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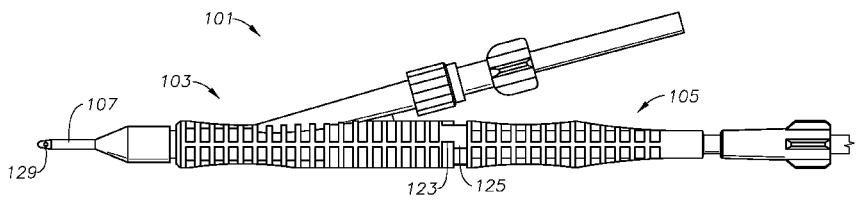


FIG. 1a

(57) Abstract: In various embodiments, a cannula device includes an irrigation handpiece portion (with a first aspiration tip for aspiration and an irrigation fluid outlet for irrigation) and an aspiration handpiece portion (configured to aspirate fluid into a second aspiration tip that extends from a distal end of the aspiration handpiece portion). The cannula device is transformable between: (a) a coaxial mode in which the aspiration handpiece portion is coupled to the irrigation handpiece portion such that fluid is aspirated through the first aspiration tip and then the second aspiration tip in series and irrigation fluid is provided through the irrigation fluid outlet, and (b) a bimanual mode in which the aspiration handpiece portion is separated from the irrigation handpiece portion to provide aspiration through the second aspiration tip while the irrigation handpiece portion continues to provide irrigation fluid through the irrigation fluid outlet.

Transformer Irrigation/Aspiration Device

Priority Claim

This application claims the benefit of priority of U.S. Provisional Patent Application Serial No. 61/831,665 titled "Transformer Irrigation/Aspiration Device", filed on June 6, 2013, whose inventors are G. Lamar Kirchhevel and Charles Kittridge Beauvias, which is hereby incorporated by reference in its entirety as though fully and completely set forth herein.

FIELD OF THE INVENTION

The present invention generally pertains to surgical devices. More particularly, but not by way of limitation, the present invention pertains to irrigation/aspiration devices.

DESCRIPTION OF THE RELATED ART

Cataract surgery may include removing a cloudy natural lens and surrounding cortex and replacing it with a clear artificial lens. Removing the natural lens may include using a powered, irrigating, vibrating tip (for lens phacoemulsification and removal) followed by an irrigating and aspirating tip for cortex removal.

Predicate cortex removal devices include coaxial and bimanual devices. The one-handed, coaxial device may include an aspirating tip surrounded by an irrigating sleeve. The two-handed, bimanual devices may include two separate instruments - one providing an irrigation cannula and the other an aspiration cannula. The coaxial device may include two tubing connections, one to provide irrigation fluid and one for aspiration vacuum while the bimanual devices may include a tubing connection for irrigation fluid on the irrigation cannula device and a separate tubing connection for vacuum on the aspiration cannula device.

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A reference herein to a patent document or any other matter identified as prior art, is not to be taken as an admission that the document or other matter was known or that the information it contains was part of the common general knowledge as at the priority date of any of the claims.

SUMMARY

Viewed from one aspect, the present invention provides a cannula device, comprising: an irrigation handpiece portion comprising a first aspiration tip configured to provide aspiration and an irrigation fluid outlet configured to provide an irrigation fluid; an aspiration handpiece portion comprising a second aspiration tip configured to provide aspiration, wherein the second aspiration tip extends from a distal end of the aspiration handpiece portion; wherein the cannula device is transformable between: a coaxial mode in which the aspiration handpiece portion is coupled to the irrigation handpiece portion such that fluid is aspirated through the first aspiration tip and then the second aspiration tip in series and the irrigation fluid is provided through the irrigation fluid outlet, and a bimanual mode in which the aspiration handpiece portion is separated from the irrigation handpiece portion to provide aspiration through the second aspiration tip while the irrigation handpiece portion continues to provide the irrigation fluid through the irrigation fluid outlet but not aspiration through the first aspiration tip.

Viewed from another aspect, the present invention provides a method, comprising: inserting an aspiration tip of an aspiration handpiece portion into a seal in an irrigation handpiece portion to place the aspiration tip of the aspiration handpiece portion in fluid communication with an aspiration pathway of the irrigation handpiece portion such that fluid entering an aspiration tip on the irrigation handpiece portion passes through an interior of the irrigation handpiece portion, into the aspiration tip of the aspiration handpiece portion, and then out of the aspiration handpiece portion; coupling the aspiration handpiece portion to the irrigation handpiece portion to form a coaxial handpiece; providing aspiration through the aspiration tip on the irrigation handpiece portion and irrigation fluid through an irrigation fluid outlet on the irrigation handpiece portion; decoupling the aspiration handpiece portion from the irrigation handpiece portion; withdrawing the aspiration tip of the aspiration handpiece portion from the seal in the irrigation handpiece portion to form two separate handpieces; and providing the irrigation fluid through the irrigation fluid outlet on the irrigation handpiece portion and aspiration through the aspiration tip on the aspiration handpiece portion.

In some embodiments, the irrigation handpiece portion and the aspiration handpiece portion may include interlocking elements for releasably coupling the distal end of the aspiration handpiece portion to the proximal end of the irrigation handpiece portion.

In coaxial mode, the aspiration handpiece portion may be coupled to the irrigation handpiece portion such that fluid is aspirated in a main incision by a first aspiration tip, on the irrigation handpiece portion, and then aspirated through a second aspiration tip, on the aspiration handpiece portion (the second aspiration tip being located at least partially inside the irrigation handpiece portion in fluid communication with the first aspiration tip). In coaxial mode, irrigation fluid may be provided through an irrigation fluid outlet on the irrigation handpiece portion. In some embodiments, the irrigation fluid outlet may be a port in an irrigation sleeve coupled to a distal end of the irrigation handpiece portion. The irrigation sleeve may at least partially surround the first aspiration tip extending from the irrigation handpiece portion.

In bimanual mode, the aspiration handpiece portion may be decoupled from the irrigation handpiece portion to provide aspiration through the second aspiration tip (placed into a second incision) while the irrigation handpiece portion continues to provide irrigation fluid through the irrigation fluid outlet (in the main incision). In bimanual mode, the irrigation handpiece portion may not provide aspiration through the first aspiration tip.

In some embodiments, the cannula device may also include a seal in a proximal end of the irrigation handpiece portion that is configured to receive the second aspiration tip when the aspiration handpiece portion is coupled to the irrigation handpiece portion. In some embodiments, the seal is cone-shaped and configured to fit within a distal portion of the irrigation handpiece portion such that the walls of the seal press against the inner wall of the irrigation handpiece portion to inhibit fluid flow between the walls of the seal and the inner wall of the irrigation handpiece portion. In some embodiments, the seal may include an O-ring configured to press against the inner wall of the irrigation handpiece portion to inhibit fluid flow between the O-ring and the inner wall of the irrigation handpiece portion. In some embodiments, the seal may be configured to inhibit aspiration fluid flow out of irrigation handpiece portion when the aspiration handpiece portion is removed from the irrigation handpiece portion. In some embodiments, the cannula device may also include a retainer to

retain the seal in the irrigation handpiece portion as the aspiration handpiece portion is inserted and withdrawn from the irrigation handpiece portion.

In some embodiments, an aspiration tip of an aspiration handpiece portion may be inserted into a seal in an irrigation handpiece portion to place the aspiration tip of the aspiration handpiece portion in fluid communication with an aspiration pathway of the irrigation handpiece portion such that fluid entering an aspiration tip on the irrigation handpiece portion passes through the interior of the irrigation handpiece portion, into the aspiration tip of the aspiration handpiece portion and then out of the aspiration handpiece portion. Once the tip is inserted, the aspiration handpiece portion may be coupled to the irrigation handpiece portion to form a coaxial handpiece. Coupling the aspiration handpiece portion to the irrigation handpiece portion may include twisting together interlocking elements on the aspiration handpiece portion and the irrigation handpiece portion. After coupling, the coaxial handpiece may then provide aspiration through the aspiration tip on the irrigation handpiece portion and irrigation fluid through an irrigation fluid outlet on the irrigation handpiece portion. To put the cannula device in bimanual mode, the aspiration handpiece portion may be decoupled from the irrigation handpiece portion and the aspiration tip of the aspiration handpiece portion may be withdrawn from the seal in the irrigation handpiece portion to form two separate handpieces. Irrigation fluid may then be provided through the irrigation fluid outlet on the irrigation handpiece portion while aspiration is provided through the aspiration tip on the aspiration handpiece portion. In some embodiments, providing irrigation fluid through the irrigation fluid outlet may include providing irrigation fluid through a port in an irrigation sleeve coupled to a distal end of the irrigation handpiece portion (the irrigation sleeve may at least partially surround the aspiration tip on the irrigation handpiece portion).

Where any or all of the terms "comprise", "comprises", "comprised" or "comprising" are used in this specification (including the claims) they are to be interpreted as specifying the presence of the stated features, integers, steps or components, but not precluding the presence of one or more other features, integers, steps or components.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is made to the following description taken in conjunction with the accompanying drawings in which:

FIGs. 1a-c illustrate the cannula device in coaxial mode, according to an embodiment;

FIG. 1d illustrates the cannula device in bimanual mode, according to an embodiment;

FIG. 2a illustrates a cross section of the coupling portion of the irrigation handpiece portion, according to an embodiment;

FIG. 2b illustrates a cross section of an alternate embodiment of the coupling portion of the irrigation handpiece portion;

FIGs. 3a-g illustrate various embodiments of the check valve;

FIGs. 4a-d illustrate insertion of the check valve and snap-in retainer into an aspiration tube, according to an embodiment;

FIG. 5 illustrates the aspiration tube with an outer O-ring, according to an embodiment;

FIGs. 6a-b illustrate the snug fit between the outer O-ring on the aspiration tube and the inner wall of the outer irrigation handpiece casing, according to an embodiment;

FIGs. 7a-d illustrate various views of the aspiration handpiece portion, according to an embodiment;

FIG. 8 illustrates a flowchart of a method for assembling the cannula device, according to an embodiment;

FIG. 9 illustrates a flowchart of a method for transforming the cannula device between coaxial and bimanual modes, according to an embodiment; and

FIG. 10 illustrates the cannula device in bimanual mode, according to an embodiment.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are intended to provide a further explanation of the present invention as claimed.

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DETAILED DESCRIPTION OF THE EMBODIMENTS

In some embodiments, an ophthalmic irrigation/aspiration cannula device 101 may support both a coaxial mode (one-handed) and a bimanual mode (two-handed). Cannula device 101 may be configured to transform between a single coaxial handpiece (as shown in FIGs. 1a-c) and separated bimanual handpieces (as shown in FIG. 1d). In both modes, irrigation fluid may be provided (e.g., into a first incision in an eye) through irrigation fluid outlet port 129 in sleeve 107 at distal end 133 of irrigation handpiece portion 103. In coaxial mode, aspiration may be provided through first aspiration tip 111 in sleeve 107, while in bimanual mode, aspiration may be provided by second aspiration tip 109 on a separated aspiration handpiece portion 105 (e.g., inserted into a second incision in the eye). In some embodiments, aspiration may not be provided through first aspiration tip 111 while in bimanual mode. When cannula device 101 is assembled for coaxial mode, the aspiration pathway may be through both the first and second aspiration tips in series, with first aspiration tip 111 inside sleeve 107 and second aspiration tip 109 inside the cannula device handle (formed at least partially from outer irrigation handpiece casing 121). Fluid may initially enter a hole in distal end 417 of first aspiration tip 111, flow through aspiration tube 117, be aspirated by second aspiration tip 109 inside the handle, and then exit cannula device 101 through connector 115 on proximal end 137 of aspiration handpiece portion 105.

In some embodiments, for bi-manual operation, cannula device 101 may be separated into the two handpieces (i.e., irrigation handpiece 103 and aspiration handpiece 105) by uncoupling aspiration handpiece portion 105 from irrigation handpiece portion 103 and removing aspiration handpiece portion 105 from irrigation handpiece portion 103. For example, as seen in FIG. 1d, aspiration handpiece portion 105 may be twisted to disengage tab 123 on aspiration handpiece portion 105 from slot 125 in irrigation handpiece portion 103 and then axially pulled to separate aspiration handpiece portion 105 from irrigation handpiece portion 103. In some

embodiments, cannula device 101 may be transformed into the two separate handpieces without adding, removing or changing tubing connections or removing sleeve 107. With aspiration handpiece portion 105 separated from irrigation handpiece portion 103, second aspiration tip 109 may then be inserted through a secondary incision in the eye for aspiration (e.g. to enable removal of sub-incision cortex). In some embodiments, cannula device 101 may be transformed back into a unitary handpiece for coaxial operation by coupling aspiration handpiece portion 105 to irrigation handpiece portion 103. For example, second aspiration tip 109 of aspiration handpiece portion 105 may be inserted into proximal end 131 of irrigation handpiece portion 103, and then aspiration handpiece portion 105 may be twisted to engage tab 123 with slot 125 to lock aspiration handpiece portion 105 to irrigation handpiece portion 103. In some embodiments, tab 123 and slot 125 may be dimensioned to provide a friction fit when aspiration handpiece portion 105 is twisted onto irrigation handpiece portion 103 to engage the tab 123 and slot 125. Other engagement mechanisms are also contemplated (e.g., tab and slot snap configuration, tube in tube friction fit, etc.)

As seen in FIG. 2a, in some embodiments, check valve 201 in irrigation handpiece portion 103 of cannula device 101 may inhibit fluid from exiting irrigation handpiece portion 103 when irrigation handpiece portion 103 and aspiration handpiece portion 105 are separated, but may allow fluid communication through tip 109 when irrigation handpiece portion 103 and aspiration handpiece portion 105 are coupled together. In some embodiments, O-ring 203 may further prevent aspiration fluid from flowing around check valve 201 between irrigation handpiece portion 103 and aspiration handpiece portion 105 when irrigation handpiece portion 103 and aspiration handpiece portion 105 are coupled together. In some embodiments, the check valve 201 and O-ring 203 may be elastomeric (e.g., made of a polymer). Other materials for the check valve and O-ring are also contemplated. In some embodiments, shallow grooves 213 in the inner wall of the outer irrigation handpiece casing 121 (e.g., see FIG. 2a) may receive corresponding ribs 501 (see FIG. 5) on

aspiration tube 117 for alignment and retention of aspiration tube 117 inside outer irrigation handpiece casing 121 and to inhibit rotation of aspiration tube 117 inside outer irrigation handpiece casing 121. In some embodiments, aspiration tube 117 may be smooth and not include ribs 501. In some embodiments, the inner wall of the outer irrigation handpiece casing 121 may be smooth (i.e., not include shallow grooves 213) and aspiration tube 117 may have a friction fit with the inner walls of irrigation handpiece casing 121. For example, ribs 501 on aspiration tube 117 may be configured to crush against the inner walls of irrigation handpiece casing 121 as aspiration tube 117 is inserted therein to provide a secure friction fit between aspiration tube 117 and irrigation handpiece casing 121.

FIG. 2b shows an alternate embodiment of irrigation handpiece portion 103 and aspiration handpiece portion 105. FIG. 2b shows a different profile for check valve 201 with a smaller base portion than shown in FIG. 2a. As shown in FIG. 2b, check valve 201 may include an axial O-ring 203 with a flat face on a side of the O-ring facing a corresponding flat face on aspiration tube 117. The rounded portion of O-ring 203 facing away from the flat face may be configured to axially press and seal against aspiration handpiece portion 105 when aspiration handpiece portion 105 is coupled to irrigation handpiece portion 103.

As seen in FIGs. 3a-b, in some embodiments, check valve 201 may be cone-shaped with aperture 207 in the tip of check valve 201 for aspiration tip 109 to pass through. In some embodiments, the aperture/tip interface may be snug such that aspiration fluid is inhibited from flowing around aspiration tip 109 when aspiration tip 109 is inserted into aperture 207. Further, aperture 207 may close or reduce in size when aspiration tip 109 is withdrawn to inhibit fluid flow through the reduced aperture when aspiration tip 109 is not present. For example, as shown in FIG. 3c, aperture 207 may be configured as a slit 207a in which both sides of slit 207a come together when aspiration tip 109 is withdrawn to prevent fluid passage through aperture 207. Aperture 207 may also include two crossing slits 207b as shown in

FIG. 3d. Other aperture shapes are also contemplated (e.g., aperture 207 may be shaped as a small circular hole 207c as shown in FIG. 3e). As seen in FIGs. 3f-g, in some embodiments, check valve 201 may include a small circular aperture 207c with a hinged flap 301. Hinged flap 301 may be formed from a transverse slit 303 (transverse as seen in the cross section of FIGs. 3f-g). Hinged flap 301 may act as a flap valve to close to form a seal when aspiration tip 109 is not present. The pressure of any fluid present in aspiration tube chamber 211 will also act to press hinged flap 301 closed. Aperture 207c may have a depth (as shown) to allow a larger tolerance for the axial position of transverse slit 303.

In some embodiments, check valve 201 may include side walls that fit against the inner walls of aspiration tube 117 inside irrigation handpiece portion 103. The snug fit between the side walls of check valve 201 and the inner walls of aspiration tube 117 may inhibit aspiration fluid flow between check valve 201 and the inner walls of aspiration tube 117. O-ring 203 may provide an additional barrier to fluid flow by further inhibiting fluid flow between O-ring 203 and the inner walls of aspiration tube 117. In some embodiments, O-ring 203 and check valve 201 may be formed of a single piece (in some embodiments, O-ring 203 and check valve 201 may be separate pieces).

In some embodiments, snap-in retainer 205 may secure O-ring 203 and check valve 201 in irrigation handpiece portion 103 when aspiration handpiece portion 105 is separated from irrigation handpiece portion 103. As seen in FIGs. 4a-b, during assembly, check valve 201 and O-ring 203 may be inserted into aspiration tube 117 followed by snap-in retainer 205 which may have tabs 401 which snap into slots 403. As seen in FIG. 4c, in some embodiments, sub-slots 405 may be sized for tabs 401 to slide into prior to tabs 401 deforming slightly and then, as seen in FIG. 4d, snapping back into slots 403. As seen in FIG. 2a, once installed, snap-in retainer 205 may inhibit removal of check valve 201 and O-ring 203. In some embodiments, snap-in retainer 205 may abut O-ring 203 or may be slightly spaced from O-ring 203. As

shown in the alternate embodiment of FIG. 2b, check valve 201 may not use snap-in retainer 205 (e.g., the friction fit between O-ring 203 and the side walls of outer irrigation handpiece casing 121 may retain check valve 201 inside outer irrigation handpiece casing 121 when aspiration handpiece portion 105 is removed).

As seen in FIG. 5, aspiration tube 117 may include an additional O-ring 119. As seen in FIGs. 6a-b, O-ring 119 may provide a friction fit between aspiration tube 117 and outer irrigation handpiece casing 121. As O-ring 119/aspiration tube 117 assembly is inserted into outer irrigation handpiece casing 121, O-ring 119 may compress inside and form a fluid tight seal with a corresponding recess in outer irrigation handpiece casing 121. In some embodiments, the fluid tight seal may inhibit irrigation fluid entering irrigation handpiece portion 103 from connector 113 from exiting proximal end 131 of irrigation handpiece portion 103. The irrigation fluid may enter irrigation handpiece portion 103 from connector 113 and flow around the outside of aspiration tube 117 between O-ring 119 and sleeve 107. Ribs 407 (as seen in FIG. 4a) may space distal end 415 of aspiration tube 117 from the inner walls of the outer irrigation handpiece casing 121 to form a channel for the irrigation fluid. Irrigation fluid may then flow through opening 411 and around aspiration tip 111 that is screwed into distal end 415 of aspiration tube 117. Sleeve 107 may snap onto or screw onto ridge 409 of outer irrigation handpiece casing 121 and receive irrigation fluid from connector 113. Irrigation fluid may then leave sleeve 107 through an irrigation fluid outlet (e.g., port 129).

As seen in FIGs. 7a-d, aspiration handpiece portion 105 may form a separated handpiece portion dedicated to aspiration for a second incision. Fluid may enter aspiration tip 109 through an aspiration port 701 (both during bimanual and coaxial mode). Aspiration tip 109 on aspiration handpiece portion 105 is shown curved, but other shapes are also contemplated (e.g., straight, angled, etc.) In some embodiments, as seen in FIG. 2a, curved aspiration tip 109 may be curved or angled to reach various anatomical structures in the eye. In some embodiments, curved aspiration tip 109

may also be curved or angled toward a bottom wall of aspiration tube 117 to more easily reach aspiration fluid being pulled into aspiration tube chamber 211 (however, cannula device 101 will also function in coaxial mode with a straight aspiration tip 109). In some embodiments, aspiration tube chamber 211 may have a larger diameter than a forward portion of aspiration tube 117 to allow aspiration fluid to pool at second aspiration tip 109 (when the coaxial handpiece is being used at an angle) to be aspirated out of second aspiration tip 109 when cannula device 101 is in coaxial mode. A vacuum may be provided in aspiration tube 117 through aspiration tip 109 when cannula device 101 is in coaxial mode.

In some embodiments, aspiration tip 111 may include a sleeve 107 (such as a polymer sleeve) coupled to (e.g., overmolded onto, screwed onto, attached through adhesive, etc.) a needle (e.g., a stainless steel cannula). Other materials for sleeve 107 and needle are also contemplated. As seen in FIG. 1b, aspiration tip 111 may include a straight needle. As seen in FIG. 1c, aspiration tip 111 and sleeve 107 may be curved. In some embodiments, as seen in FIG. 1c, aspiration tip 111 and sleeve 107 may be curved in an opposite direction (i.e., a direction that points away) from a side of irrigation handpiece portion 103 with irrigation connector 113 as irrigation connector 113 will most likely extend on the top of a surgeon's grasp and the opposite curve of aspiration tip 111 and sleeve 107 will utilize the surgical "free" space below irrigation handpiece portion 103 ("free" in the sense that the space is not obstructed by the incoming irrigation line). As seen in FIG. 1d, aspiration tip 109 may also include a curved needle. Other needle shapes for aspiration tip 111 and aspiration tip 109 are also contemplated (e.g., angled, straight, etc.) Likewise, other sleeve shapes for sleeve 107 are also possible (e.g., angled, straight, etc.) In some embodiments, the needle for aspiration tip 111 may be bare or be overmolded by a polymer coating. In some embodiments, the needle for aspiration tip 109 may be bare or may be overmolded by a polymer coating.

As seen in FIG. 2a, in some embodiments, tubing connections to irrigation handpiece portion 103 may include various medical luer fittings. For example, tubing connection 113 may include a female locking luer as shown in FIG. 2a (e.g., to couple to male connector 209). Tubing connections to aspiration handpiece portion 105 may also include various medical luer fittings (e.g., male luer 115 on proximal end 137 of aspiration handpiece portion 105 to couple to female connector 127). Other connection types are also contemplated (e.g., as seen in FIG. 2b, connector 113 may be a female connector). Connector 113 may be configured to receive an irrigation line at an angle β (e.g., β may be approximately in a range of 10 degrees to 25 degrees) to reduce bends in the irrigation line (which may inhibit fluid flow) and make aspiration handpiece portion 105 or irrigation handpeice portion 103 easier to hold in the hand). Other β angles are also contemplated (e.g., β may be approximately in a range of between 5 degrees and 90 degrees). In some embodiments, aspiration luer 115 for aspiration may be on the end of aspiration handpiece portion 105 (other locations for luer 115 are also possible). Other tubing connections for the irrigation inlet and the aspiration outlet are also contemplated (e.g., friction fit, adhesive, etc.)

FIG. 8 illustrates a flowchart for a method of assembling cannula device 101. The elements provided in the flowchart are illustrative only. Various provided elements may be omitted, additional elements may be added, and/or various elements may be performed in a different order than provided below.

At 801, aspiration tip 111 may be coupled to distal end 415 of aspiration tube 117. For example, aspiration tip 111 may be screwed into an opening in aspiration tube 117.

At 803, check valve 201 may be inserted into proximal end 413 of aspiration tube 117 until O-ring 203 of check valve 201 abuts a recessed feature 419 of aspiration tube 117.

At 805, snap-in retainer 205 may be inserted behind check valve 201 until one or more tabs 401 on snap-in retainer 205 snap into receiving holes 403 on aspiration tube 117. Other attachment mechanisms for snap-in retainer 205 may be used. For example, snap-in retainer 205 may be coupled to aspiration tube 117 through an adhesive, a friction fit, etc. In some embodiments, snap-in retainer 205 may not be used (e.g., as seen in the embodiment shown in FIG. 2b).

At 807, assembled aspiration tube 117 may be inserted into irrigation handpiece outer casing 121 until outer O-ring 119 on aspiration tube 117 abuts recessed feature 601 on the interior of irrigation handpiece outer casing 121. In some embodiments, ribs 501 may be aligned with receiving grooves 213 on the interior of outer irrigation handpiece casing 121.

At 809, aspiration tip 109 may be coupled to distal end 135 of aspiration handpiece portion 105. For example, aspiration tip 109 may be screwed into receiving threads on aspiration handpiece portion 105.

At 811, aspiration handpiece tip 109 may be inserted into check valve 201 at proximal end 131 of irrigation handpiece portion 103. As seen in FIGs. 3c-3e, check valve 201 may include aperture 207 to allow aspiration handpiece tip 109 to pass through check valve 201.

At 813, aspiration handpiece portion 105 may be coupled to irrigation handpiece portion 103. For example, the end of aspiration handpiece portion 105 may be inserted into proximal end 131 of irrigation handpiece portion 103 and then twisted to engage tab 123 on the aspiration handpiece portion 105 with slot 125 on irrigation handpiece portion 103. In some embodiments, irrigation handpiece portion 103 may have tab 123 and aspiration handpiece portion 105 may have slot 125. Other coupling techniques are also possible (e.g., a friction fit between irrigation handpiece portion 103 and aspiration handpiece portion 105).

The elements of flowchart 801-813 may also be reversed to disassemble the cannula device 101. Assembly/disassembly may allow parts or all of the cannula device 101 to be cleaned and/or sterilized in order to be reusable. In some embodiments, parts of the cannula device 101 may be reused while other parts (e.g., the aspiration tips 109 and/or 111) may be disposed of between uses (with new tips installed for each subsequent use). In some embodiments, the entire cannula device 101 may be disposable. In some embodiments, the entire cannula device 101 may be reusable.

FIG. 9 illustrates a flowchart for a method of using cannula device 101. The elements provided in the flowchart are illustrative only. Various provided elements may be omitted, additional elements may be added, and/or various elements may be performed in a different order than provided below.

At 901, assembled cannula device 101 in coaxial mode may be inserted into first incision 1001 in the eye (e.g. see incision 1001 in FIG. 10).

At 903, irrigation may be provided through sleeve 107 and aspiration may be provided through aspiration tip 111 of cannula device 101.

At 905, second incision 1003 may be made in the eye.

At 907, aspiration handpiece portion 105 may be de-coupled from irrigation handpiece portion 103. For example, as seen in FIG. 1d, aspiration handpiece portion 105 may be twisted to disengage tab 123 on aspiration handpiece portion 105 from slot 125 in irrigation handpiece portion 103 and then axially pulled to separate aspiration handpiece portion 105 from irrigation handpiece portion 103. In some embodiments, aspiration handpiece portion 105 may be removed from irrigation handpiece portion 103 while sleeve 107 and tip 111 remain in incision 1001. In some

embodiments, sleeve 107 and tip 111 may be withdrawn from incision 1001 prior to removing aspiration handpiece portion 105 from irrigation handpiece portion 103.

At 909, tip 109 of aspiration handpiece portion 105 may be inserted into second incision 1003 in the eye.

At 911, as irrigation continues through irrigation handpiece portion 103 through sleeve 107, aspiration may be provided through tip 109 of aspiration handpiece portion 105 in second incision 1003.

At 913, aspiration handpiece tip 109 may be withdrawn from second incision 1003 in the eye.

At 915, aspiration handpiece tip 109 may be inserted into check valve 201 at proximal end 131 of irrigation handpiece portion 103.

At 917, aspiration handpiece portion 105 may be coupled to irrigation handpiece portion 103. In some embodiments, aspiration handpiece portion 105 may be coupled to irrigation handpiece portion 103 while sleeve 107 and tip 111 remain in incision 1001. In some embodiments, sleeve 107 and tip 111 may be withdrawn from incision 1001 prior to coupling aspiration handpiece portion 105 to irrigation handpiece portion 103.

Various modifications may be made to the presented embodiments by a person of ordinary skill in the art. Other embodiments of the present invention will be apparent to those skilled in the art from consideration of the present specification and practice of the present invention disclosed herein. It is intended that the present specification and examples be considered as exemplary only with a true scope and spirit of the invention being indicated by the following claims and equivalents thereof.

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WHAT IS CLAIMED IS:

1. A cannula device, comprising:

an irrigation handpiece portion comprising a first aspiration tip configured to provide aspiration and an irrigation fluid outlet configured to provide an irrigation fluid;

an aspiration handpiece portion comprising a second aspiration tip configured to provide aspiration, wherein the second aspiration tip extends from a distal end of the aspiration handpiece portion;

wherein the cannula device is transformable between:

a coaxial mode in which the aspiration handpiece portion is coupled to the irrigation handpiece portion such that fluid is aspirated through the first aspiration tip and then the second aspiration tip in series and the irrigation fluid is provided through the irrigation fluid outlet, and

a bimanual mode in which the aspiration handpiece portion is separated from the irrigation handpiece portion to provide aspiration through the second aspiration tip while the irrigation handpiece portion continues to provide the irrigation fluid through the irrigation fluid outlet but not aspiration through the first aspiration tip.

2. The cannula device of claim 1, wherein the irrigation fluid outlet is a port in an irrigation sleeve coupled to a distal end of the irrigation handpiece portion, wherein the irrigation sleeve at least partially surrounds the first aspiration tip extending from the irrigation handpiece portion.

3. The cannula device of claim 1 or claim 2, further comprising a seal in a proximal end of the irrigation handpiece portion, wherein the seal is configured to receive the second aspiration tip when the aspiration handpiece portion is coupled to the irrigation handpiece portion.

4. The cannula device of claim 3, wherein the seal is cone-shaped and configured to fit within the proximal end of the irrigation handpiece portion such that walls of the seal press against an inner wall of the irrigation handpiece portion to inhibit fluid flow between the walls of the seal and the inner wall of the irrigation handpiece portion.

5. The cannula device of claim 3 or claim 4, wherein the seal comprises an O-ring configured to press against an inner wall of the irrigation handpiece portion to inhibit fluid flow between the O-ring and the inner wall of the irrigation handpiece portion.

6. The cannula device of any one of claims 3 to 5, wherein the seal is configured to inhibit aspiration fluid flow out of the irrigation handpiece portion when the aspiration handpiece portion is removed from the irrigation handpiece portion.

7. The cannula device of any one of claims 3 to 6, further comprising a retainer to retain the seal in the irrigation handpiece portion as the aspiration handpiece portion is inserted and withdrawn from the irrigation handpiece portion.

8. The cannula device of any one of claims 1 to 7, wherein the irrigation handpiece portion and the aspiration handpiece portion include interlocking elements for releasably coupling the distal end of the aspiration handpiece portion to a proximal end of the irrigation handpiece portion.

9. The cannula device of any one of claims 1 to 8, wherein the irrigation handpiece portion further comprises an irrigation connector configured to couple to an irrigation line providing the irrigation fluid to the irrigation handpiece portion and wherein the second aspiration tip is curved in a direction that points away from a side of the irrigation handpiece portion comprising the irrigation connector.

10. A method, comprising:

inserting an aspiration tip of an aspiration handpiece portion into a seal in an irrigation handpiece portion to place the aspiration tip of the aspiration handpiece portion in fluid communication with an aspiration pathway of the irrigation handpiece portion such that fluid entering an aspiration tip on the irrigation handpiece portion passes through an interior of the irrigation handpiece portion, into the aspiration tip of the aspiration handpiece portion, and then out of the aspiration handpiece portion;

coupling the aspiration handpiece portion to the irrigation handpiece portion to form a coaxial handpiece;

providing aspiration through the aspiration tip on the irrigation handpiece portion and irrigation fluid through an irrigation fluid outlet on the irrigation handpiece portion;

decoupling the aspiration handpiece portion from the irrigation handpiece portion;

withdrawing the aspiration tip of the aspiration handpiece portion from the seal in the irrigation handpiece portion to form two separate handpieces; and

providing the irrigation fluid through the irrigation fluid outlet on the irrigation handpiece portion and aspiration through the aspiration tip on the aspiration handpiece portion.

11. The method of claim 10, wherein providing the irrigation fluid through the irrigation fluid outlet comprises providing irrigation fluid through a port in an irrigation sleeve coupled to a distal end of the irrigation handpiece portion, wherein the irrigation sleeve at least partially surrounds the aspiration tip on the irrigation handpiece portion.

12. The method of claim 10 or claim 11, wherein coupling the aspiration handpiece portion to the irrigation handpiece portion comprises twisting together interlocking elements on the aspiration handpiece portion and the irrigation handpiece portion.

13. The method of any one of claims 10 to 12, wherein coupling the aspiration handpiece portion to the irrigation handpiece portion and decoupling the aspiration handpiece portion from the irrigation handpiece portion does not require removing irrigation or aspiration tubing connections and does not require removing a sleeve from the irrigation handpiece portion.

14. The cannula device of any one of claims 1 to 9, wherein both the first aspiration tip and second aspiration tip are curved.

25 15. The cannula device of claim 1, wherein the irrigation handpiece portion further comprises a sleeve having a distal end and a proximal end, wherein the proximal end is coupled to the irrigation handpiece portion and wherein the irrigation fluid exits the sleeve through the distal end, and wherein in the coaxial mode, the first aspiration tip extends to the distal end of the sleeve.

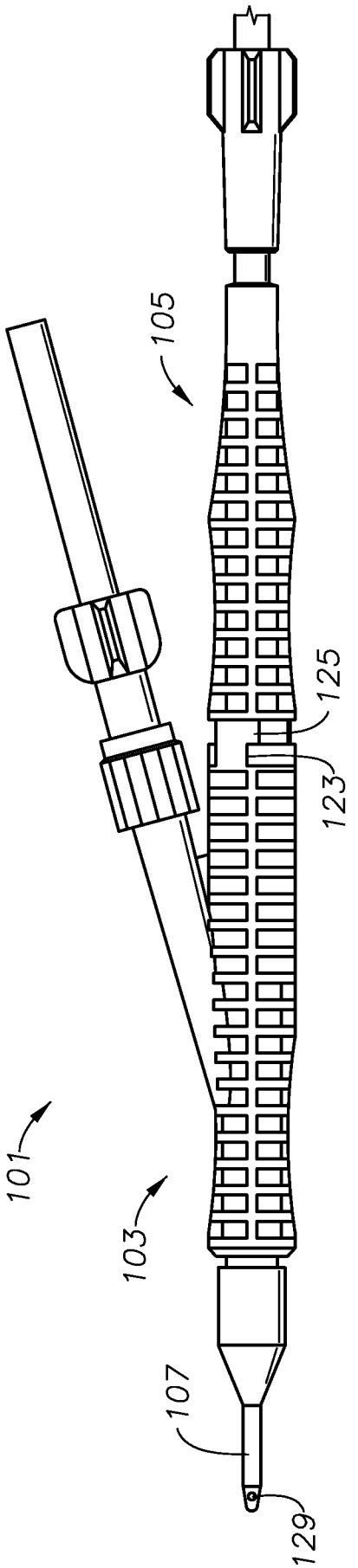

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FIG. 1a

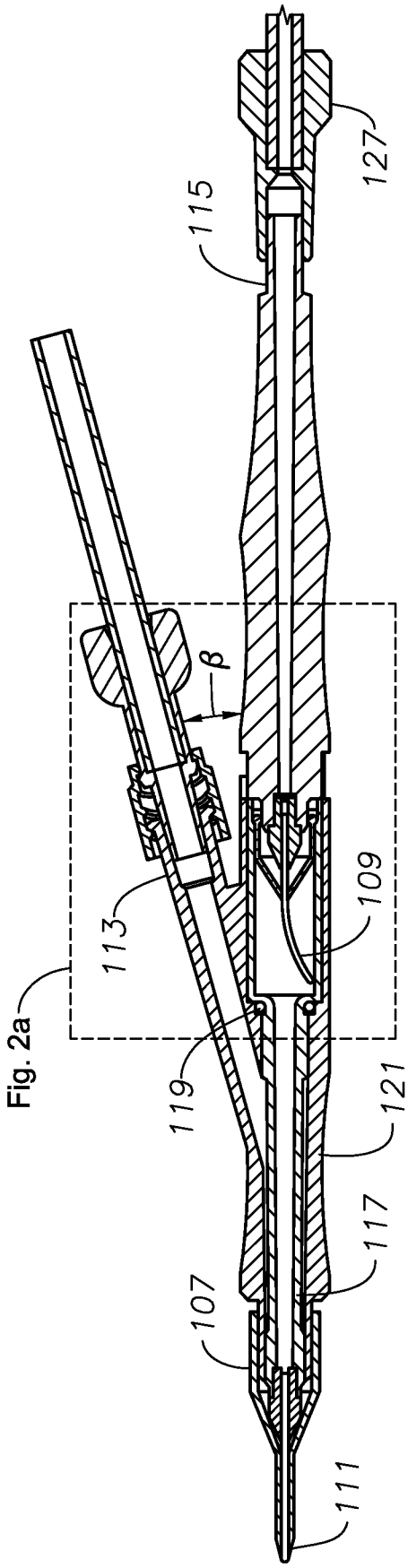

β
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Fig. 2a

FIG. 1b

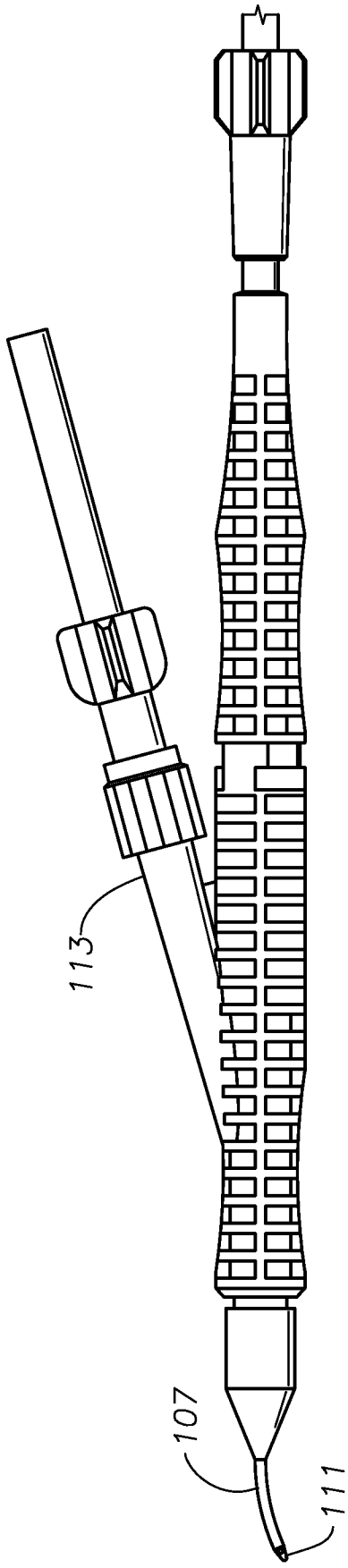


FIG. 1c

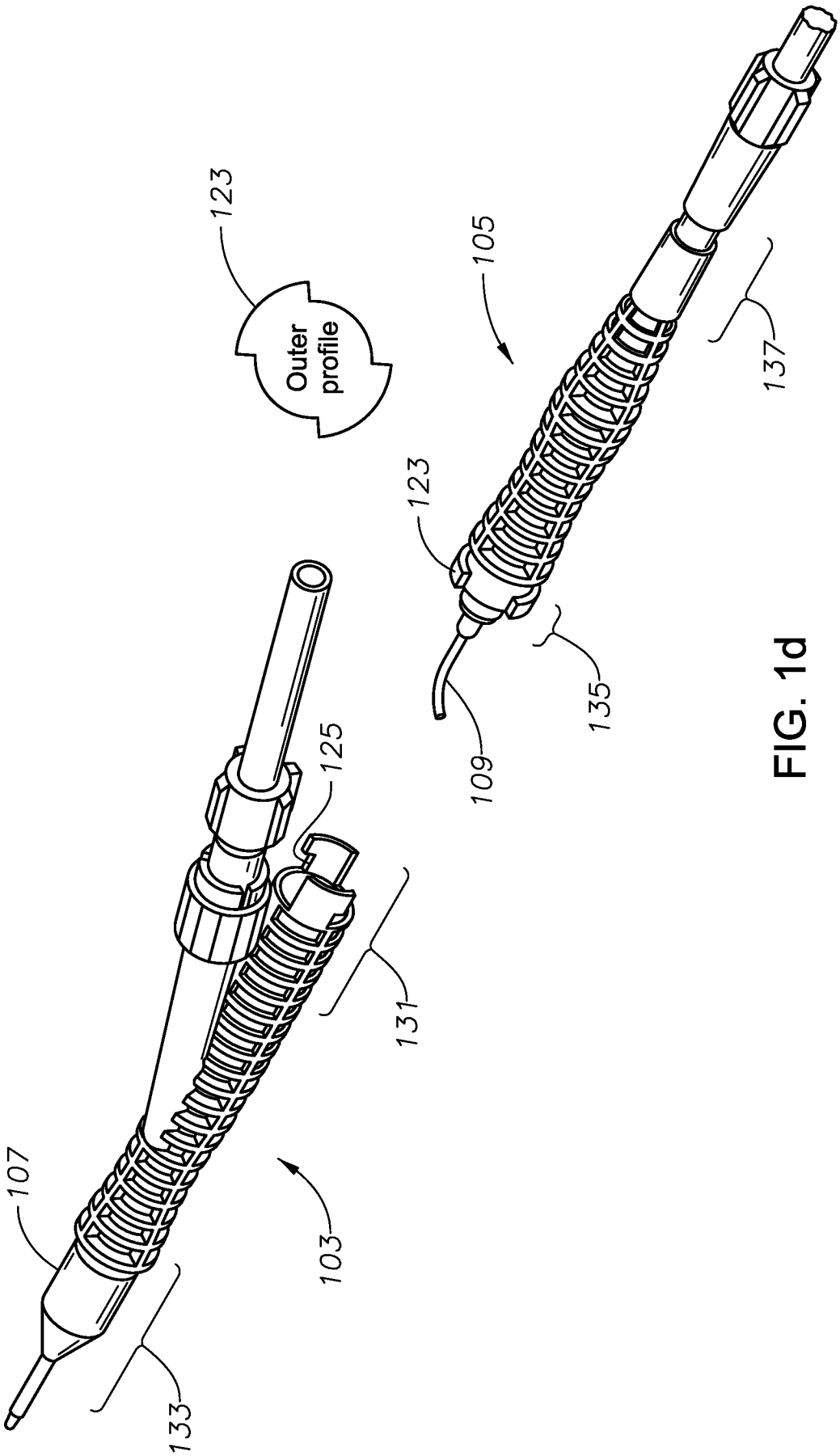


FIG. 1d

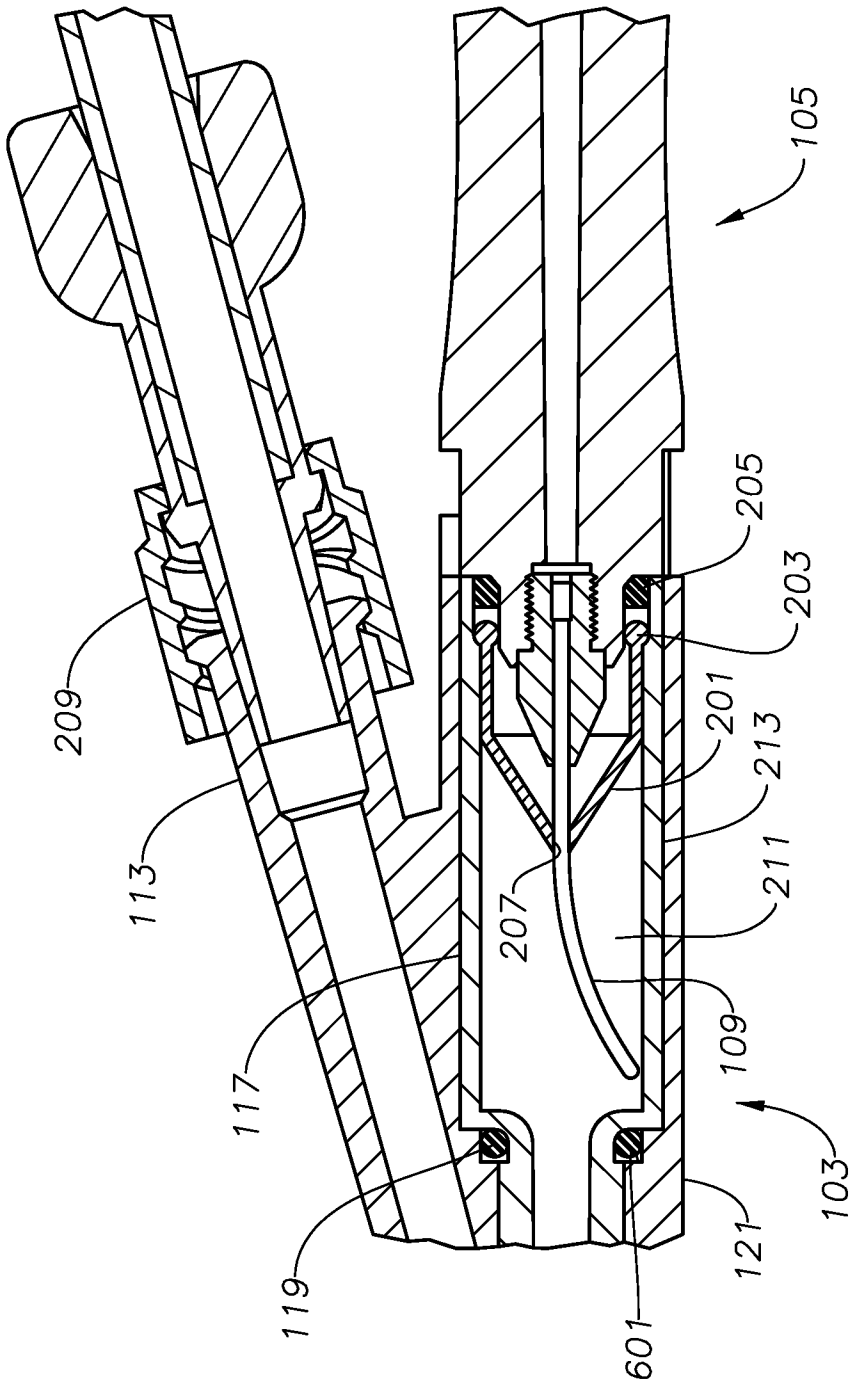


FIG. 2a

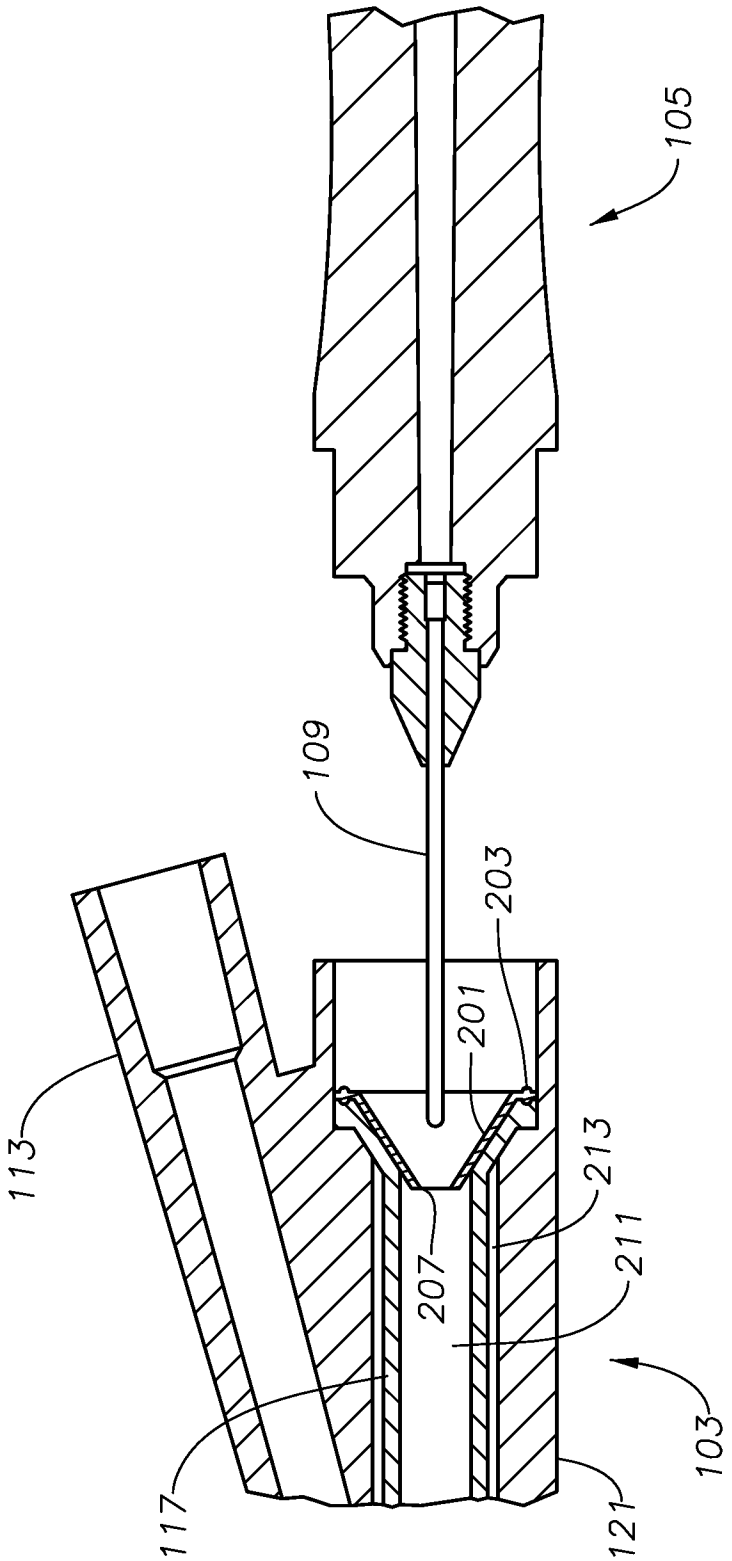


FIG. 2b

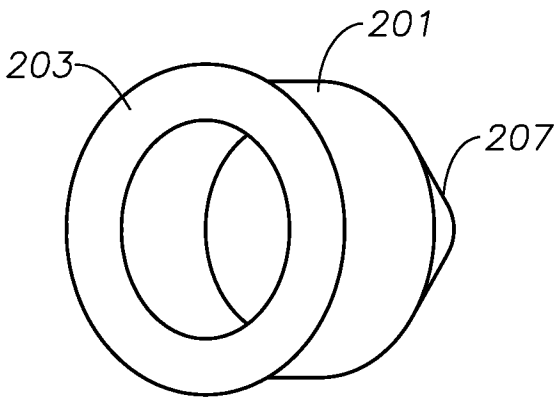


FIG. 3a

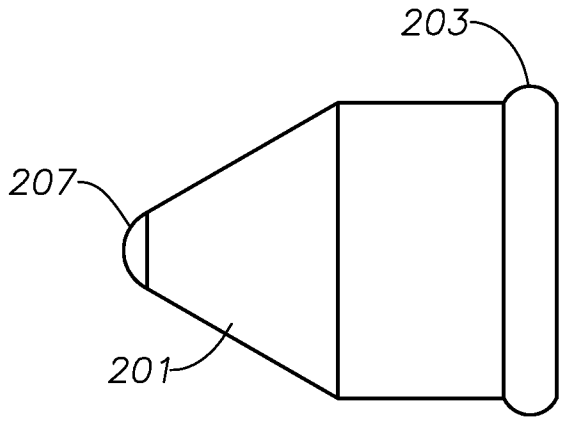


FIG. 3b

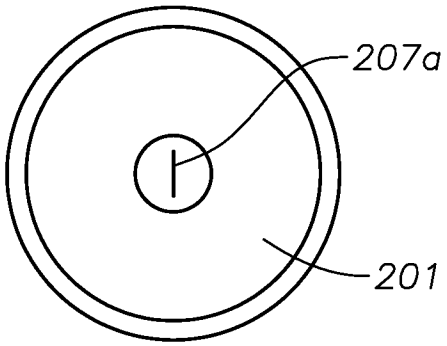


FIG. 3c

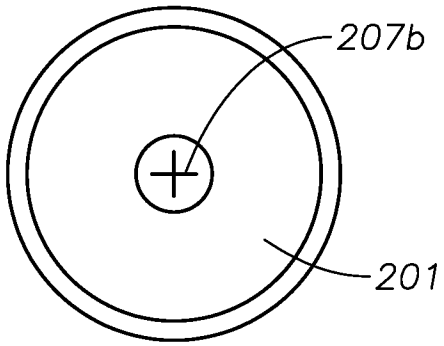


FIG. 3d

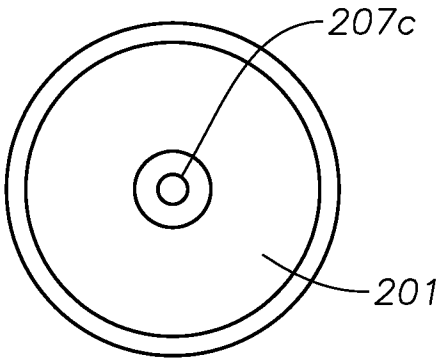


FIG. 3e

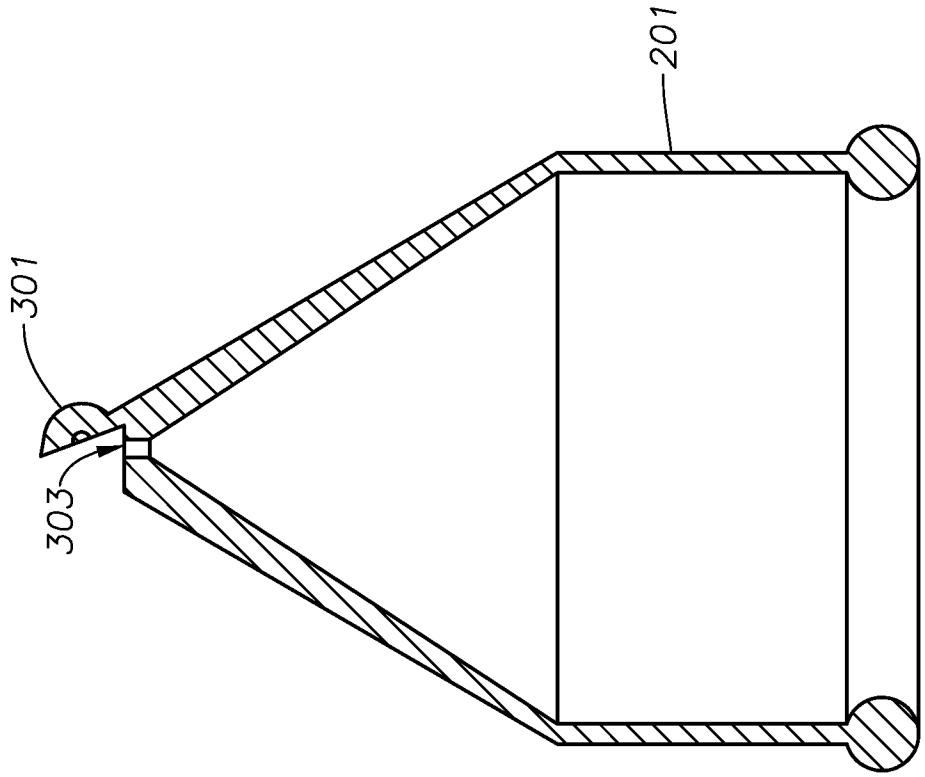


FIG. 3g

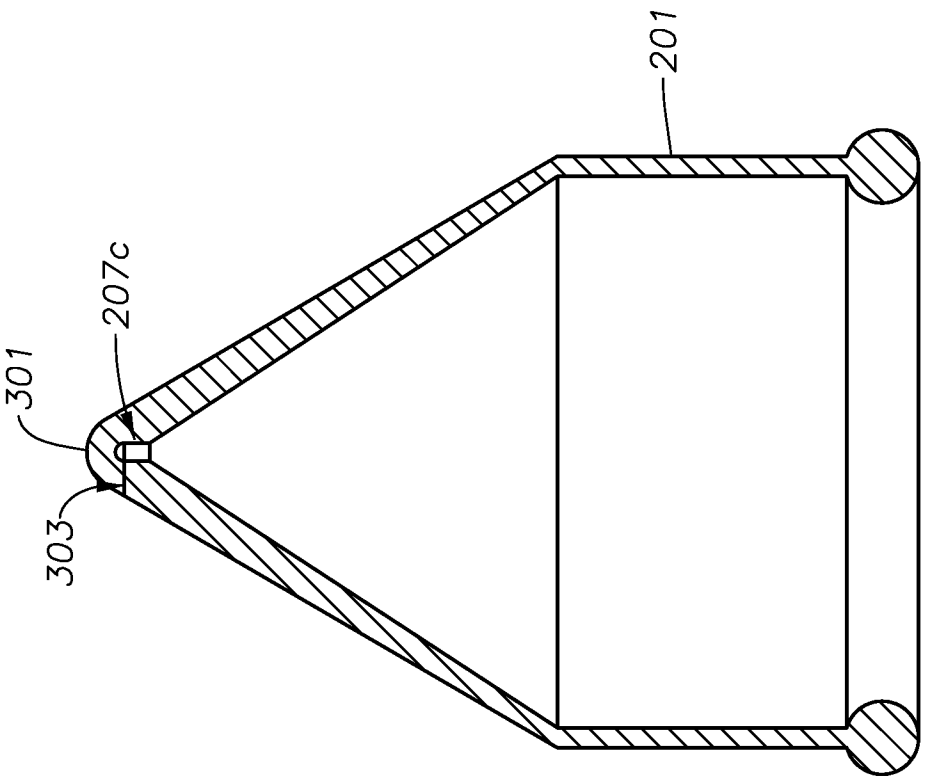


FIG. 3f

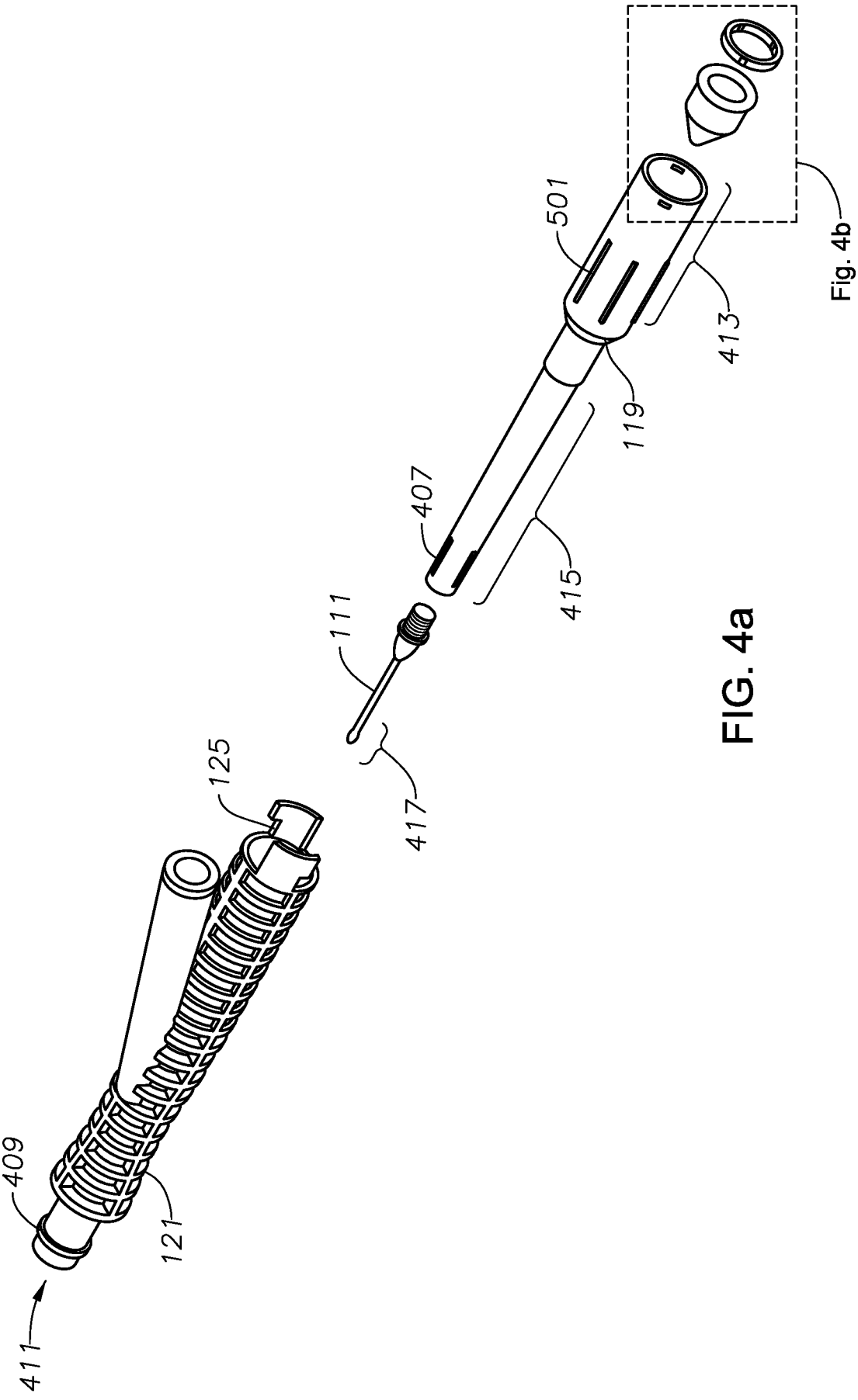


FIG. 4a

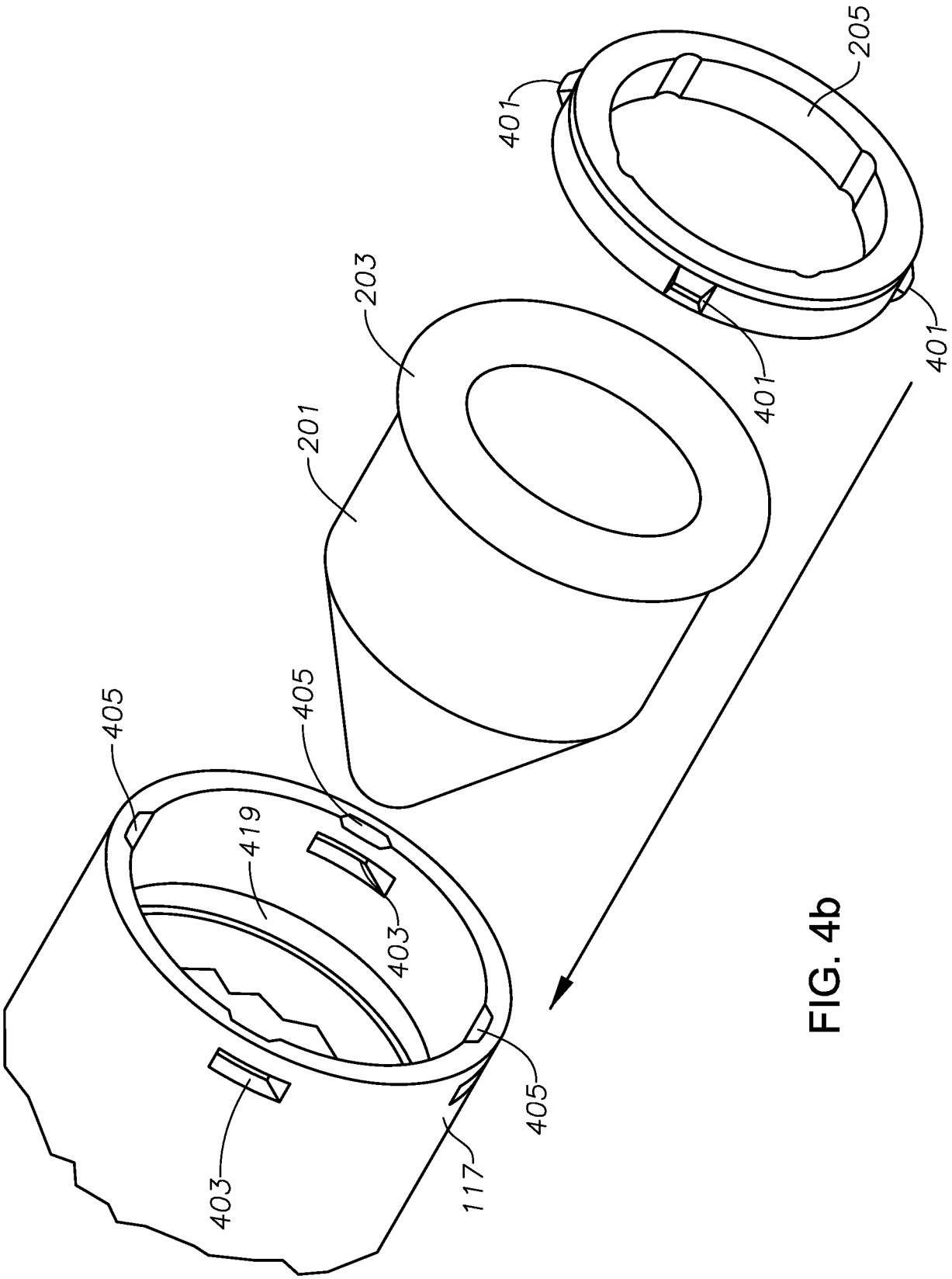


FIG. 4b

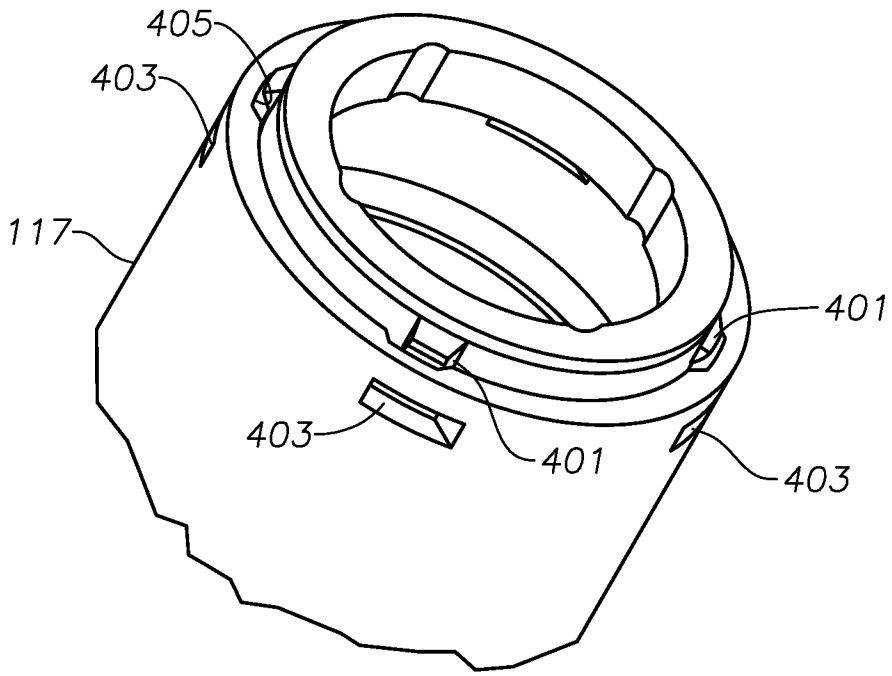


FIG. 4c

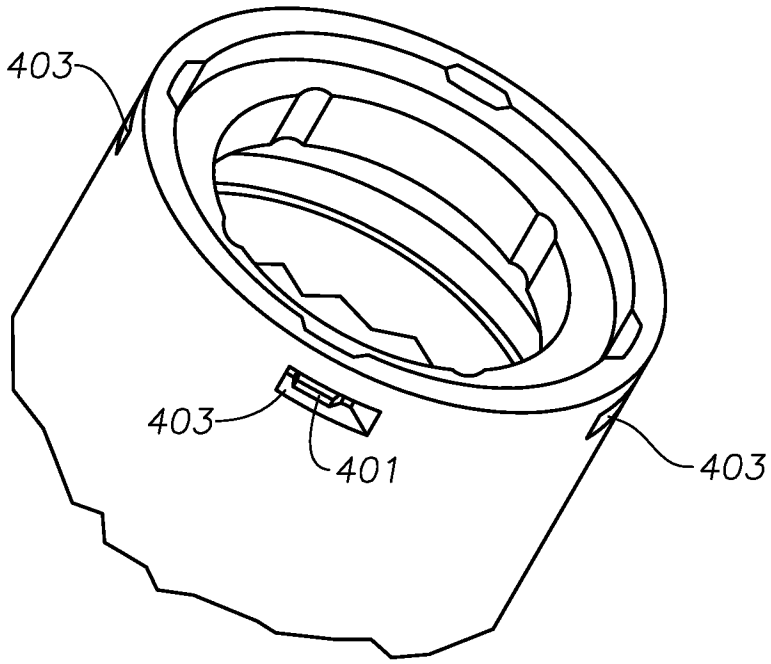


FIG. 4d

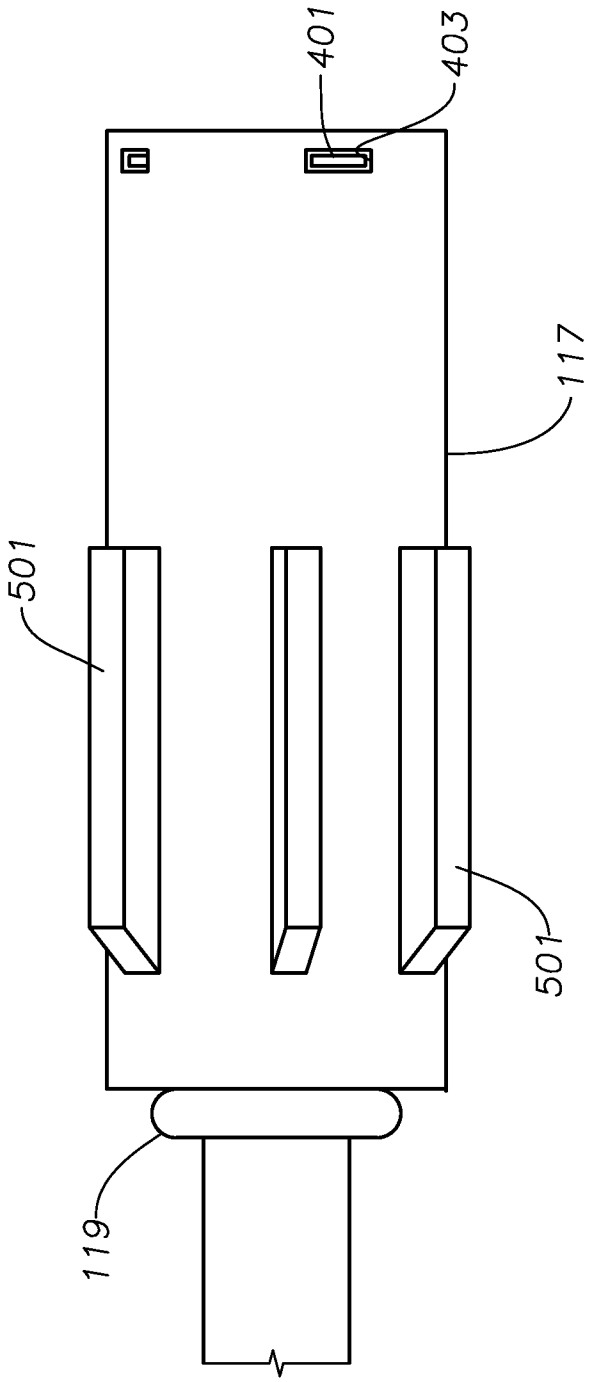


FIG. 5

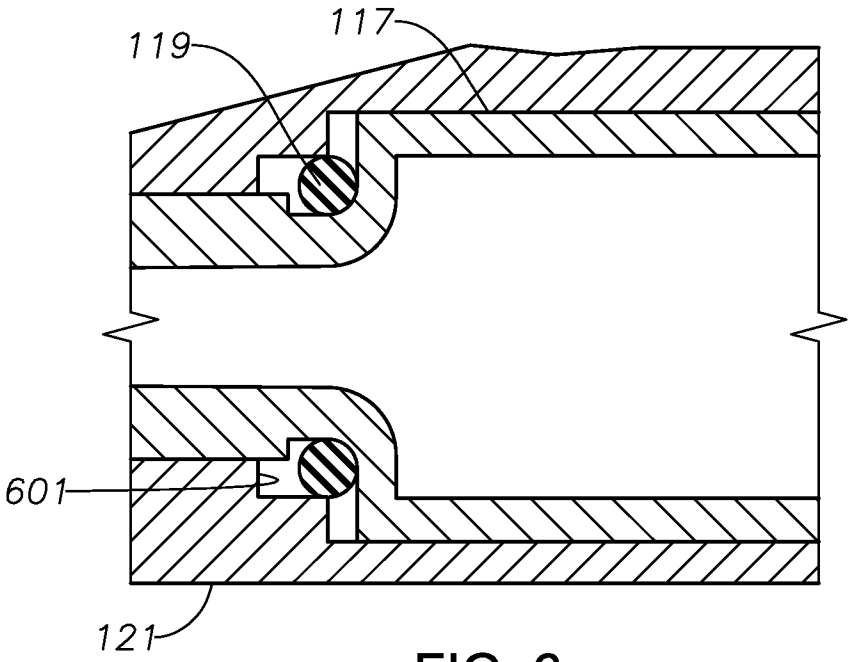


FIG. 6a

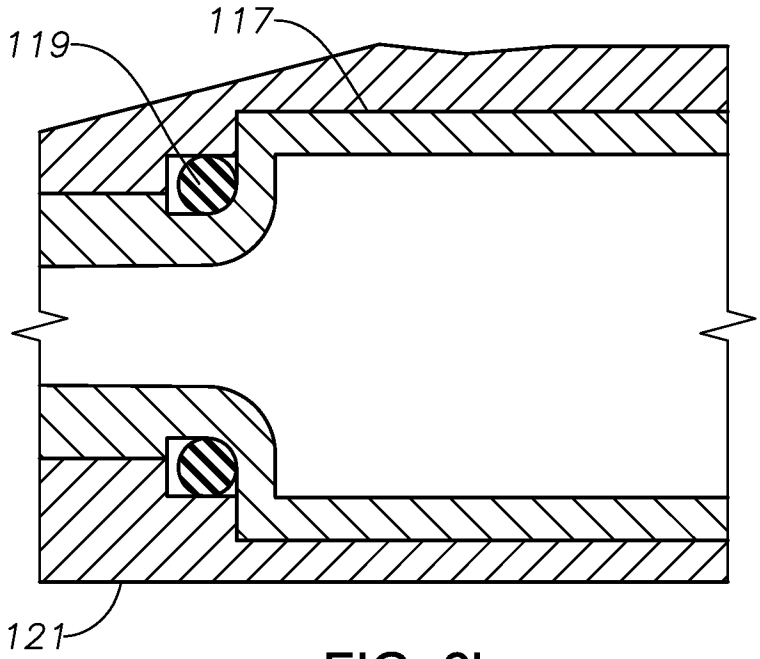


FIG. 6b

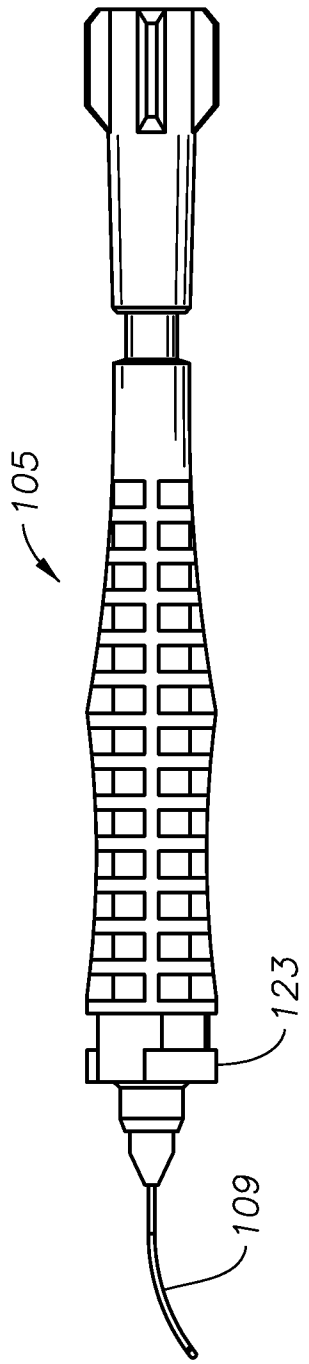


FIG. 7b

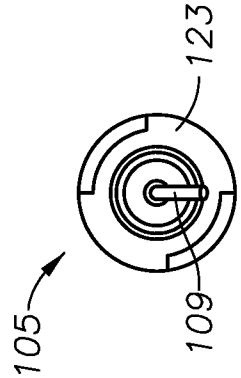


FIG. 7a

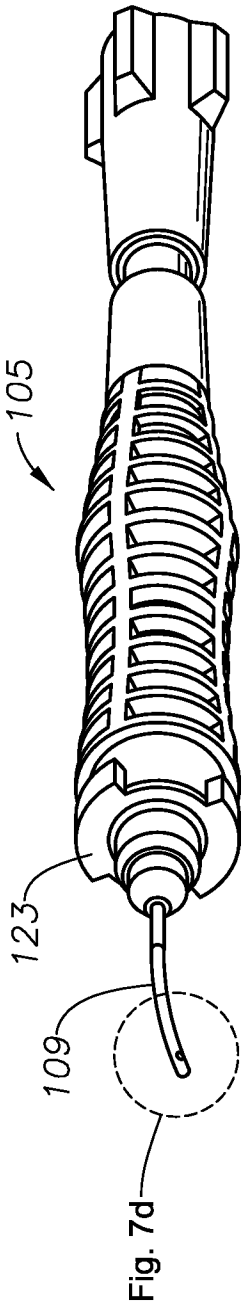


FIG. 7c

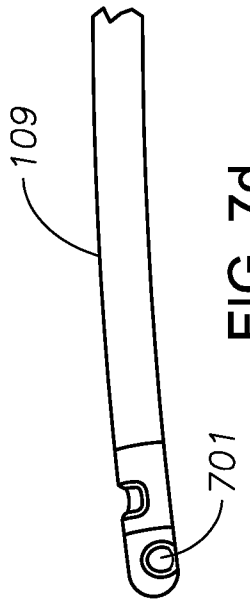


FIG. 7d

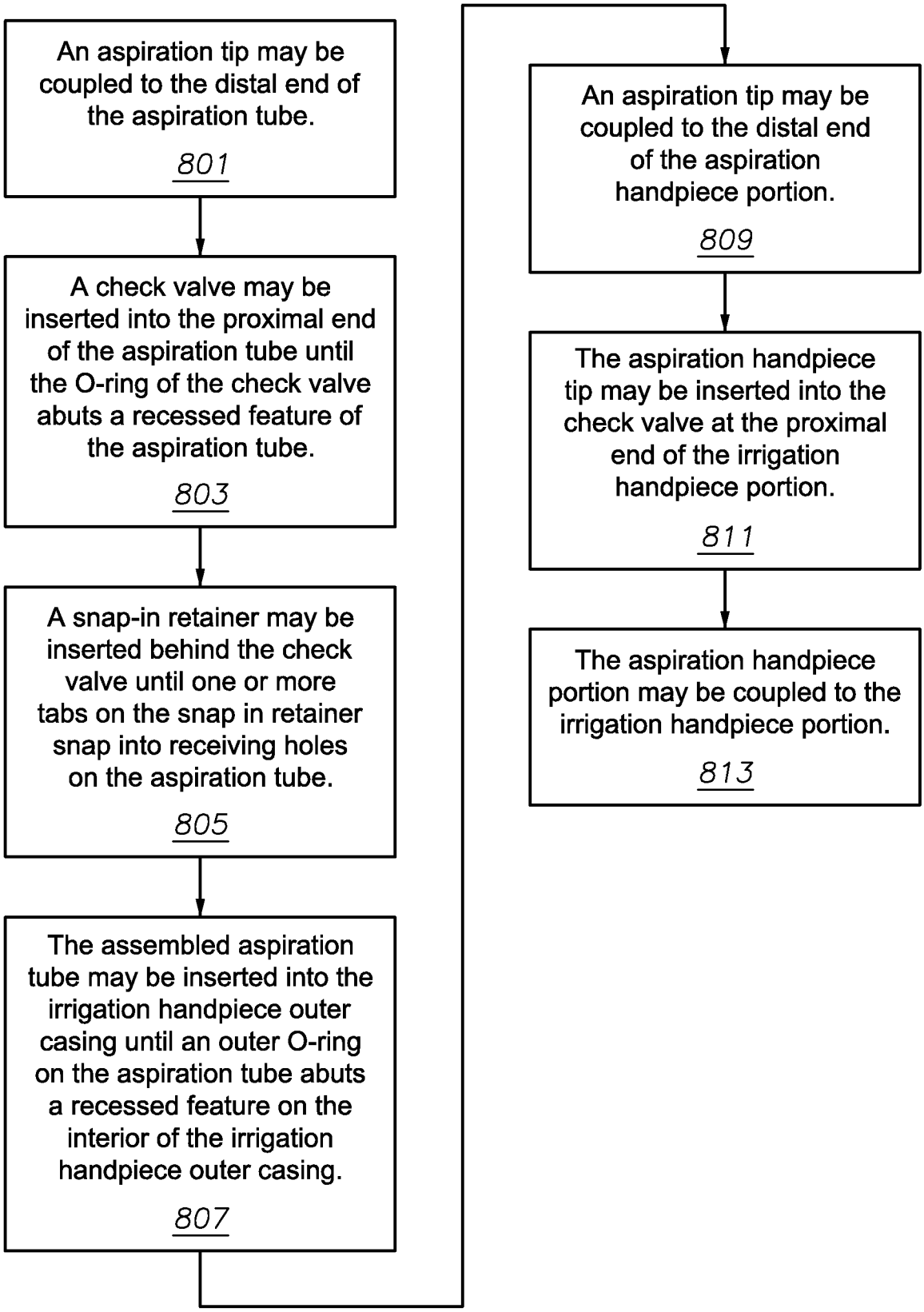

An aspiration tip may be coupled to the distal end of the aspiration tube.
801
A check valve may be inserted into the proximal end of the aspiration tube until the O-ring of the check valve abuts a recessed feature of the aspiration tube.
803
A snap-in retainer may be inserted behind the check valve until one or more tabs on the snap in retainer snap into receiving holes on the aspiration tube.
805
The assembled aspiration tube may be inserted into the irrigation handpiece outer casing until an outer O-ring on the aspiration tube abuts a recessed feature on the interior of the irrigation handpiece outer casing.
807
An aspiration tip may be coupled to the distal end of the aspiration handpiece portion.
809
The aspiration handpiece tip may be inserted into the check valve at the proximal end of the irrigation handpiece portion.
811
The aspiration handpiece portion may be coupled to the irrigation handpiece portion.
813

FIG. 8

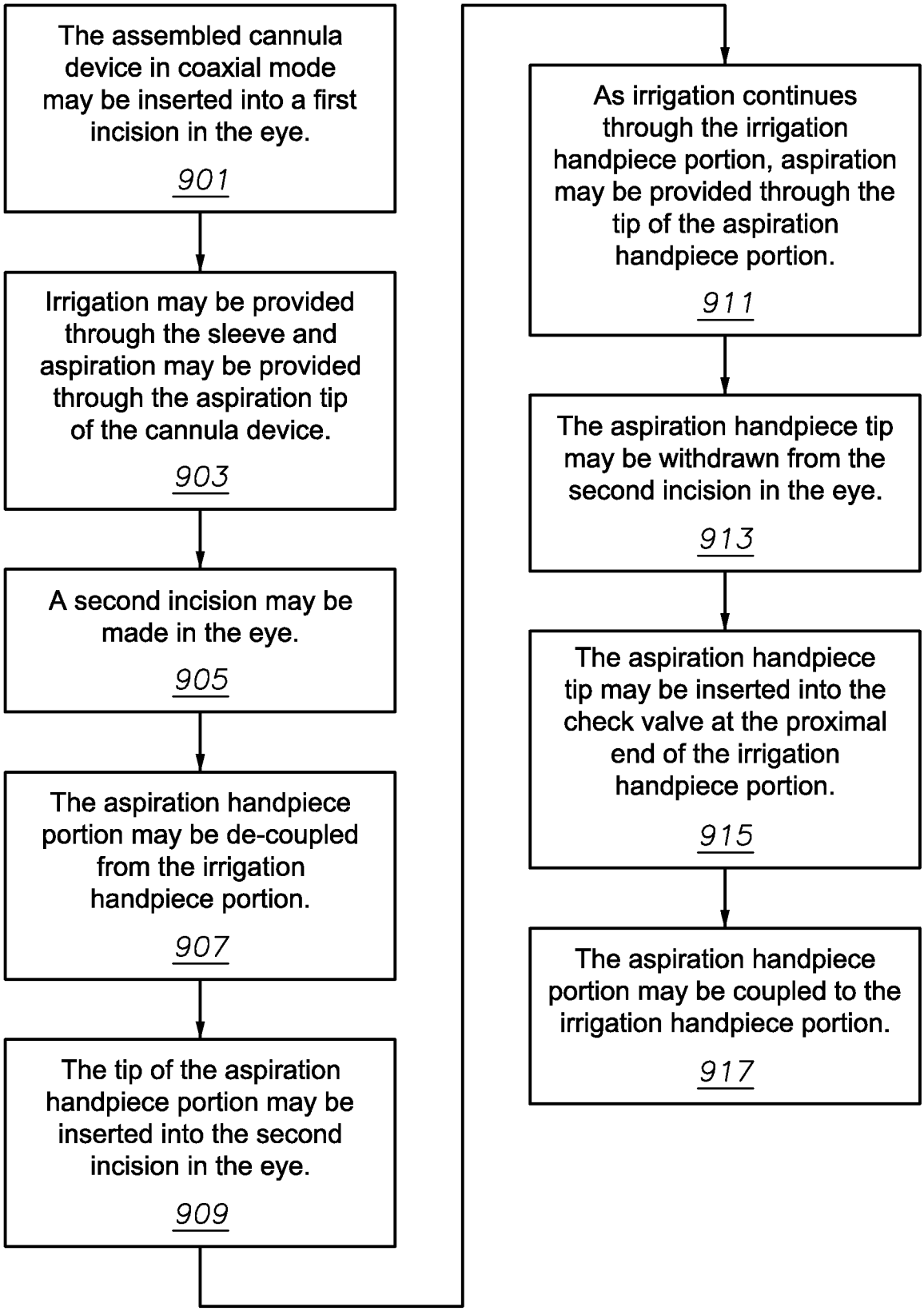

The assembled cannula device in coaxial mode may be inserted into a first incision in the eye.
901
Irrigation may be provided through the sleeve and aspiration may be provided through the aspiration tip of the cannula device.
903
A second incision may be made in the eye.
905
The aspiration handpiece portion may be de-coupled from the irrigation handpiece portion.
907
The tip of the aspiration handpiece portion may be inserted into the second incision in the eye.
909
As irrigation continues through the irrigation handpiece portion, aspiration may be provided through the tip of the aspiration handpiece portion.
911
The aspiration handpiece tip may be withdrawn from the second incision in the eye.
913
The aspiration handpiece tip may be inserted into the check valve at the proximal end of the irrigation handpiece portion.
915
The aspiration handpiece portion may be coupled to the irrigation handpiece portion.
917

FIG. 9

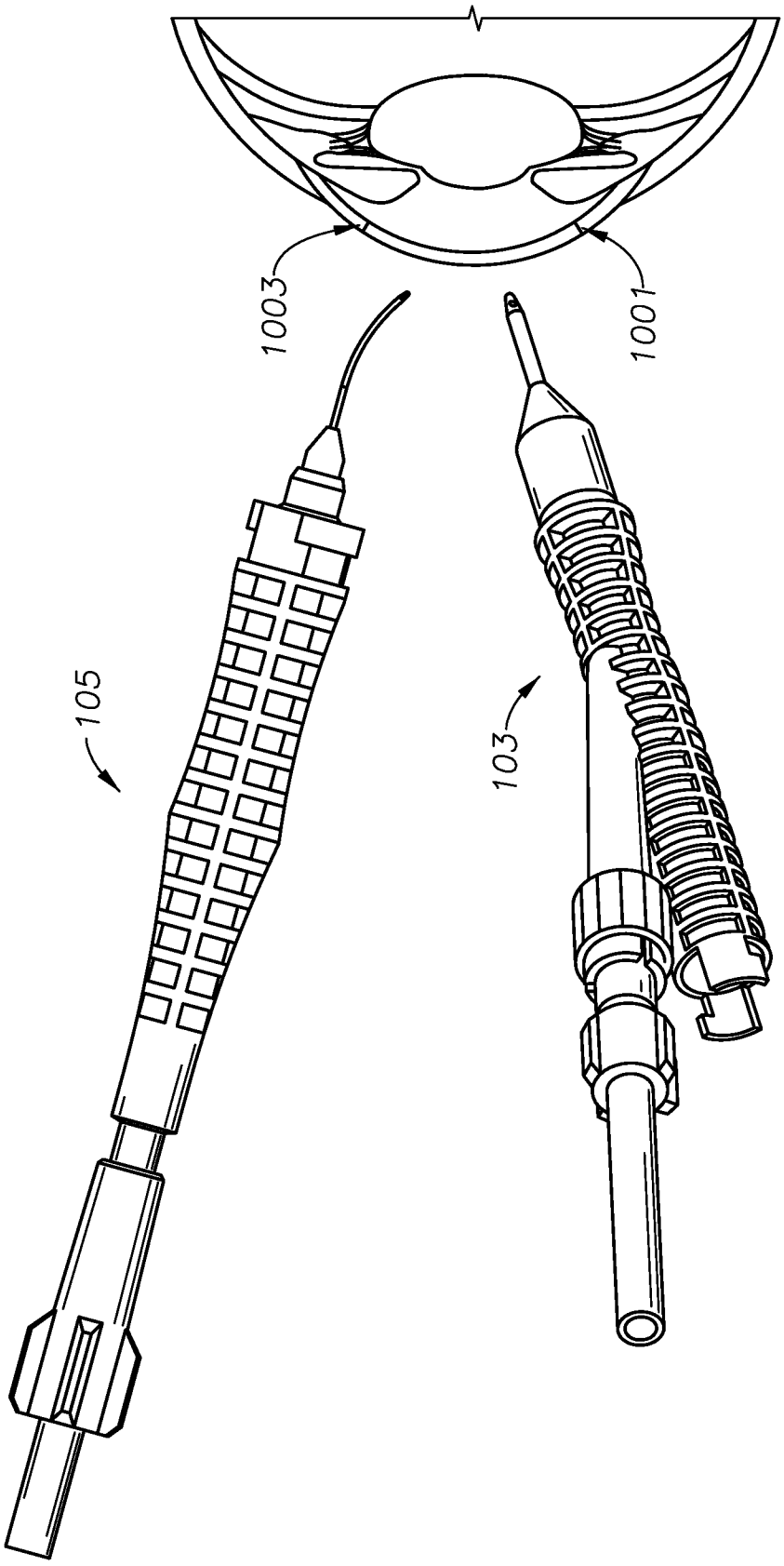


FIG. 10