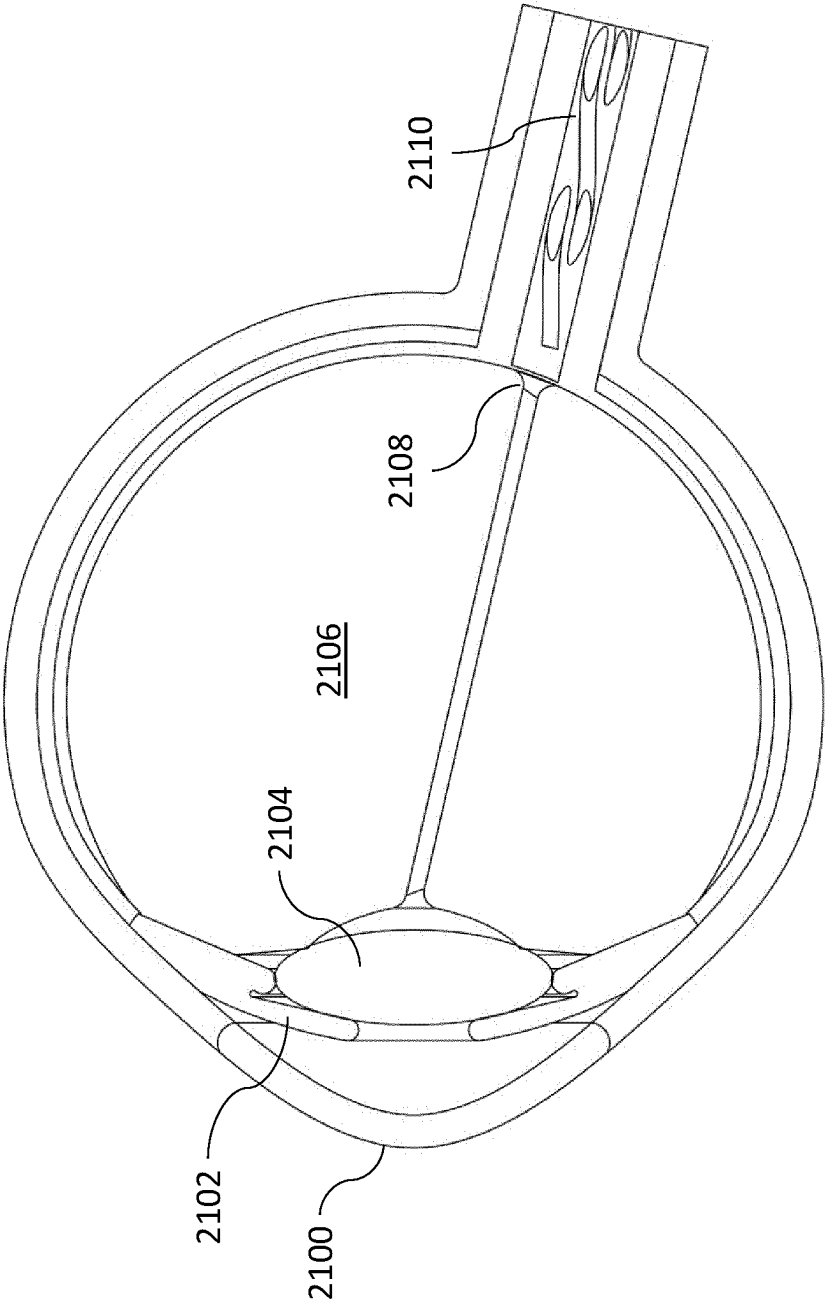


FIG. 21A

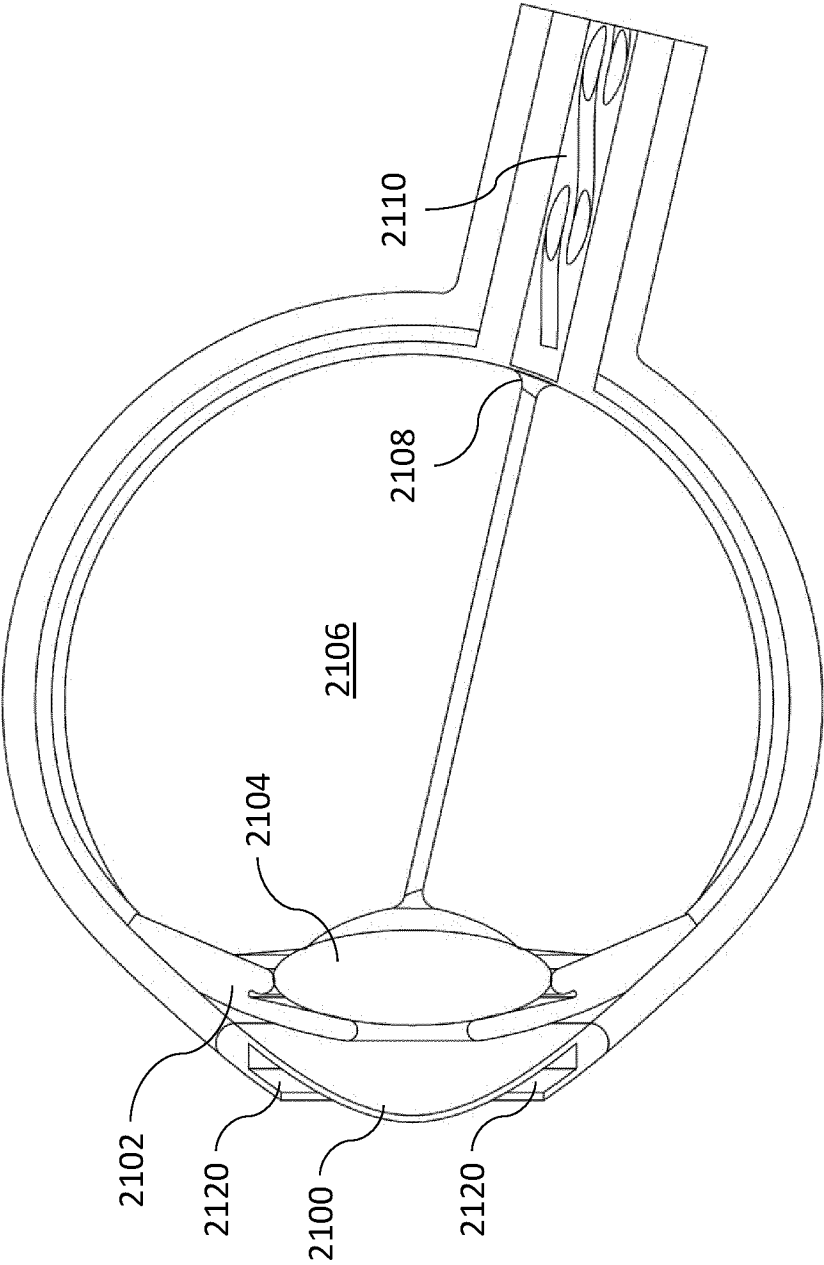


FIG. 21B

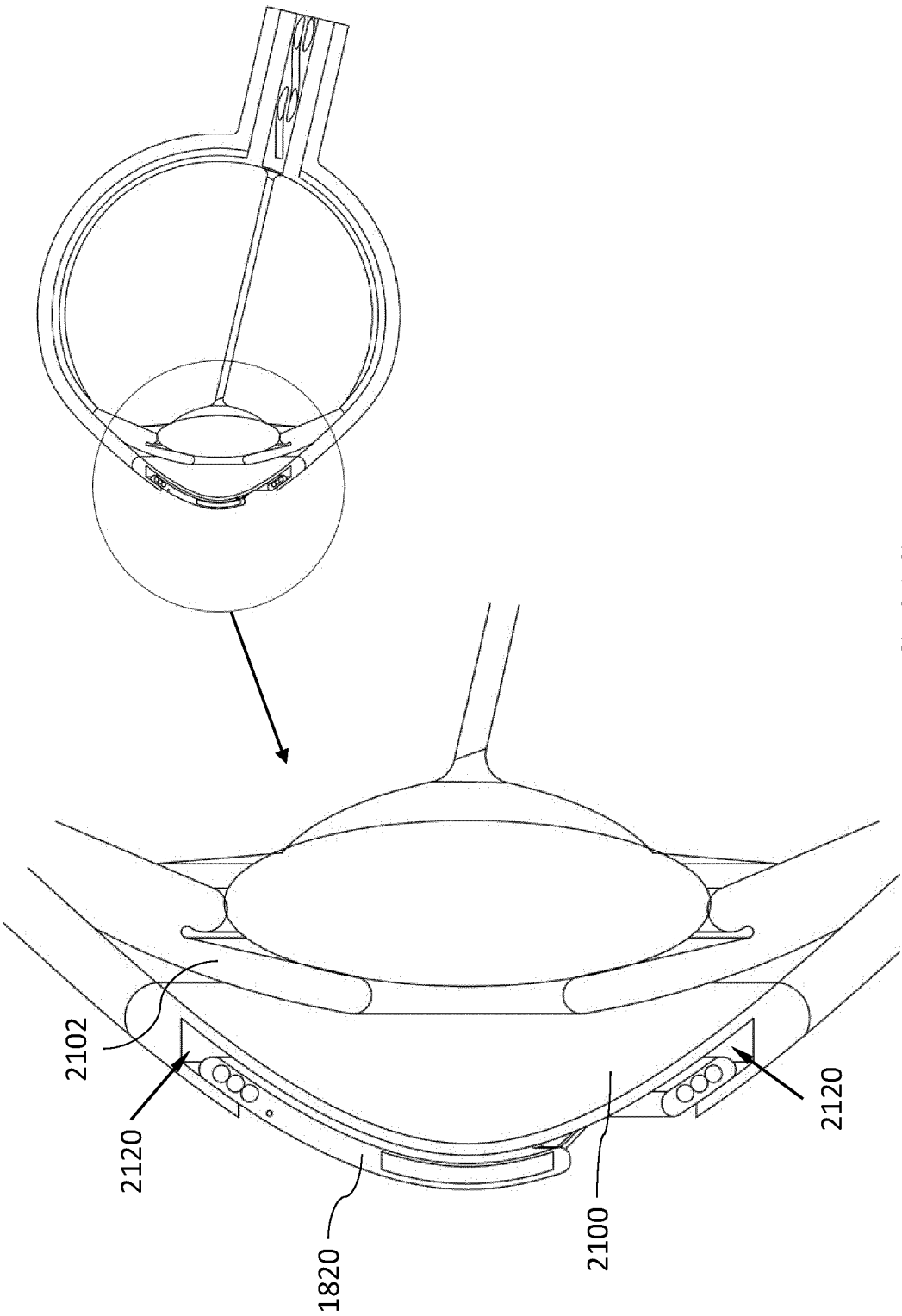


FIG. 21C

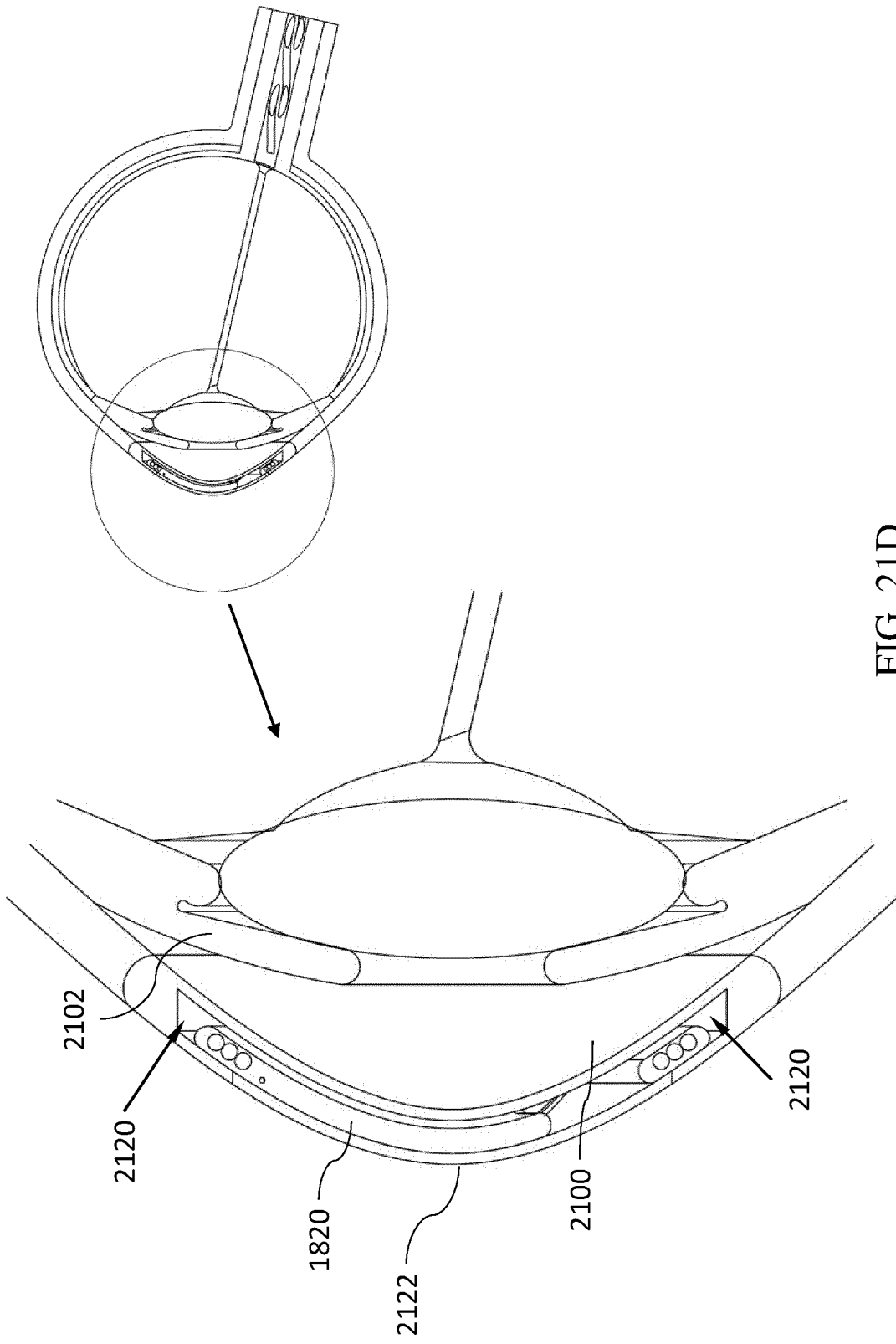


FIG. 21D

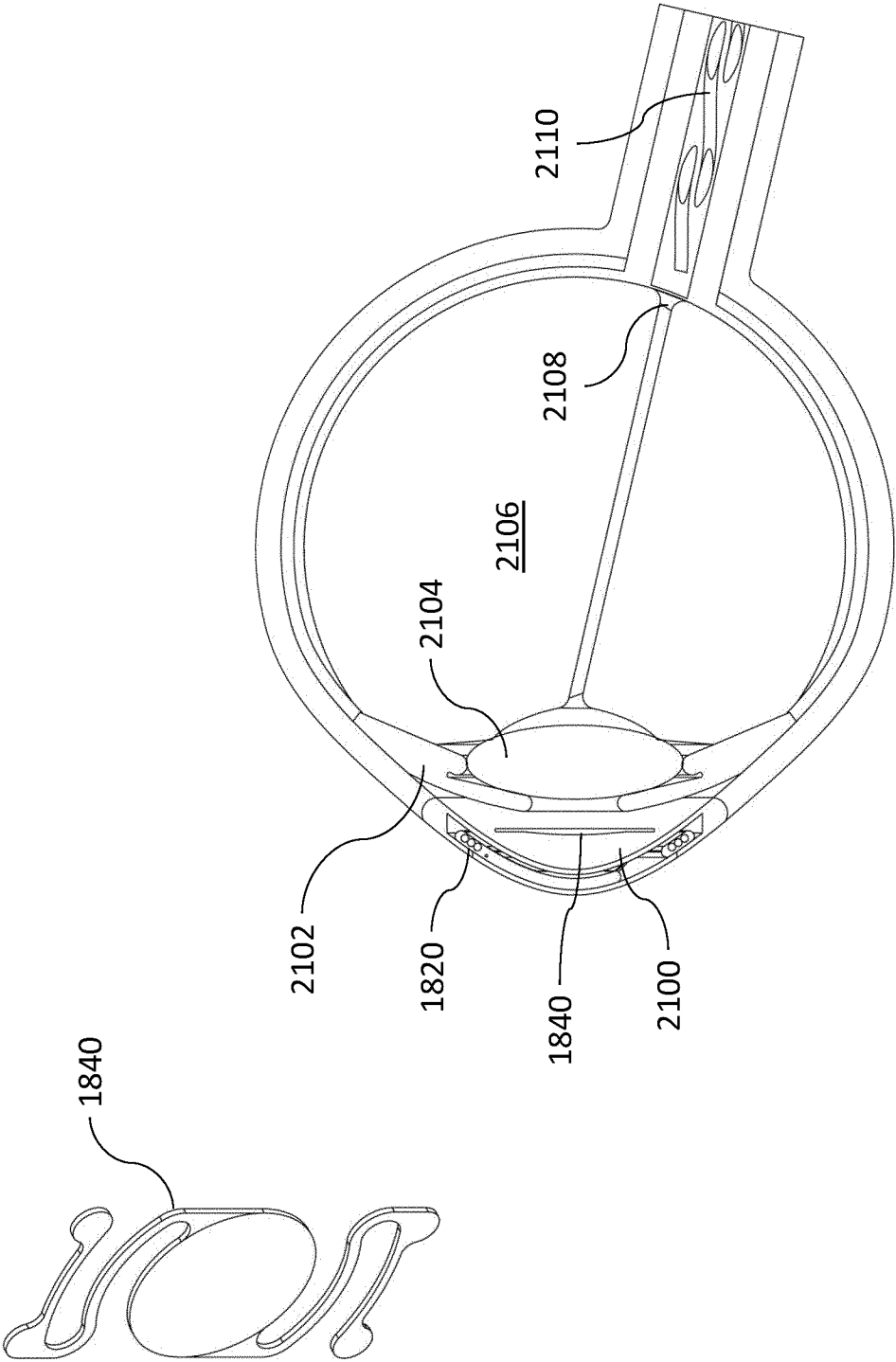


FIG. 21E

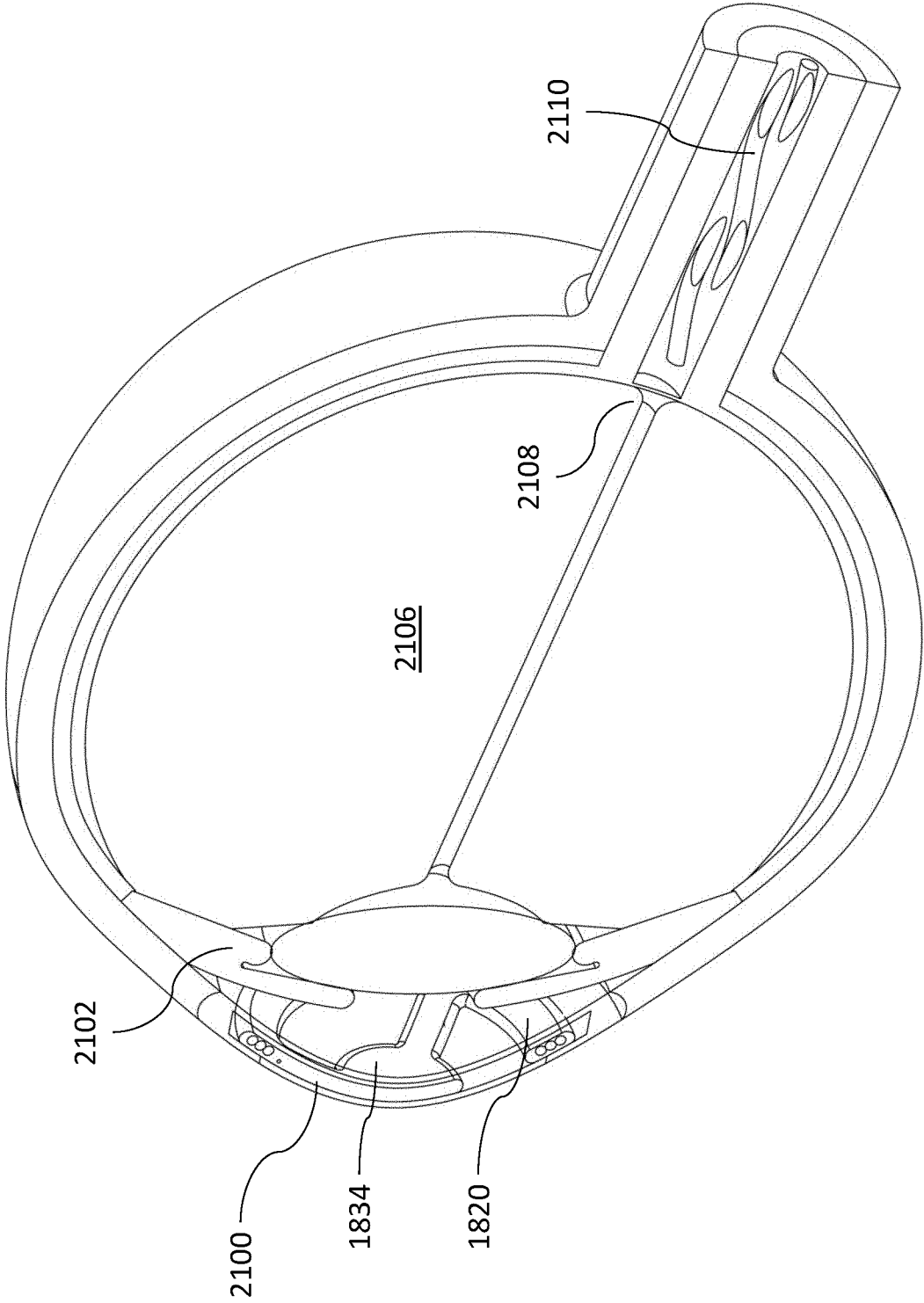


FIG. 22

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/075851

A. CLASSIFICATION OF SUBJECT MATTER INV. A61F2/14 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) A61F		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2018/039478 A1 (MASSACHUSETTS EYE & EAR INFIRMARY [US]) 1 March 2018 (2018-03-01)	1-3,
Y	paragraphs [0042] - [0050]; figures 1-6E	5-13, 15

X	WO 2019/055477 A2 (BOARD OF TRUSTEES OF THE UNIV OF ILLINOIS [US])	1-15,
Y	21 March 2019 (2019-03-21)	58-69,
Y	paragraphs [0118], [0122]; figures 7D, 10A	82-96

X	WO 2012/044624 A1 (SHIUEY YICHIEH [US]; REHAL MICHAEL [US])	1-3, 5-15
Y	5 April 2012 (2012-04-05)	14, 16, 17
Y	paragraphs [0036] - [0045]; figures 7C, 8A, 8C	14, 16, 17

-/--		
☒ 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 21 December 2022	Date of mailing of the international search report 27/02/2023	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Prechtel, A	

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2022/075851

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 458 870 A (STONE WILLIAM JR) 5 August 1969 (1969-08-05) column 2, lines 16-32; figures 2-6 -----	16, 17
Y	US 3 945 054 A (FEDOROV SVYATOSLAV NIKOLAEVICH ET AL) 23 March 1976 (1976-03-23) columns 3-4; figures 1-8 -----	16, 17
Y	US 2004/117011 A1 (AHARONI ELI [IL] ET AL) 17 June 2004 (2004-06-17) paragraph [0033]; figure 1 -----	58-69, 82-96
Y	WO 2020/231518 A1 (VERILY LIFE SCIENCES LLC [US]) 19 November 2020 (2020-11-19) paragraphs [0022], [0027]; figures 1-3 -----	58-69, 82-96

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2022/075851

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: **18-34, 70-81, 97-111**
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT – Method for treatment of the human or animal body by surgery
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:
1-17, 58-69, 82-96

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-17, 58-69, 82-96

An intracorneal implant with a central optical part and peripheral haptic implantable such the the posterior end abuts a thin layer of corneal tissue and with an image generator in the central optical part.

2. claims: 35-57

An implantable corneal tissue scaffold.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2022/075851

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2018039478 A1	01-03-2018	US 2019192281 A1 WO 2018039478 A1	27-06-2019 01-03-2018
WO 2019055477 A2	21-03-2019	EP 3664747 A2 US 2020197223 A1 WO 2019055477 A2	17-06-2020 25-06-2020 21-03-2019
WO 2012044624 A1	05-04-2012	BR 112017022623 A2 CN 103260551 A CN 107530164 A CN 108309509 A EP 2621405 A1 EP 3285688 A1 EP 3427693 A1 EP 3730093 A1 ES 2704162 T3 ES 2821423 T3 JP 6560106 B2 JP 6685265 B2 JP 7012770 B2 JP 2013540521 A JP 2016028769 A JP 2018008141 A JP 2020116406 A SA 517390208 B1 US 2015223930 A1 US 2015257873 A1 US 2020179100 A1 US 2020246133 A1 WO 2012044624 A1 WO 2016171737 A1	10-07-2018 21-08-2013 02-01-2018 24-07-2018 07-08-2013 28-02-2018 16-01-2019 28-10-2020 14-03-2019 26-04-2021 14-08-2019 22-04-2020 28-01-2022 07-11-2013 03-03-2016 18-01-2018 06-08-2020 14-11-2021 13-08-2015 17-09-2015 11-06-2020 06-08-2020 05-04-2012 27-10-2016
US 3458870 A	05-08-1969	CH 451403 A DE 1491231 A1 GB 1044420 A IT 1052956 B US 3458870 A	15-05-1968 14-05-1969 28-09-1966 31-08-1981 05-08-1969
US 3945054 A	23-03-1976	NONE	
US 2004117011 A1	17-06-2004	AU 2003288500 A1 CA 2510324 A1 CA 2759906 A1 EP 1585462 A2 ES 2623878 T3 JP 2006509575 A US 2004117011 A1 US 2005062679 A1 US 2005065602 A1 US 2005154457 A1 US 2005209691 A1 US 2005222680 A1 WO 2004054469 A2	09-07-2004 01-07-2004 01-07-2004 19-10-2005 12-07-2017 23-03-2006 17-06-2004 24-03-2005 24-03-2005 14-07-2005 22-09-2005 06-10-2005 01-07-2004
WO 2020231518 A1	19-11-2020	US 2022252849 A1 WO 2020231518 A1	11-08-2022 19-11-2020