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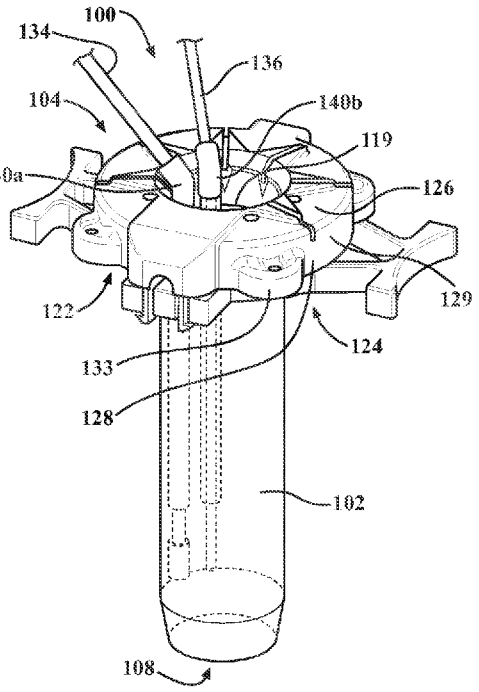
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(54) Title: FLEXIBLE INSTRUMENT ADAPTER FOR SURGICAL ACCESS ASSEMBLY

FIG. 1A



(57) Abstract: A surgical access assembly may include an outer sheath defined by an open distal end and an open proximal end and including a hollow body portion therebetween, a rim portion arranged at the proximal end of the outer sheath, and a flexible instrument adapter having cap and a clamp, the cap including a housing defining an opening, the clamp configured to selectively secure the cap to the rim portion. The cap including a guide tube coupled to the housing at the opening and configured to extend at least partially into the outer sheath to receive a flexible instrument at the cap and guide a flexible instrument proximate to a tissue.

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FLEXIBLE INSTRUMENT ADAPTER FOR SURGICAL ACCESS ASSEMBLY

RELATED APPLICATIONS

[0001] This PCT application claims priority to U.S. Provisional Application No. 63/597,499, filed on November 9, 2023, wherein is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates generally to a surgical access system for use with delicate and critical tissues, as well as methods of accessing and performing surgery using same. More specifically, the present disclosure relates to a flexible instrument delivery device for delivering instruments, such as an imaging device, to the tissues.

BACKGROUND

[0003] Diagnosis and treatment of conditions affecting the human body, and specifically the brain, are among the most difficult and complex problems that face the medical profession. The brain is a complex and delicate, soft, multi-component tissue structure that controls bodily functions through a complex neural network connected to the rest of the body through the spinal cord. The brain and spinal cord are contained within and protected by significant bony structures, e.g., the skull and the spine. Given the difficulty of accessing the brain through the hard bony protective skull and the delicate network and complex interactions that form the neural communication network contained within the brain that define the human body's ability to carry on its functions of speech, sight, hearing, functional mobility, reasoning, emotions, respiration and other metabolic functions, the diagnosis and treatment of brain disorders present unique challenges not encountered elsewhere in the body.

[0004] For example, abnormalities such as intracranial cerebral hematomas (ICH), abscesses, glioblastomas (GB), metastases (mets) and functional diseases that manifest themselves in the intraparenchymal subcortical space (i.e., the white matter) of the brain are particularly challenging to access, let alone treat. The brain contains eloquent communication structures (neural network)

which are located in the subcortical space, called fiber tracts and fascicles. Thus, traditionally, unless the ICH, GB, and/or mets were considered anything but "superficial," such conditions have been considered challenging to access, simply because accessing deeper abnormalities (ICH, GB and/or mets) was often considered just as damaging as letting the condition take its course. Similarly, tissue abnormalities such as tumors, cysts and fibrous membrane growths which manifest within the intraventricular space of the brain are considered challenging to safely access and often deemed inoperable, due to their locations within the brain.

[0005] In order to assist in diagnosis and subsequent treatment of tissue disorders, clear, accurate imaging of brain tissue through the skull is required. In recent years significant advances have been made in imaging technology, including stereotactic X-ray imaging, Computerized Axial Tomography (CAT), Computerized Tomographic Angiography (CTA), Position Emission Tomography (PET) and Magnetic Resonance Imaging (MRI), Diffusion Tensor Imaging (DTI) and Navigation systems (instrument position tracking systems). These imaging devices and techniques permit the surgeon to observe conditions within the brain in a non-invasive manner without opening the skull, as well as provide a map of critical structures surrounding an area of interest, including structures such as blood vessels, membranes, tumor margins, cranial nerves, including fiber tracts and fascicles. If an abnormality is identified through the use of one or more imaging modalities and/or techniques, it may be necessary or desirable to biopsy or remove the abnormality.

SUMMARY

[0006] One general aspect includes a neurosurgical access assembly for guiding a flexible instrument. The neurosurgical access assembly includes an outer sheath defined by an open distal end and an open proximal end and including a hollow body portion therebetween and a rim portion arranged at the proximal end of the outer sheath. The assembly also includes a flexible instrument adapter including a cap and a securing member coupled to the cap, the cap including a housing and a first guide tube. The housing defines an opening. The first guide tube is coupled to the housing and positioned within the opening. The guide tube is configured to extend at least partially into the outer sheath to receive a flexible instrument and guide the flexible instrument proximate

to a tissue in the hollow body portion. The assembly also includes the securing member configured to selectively secure the cap to the rim portion of the outer sheath.

[0007] One general aspect includes a flexible instrument adapter for a surgical access system. The flexible instrument adapter includes a cap having a housing defining a ring shape that defines an opening at the center thereof. The ring cap includes a first guide tube coupled to the housing and disposed within the opening. The adapter also includes a clamp coupled to the ring cap and configured to selectively secure the ring cap to a rim portion of an outer sheath.

[0008] One general aspect includes an adapter for a surgical access system. The adapter includes a ring cap having a ring-shaped housing that defines an opening at the center. The adapter also includes a clamp fixed to the ring cap and configured to selectively secure the ring cap to a rim portion of an outer sheath. The clamp may include a first wing and a second wing, each of which extend from the ring-shaped housing. The wing includes a locking arm. The ring-shaped housing defines a first detent and a second detent. Compression of the first and second wings towards the ring-shaped housing causes the locking arms to engage their respective detent of the first and second detent to fix the clamp to the outer sheath.

[0009] One general aspect includes an adapter for coupling to an outer sheath that includes a rim portion to form a surgical access system. The adapter includes a ring cap having a ring-shaped housing that defines an opening at the center. The adapter also includes a clamp fixed to the ring cap. The clamp including a gripper portion configured to engage with the rim portion to secure the cap to the rim portion when the cap is coupled to the outer sheath in an installed state. The clamp defines a finger rest and an arm. The finger rests are connected to the gripper portion via the arm. The clamp is configured such that the arm is configured to bend in response to force being applied to the finger rest.

[0010] One general aspect includes a method of providing access to a desired anatomical location. The method includes positioning an outer sheath in a desired location in sub-cortical anatomy. The outer sheath defines an access channel. The method also includes providing a flexible instrument adapter including a cap including a housing and a first guide member, and a visualization instrument. The housing defines an opening. The first guide member is coupled to the housing. The visualization instrument is coupled to the guide member. The method also

includes attaching the flexible instrument adapter to the outer sheath after the outer sheath has been positioned in the sub-cortical location. The method may include positioning a second instrument through the access channel defined by the outer sheath.

[0011] One general aspect includes a neurosurgical access assembly for guiding a flexible instrument. The neurosurgical access assembly includes an outer sheath defined by an open distal end and an open proximal end and including a hollow body portion therebetween and a rim portion arranged at the proximal end of the outer sheath. The assembly also includes a flexible instrument adapter including a cap and a securing member coupled to the cap. The cap including a housing and a visualization instrument, the housing defining an opening, the visualization instrument coupled to the housing and positioned within the opening, the visualization instrument being configured to extend at least partially into the outer sheath. The assembly also includes the securing member configured to selectively secure the cap to the rim portion of the outer sheath.

[0012] One general aspect includes a neurosurgical access assembly for guiding a flexible instrument. The neurosurgical access assembly includes an outer sheath defined by an open distal end and an open proximal end and including a hollow body portion therebetween and a rim portion arranged at the proximal end of the outer sheath. The assembly also includes a flexible instrument adapter including a cap and a securing member coupled to the cap. The cap includes a housing and a first guide member. The housing defines an opening. The first guide member coupled to the housing and positioned within the opening. The guide member is configured to extend at least partially into the outer sheath to receive a flexible instrument and guide the flexible instrument proximate to a tissue in the hollow body portion. The securing member is configured to selectively secure the cap to the rim portion of the outer sheath.

[0013] A surgical access assembly may include an outer sheath defined by an open distal end and an open proximal end including a hollow body portion therebetween, and a rim portion arranged at the proximal end of the outer sheath. The access assembly may include a flexible instrument adapter having a ring cap and a clamp. The ring cap defines a ring-shaped housing defining an opening at the center thereof. The clamp is configured to selectively secure the ring cap to the rim portion. The ring cap includes at least one guide tube arranged on the ring-shaped housing at the opening. The guide tube is configured to extend at least partially into the outer

sheath to receive a flexible instrument at the ring cap and provide a flexible instrument proximate to a tissue.

[0014] A flexible instrument adapter for a surgical access system may include a ring cap having a ring-shaped housing and defining an opening at the center thereof, the ring cap including at least one guide tube arranged on the ring-shaped housing at the opening and configured to extend at least partially into an outer sheath to receive a flexible instrument at the ring cap and provide a flexible instrument proximate to a tissue, and a clamp fixed to the ring cap and configured to selectively secure the ring cap to a rim portion of the outer sheath.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Exemplary embodiments of the present disclosure will now be described in greater detail with reference to the attached figures, in which:

[0016] FIG. 1A illustrates a perspective view of a surgical access assembly having a flexible instrument adapter arranged on a hollow outer sheath.

[0017] FIG. 1B illustrates a perspective view of a surgical access assembly having another example of a flexible instrument adapter arranged on a hollow outer sheath.

[0018] FIG. 2 illustrates a bottom perspective view of the flexible instrument adapter of FIG. 1.

[0019] FIG. 3 illustrates a partial side perspective view of the surgical access assembly of FIG. 1 with the flexible instrument adapter in an installed position.

[0020] FIG. 4 illustrates a bottom perspective view of another example of a flexible instrument adapter.

[0021] FIG. 5 illustrates a cross-sectional view of the flexible instrument adapter of FIG. 4.

[0022] FIG. 6 illustrates a perspective view of a ring cap of the flexible instrument adapter of FIG. 1.

[0023] FIG. 7 illustrates a cross-sectional view of the ring cap of FIG. 6.

[0024] FIG. 8 illustrates a perspective view of a surgical access assembly having another example of a flexible instrument adapter arranged on a hollow outer sheath.

[0025] FIG. 9 illustrates a side view of the surgical access assembly of FIG 8.

[0026] FIG. 10 illustrates a perspective view of another example of a flexible instrument adapter having a key.

[0027] FIG. 11 illustrates a cross-sectional view of a surgical access assembly having an example tube with a bend.

[0028] FIG. 12 shows a perspective view of alternative flexible instrument adapter coupled to an outer sheath, including a visualization instrument.

[0029] FIG. 13 shows the flexible instrument adapter of FIG. 12 without the outer sheath, including a visualization instrument.

[0030] FIG. 14 shows a top view of the flexible instrument adapter of FIG.12 coupled to an outer sheath, including a visualization instrument.

[0031] FIG. 15 shows a bottom view of the flexible instrument adapter of FIG. 12 coupled to the outer sheath, including a visualization instrument.

[0032] FIG. 16 shows a perspective view of the bottom of the flexible instrument adapter of FIG. 12.

[0033] FIG. 17 shows a perspective view of the flexible instrument adapter of FIG. 12 without the visualization instrument.

[0034] FIG. 18 shows a perspective view of a top of a further alternative flexible instrument adapter coupled to an outer sheath.

[0035] FIG. 19 shows a top view of the flexible instrument adapter of FIG. 18.

[0036] FIG. 20 shows a partial perspective view of a bottom of the flexible instrument adapter of FIG. 18 coupled to an outer sheath.

[0037] FIG. 21 shows a flow chart of an exemplary surgical method that may be used with the flexible instrument adapters described.

DETAILED DESCRIPTION

[0038] Referring now to the discussion that follows and also to the drawings, illustrative approaches to the disclosed assemblies and methods are shown in detail. Although the drawings represent some possible approaches, the drawings are not necessarily to scale and certain features may be exaggerated, removed, or partially sectioned to better illustrate and explain the present disclosure. Further, the descriptions set forth herein are not intended to be exhaustive or otherwise limit or restrict the claims to the precise forms and configurations shown in the drawings and disclosed in the following detailed description.

[0039] Described herein is a surgical access assembly, various components for use in same, and a method of using the surgical access assembly. While the assembly is often referred to as a neurosurgical access assembly, the access assembly may be used for other surgical approaches. The components disclosed herein provide surgeons with an enhanced ability to minimize trauma to the patient while providing efficient, improved, minimally invasive surgical techniques including imaging of the site.

[0040] The surgical access assembly may include an attachable flexible instrument adapter, having a guide tube configured to extend within a lumen of a sheath of the surgical access system. The flexible instrument adapter may form a ring-like housing and be configured to be placed over a rim portion of the sheath. The housing defines an opening in the center, creating a doughnut like shape and a hollow and open underside to receive the rim portion of the sheath. At least one guide tube is arranged on the ring cap at the opening and is configured to receive a flexible instrument such as an imaging device or light source. The guide tube may extend at least partially down the sheath to deliver the flexible instrument to the surgical site.

[0041] The guide tube may be angled with respect to the top surface of the ring cap in order to more easily receive the flexible instrument. The guide tube may include a bent portion to alter the

direction of the flexible instrument prior to the flexible instrument extending down the sheath. In the examples here, the bent portion allows the flexible instruments to extend generally down the outer sheath. In one example, more than one guide tube may be included as part of the flexible instrument adapter to concurrently accommodate multiple flexible instruments.

[0042] The clamp may be a spring clamp configured to be biased to be placed over the rim portion and then released to a gripping and installed state to engage the rim portion. The clamp may engage the side of the rim portion on at least two sides and include a lip to engage the underside of the rim portion to prevent the flexible instrument adapter from being removed from the rim portion during use.

[0043] FIGS. 1A and 1B illustrate a perspective view of a surgical access assembly 100 having a flexible instrument adapter 104 arranged on an outer sheath 102, which may be hollow. The outer sheath 102 may be defined by a distal end 108 and a proximal end 116 and include a body portion 118, which may be generally hallow. As best illustrated in FIG. 3, a rim portion 120 is configured as a ring, as illustrated in the drawings. The rim portion 120 may be configured as a grip portion, allowing for engagement by the surgeon. In this example, the rim portion 120 may be fixedly secured to the body portion 118 at the proximal end 116. The outer periphery may further be provided with a textured surface to provide for ease of gripping the outer sheath 102. The rim portion 120 may define a plurality of holes.

[0044] Referring to FIGS. 1A and 1B, in one example, the body portion 118 is constructed of a clear biocompatible material that permits viewing of normal tissue, abnormal tissue, as well as critical structures that are disposed outside of body portion 118 when the outer sheath 102 is disposed within such tissue. In one exemplary arrangement, the outer sheath 102 is constructed of polycarbonate, though other biocompatible materials may be employed, including resins. The distal end 108 of the outer sheath 102 may include a tapered portion 130. The tapered portion 130 may serve to ease transitions of the outer sheath 102 into body tissue.

[0045] The outer sheath 102 is not intended to be limited to brain tissue applications, but may be a port configured to receive the flexible instrument. In one other example, the outer sheath 102 may be used for abdominal procedures. As explained, a flexible instrument adapter 104 may be configured to selectively attach to the rim portion 120 of the outer sheath 102.

[0046] The flexible instrument adapter 104 may include a cap 122 and a clamp 124. The cap 122 may include a top surface 126 and a wall member 128 extending around and downward from the outer perimeter of the top surface 126 to define a housing 129 defining a cavity. The housing 129 may be generally circular. An opening 119 is defined in the center of the housing 129 to allow for visibility into the outer sheath 102, receive medical instruments, etc. The cavity of the cap 122 is configured to encapsulate at least a portion of the rim portion 120 when the flexible instrument adapter 104 is installed on the outer sheath 102.

[0047] At least one retaining element 133 may extend radially outward from the wall member 128 of the cap 122. Each of the at least one retaining elements 133 may define a hole 132. A suitable retaining member may extend through each hole 132 and may be used to affix or attach the cap 122 to a surface. Suitable retaining members include, but are not limited to, bridle sutures, flexible bands with retaining hooks, or repositionable retractor arms.

[0048] The flexible instrument may be any instrument to be flexibly introduced to or proximate to the tissue via the body portion 118 of the outer sheath 102. In one example, the flexible instrument may be a visualization device, such as camera 134 and/or a light source 136, or combinations thereof to acquire images of the surgical site to permit visualization of neuro anatomy, such as tumors, vessels, fiber tracts, and healthy tissue, in real-time. The camera 134 may enable the surgeon to have real-time information about the neuro anatomy locations after placement of the outer sheath 102. The camera 134 may be configured to be able to receive and process specific wavelengths of images. The light source 136 may be configured provide light at specific wavelengths to illuminate fluorescing agents which are exogenously or endogenously induced within the tissue at the surgical site. The camera 134 may be a fiberoptic camera having glass fibers configured to receive images. Similarly, the light source 136 may include a fiber to deliver light. The camera 134 may be referred to a CMOS camera, which includes a CMOS sensor at its distal end. While it is contemplated that the camera 134 and light source 136 can be configured as one integral assembly, it is also contemplated that the light source 136 could be separate from the camera 134 and positioned in guide tube 140b separate from the camera 134. The camera 134 may be understood as a device that includes an imaging sensor.

[0049] In order to achieve visualization of the site by the surgeon, ancillary light may be provided to the site. This light may be provided by a light source 136 within the surgical access assembly 100. The light source 136 may also be integrated into a camera assembly and delivered to the surgical site via a tube within a sheath. Additionally or alternatively, the light source 136 may be separate from the camera assembly. Additionally, the described system herein may be used in conjunction with standard operating imaging/light systems such as operating microscopes, exoscopes, and or endoscopes.

[0050] More specifically, fluorescent markers may be used (either endogenous or exogenously induced) to help distinguish certain cells within the body tissue. Certain compounds may cause cancerous tissue to become visible, or illuminate, in response to specific light wavelengths being delivered on to the tissue. This may aid in allowing the surgeon to differentiate and identify tissues. The light source 136 within the surgical access assembly 100 may deliver this light to the site.

[0051] Other types of tissue analysis may be delivered and available via the flexible instrument adapter 104. In one example, spectroscopic analysis of the tissue via laser interrogation at a specific frequency to interrogate the tissue may be delivered via the flexible instrument. In this example, the provided laser may bounce off of the tissue and the receiver of the laser console may classify the tissues. Other forms of tissue interrogation may also be provided via the flexible instrument adapter 104. Further, biopsy or resection devices, therapy devices, as well as light sources, optical imaging devices, other surgical probes, and instruments for intracranial, spinal, abdominal procedures, and more.

[0052] In other examples, the flexible instrument may be a resection instrument. In still other examples, the flexible instrument could be a tissue removal instrument, a bipolar instrument, a monopolar instrument, an ablation instrument, a suction instrument, a light emitting instrument, a tissue interrogation instrument, a tissue acquisition instrument, or combinations thereof.

[0053] The flexible instrument adapter 104 may include a first guide tube 140a included in the cap 122 extending from the cap 122 into the outer sheath 102, without substantially filling or blocking the lumen of the outer sheath 102. The first guide tube 140a may extend at least partially down the outer sheath 102 within the lumen. The first guide tube 140a may be rigid enough to form a generally straight guide within the outer sheath 102. The first guide tube 140a may be angled with

respect to the top surface 126 of the cap 122 and may include a first bent portion 131 to alter the trajectory of the flexible instrument therein. This is discussed in more detail below.

[0054] A second guide tube 140b may also be arranged on the cap 122 of the flexible instrument adapter 104. The second guide tube 140b may receive other flexible instruments, such as the light source 136. In one example, the light source 136 may be a fiber optic light source. The first and second guide tubes 140a, 140b, may be arranged at the opening 119 of the cap 122. In the example illustrated in FIG. 1A, the second guide tube 140b may be arranged adjacent to the first guide tube 140a, while in the example illustrated in FIG. 1B, the second guide tube 140b may be arranged opposite the first guide tube 140a.

[0055] In one example, where the first guide tube 140a is configured to deliver a camera 134 and the second guide tube 140b is configured to deliver a light source 136, the second guide tube 140b may be configured to stop the distal end of the light source 136 at a specific distance relative to the distal end of the camera 134. For example, the second guide tube 140b may be configured to stop the light fiber at approximately 30mm proximal to the tip of the camera 134. Such an arrangement may allow for glare mitigation.

[0056] While two guide tubes 140a, 140b are illustrated in the figures herein, more or less guide tubes 140 may be considered. In one example, four guide tubes could be included around the opening 119 of the cap 122. In this example, two cameras and two light sources could be used concurrently. In the example where multiple guide tubes are included, the guide tubes may be space equidistantly from each other around the opening 119. However, the guide tubes may be placed adjacent to some and spaced from others at varied positions about the opening 119. For example, a first and second guide tubes 140a, 140b may be equidistantly spaced from one another around a circumference of the opening 119 of the cap 122.

[0057] The guide tubes 140 may be transparent so as to allow the distance the flexible instrument travels there down to be visible. The transparent nature may also aid in the transmission of light when a light fiber is used as one of the instruments as well as lessoning reflection of any light, increasing overall visibility through the sheath, etc. The transparent nature, in certain implementations, of the guide tube when used to deliver an optics instrument so as to allow

imaging to be achieved along the entire axis of the guide tube 140 regardless of where the optics imaging is device placed along the guide tube 140a.

[0058] The guide tubes described herein may define a lumen that defines an interior surface. The guide tube may be selected such that the interior surface is non-reflective. For example, the interior surface of the guide tube may be selected from a group of a first material having light-absorbing properties and a second material being non-reflective. The properties of the interior surface of the guide tube may be achieved in different ways, depending on the nature of the material that the guide tube is formed from. For example, if the guide tube is manufactured stainless steel, the light-absorbing interior surface is an oxidized stainless steel surface. Alternatively, the guide tube may include a coating on the interior surface to achieve the non-reflective or light absorbing properties, such as an enamel coating, a ceramic coating or polymeric coating. Various treatments of the guide tube are also contemplated to provide for these properties of the interior surface, such as chemical etching, acid-etching, or sol-gel coating.

[0059] In addition, it is also contemplated that the exterior surface of the guide tube(s) described throughout may exhibit advantageous properties, such as light-absorbing properties or non-reflective properties. These properties may be achieved by treating the exterior surface or coating the exterior surface, such as treating the exterior surface or coating the exterior surface in the same manners as described above with respective to the interior surface.

[0060] The guide tubes 140a, 140b may form a taper extending between the distal end of the guide tubes 140a, 140b to the proximal end of the guide tubes 140a, 140b, where the guide tubes 140a, 140b are narrowest towards the distal end as they extend towards the distal end 108 of the outer sheath 102. That is, the diameter at a mouth opening 147 (described in more detail with respect to FIG. 7), may be larger than the diameter of the guide tube 140a, 140b at its distal end. The taper may allow the flexible instruments to be secure as they approach the distal end 108 of the outer sheath 102, but also allow enough flexibility so that the flexible instruments may be easily translated through the guide tubes 140a, 140b.

[0061] The opening 119 may allow for a wide opening into the corridor of the outer sheath 102. In this, the opening 119 may be the same diameter as that of the outer sheath 102. Moreover, the cap 122 may accommodate for different diameters of surgical instruments.

[0062] During use, and when the flexible instrument adapter 104 is installed on the rim portion 120, the instrument may be inserted into the guide tube 140a, 140b. The guide tube 140a, 140b may define a channel, and the guide tube 140a, 140b may include a first bent portion 131 so as to guide the instrument downward into the outer sheath 102. Once inserted into the guide tube 140a, 140b, the instrument may be selectively and manually forced into the lumen of the outer sheath 102 and toward the distal end 108 of the sheath. Similarly, the instrument may be retracted away from the distal end 108.

[0063] As best shown in FIGS. 2 and 3, the clamp 124 may be a spring clamp configured to selectively engage the rim portion 120 of the outer sheath 102 and secure the flexible instrument adapter 104 to the rim portion 120. Referring to FIG. 3, the clamp 124 may be configured as a unitary member. The clamp 124 may further include a first and a second gripping portion 138a, 138b, an attachment portion 180 at each of the gripping portions 138a, 138b, and finger rests 182a, 182b. The attachment portion 180 is configured to form a lip to engage a bottom side of the rim portion 120 when the flexible instrument adapter 104 is in an installed position. The lip prevents the cap 122 form being lifted upwards and off of the outer sheath 102. The lips may be oriented to be substantially parallel to a plane of the top surface 126 of the cap housing 129.

[0064] A pair of finger rests 182a, 182b are disposed substantially opposite one another, and each finger rest 182a, 182b is disposed between the first and second gripping portions 138a, 138b. As shown, arms 184 extend between the gripping portions 138a, 138b and the adjacent ones of the finger rests 182a, 182b. The portion of each arm 184 may be configured so as to accommodate the rim portion 120 therein. Each arm 184 may have sufficient flexibility to allow it to deviate from its usual configuration so as to allow the gripping portions 138a, 138b to move apart from one another in response to the finger rests 182a, 182b being biased toward one another to facilitate engagement and disengagement of the clamp 124, cap 122 and rim portion 120.

[0065] The face surfaces of the gripping portions 138a, 138b may be configured with sufficient curvature to allow them to accommodate a portion of the rim portion 120 of the outer sheath 102. The face surfaces may have ridges and grooves disposed on them which may be configured in such a way to frictionally engage ridges and grooves that may be disposed on the rim portion 120. In

one exemplary arrangement, the ridges and grooves are sized such that corresponding ridges and grooves on the rim portion 120 may be meshed.

[0066] The finger rests 182a, 182b may have a curvature that will allow fingers to comfortably rest in the finger rest 182a, 182b. Additionally, the finger rests 182a, 182b may have a textured surface to provide texture or anti-slip features for fingers.

[0067] The finger rests 182a, 182b may be biased away from one another. Compressing the finger rests 182a, 182b toward one another will move the second gripping portion 138b away from the first gripping portion 138a while the first gripping portion 138a, which is secured to the cap 122, remains stationary in relation to the cap 122. Once the second gripping portion 138b has been moved a sufficient distance away from the first gripping portion 138a, the rim portion 120 may be inserted between the first and second gripping portions 138a, 138b, and the finger rests 182a, 182b may be released to their biased positions. Releasing the finger rests 182a, 182b may cause the second gripping portion 138b to move toward the first gripping portion 138a, and cause both gripping portions 138a, 138b to contact the outer perimeter of the rim portion 120, thus securing the rim portion 120 to the cap 122. Spacing of ridges and grooves on the faces of the gripping portions 138a, 138b may coincide with the spacing of ridges and grooves of rim portion 120, providing a larger contact area between the rim portion 120 and the clamp 124 for a more secure connection.

[0068] To remove the flexible instrument adapter 104 from the rim portion 120, the finger rests 182a, 182b may be compressed toward one another, causing the second gripping portion 138b to move away from the first gripping portion 138a, thus releasing the rim portion 120. Once the rim portion 120 has been released, it may be separated from the flexible instrument adapter 104.

[0069] The cap 122 may be secured to the clamp 124 via an attachment mechanism 188. In the examples shown in FIGS. 1-3, the attachment mechanism 188 may include a pair of projections 192 extending downward from a portion of the wall member 128 to engage with a pair of slots 190 defined by the clamp 124 at the first gripping portion 138a. The slots 190 may mate with the projections 192 to fix the clamp 124 to the cap 122. In the example shown in FIG. 2, two slots 190 are used with two projections 192. However, more or less pairs of slots 190 and projections 192 may be appreciated.

[0070] The projections 192 extend to a distal end 194 having a width wider than that of a proximal end of the projection 192. The projection 192 extends to a distal end 194 having a greater width than that of the slot 190 to maintain the projection 192 in the slot 190 and fix the ring cap 122 to the clamp 124.

[0071] The distal end 194 of the projections 192 may thus prevent vertical movement of the projections 192 within the slots 190 and maintain the projections 192 within the slots 190, but still allowing lateral movement therein. In this way, the projections 192 allow the cap 122 to be fixed to the clamp 124 while still allowing for lateral translation of the cap 122 with respect to the clamp 124. Such lateral translation may be necessary to accommodate for the bowing or bending of the arms 184 when the finger rests 182a, 182b are compressed during installation.

[0072] FIG. 4 illustrates a bottom perspective view of flexible instrument adapter 204. FIG. 5 illustrates a cross-sectional view of the flexible instrument adapter 204 of FIG. 4. The flexible instrument adapter 204 may include a wall member 228 surrounding a circumferential edge of a top surface 226 forming the cap 222. Similar to the cap 122 of FIGS. 1-3, the top surface 226 defines an opening 219 configured to receive one or more surgical instruments. In one example, the top surface 226 may be beveled inwardly so as to direct surgical instruments into the opening 219.

[0073] The cap 222 may be attached to a clamp 224. The clamp 224 in this example may include two arms 203, 205. Each arm 203, 205 may form an arch-like shape and extend along at least a portion of the periphery of the cap 222. A space 209 may be arranged between the distal ends of the arms 203, 205. A pivot point 211 may be realized along a center portion of each of the arms 203, 205. In use, the arms 203, 205 may be pinched at each of the spaces 209 to pivot the arms 203, 205 outwardly enough to place the cap 222 over the rim portion 120. Once the cap 222 is placed on the rim portion 120, the clamp 224 may be released. Upon being released, the pivot points 211 of the arms 203, 205 retract to their normal position and engage the rim portion 120 to secure the cap 222 to the rim portion 120. At least one of the arms 203, 205 may include an attachment portion 280 configured to form a lip to engage a bottom side of the rim portion 120 when the flexible instrument adapter 204 is in the installed position.

[0074] The cap 222 may be placed on the rim portion 120 when the arms 203, 205 are in an unattached configuration. To secure the cap 222 to the rim portion 120, the arms 203, 205 may be locked.

[0075] FIG. 6 illustrates a perspective view of a ring cap 122 of the flexible instrument adapter 104 of FIG. 1. FIG. 7 illustrates a cross-sectional view of the cap 122 of FIG. 6. The guide tube 140a, 140b includes the first bent portion 131 configured to receive a flexible instrument at an angled portion 151 relative to a top surface 126 of the housing 129 of the cap 122 and translate the flexible instrument to extend into and vertical portion 153 to at least a portion of the outer sheath 102. However, the vertical portion 153 may also extend at an offset or angle relative to the clamp 224 (see Fig. 5). This is discussed in more detail with respect to FIG. 11.

[0076] The guide tube 140 defines a mouth opening 147 at the top surface 126 configured to receive the flexible instrument. The mouth opening 147 may have a first diameter while the remaining portions of the guide tube 140 may have a second diameter, smaller than the first diameter. That is, the mouth opening 147 allows for a larger opening than the canula of the guide tube 140. This may allow for easy of entry of the flexible instrument into the guide tube 140 at the mouth opening 147. Further, a frictional member, such as a O-ring 157 may be arranged within the mouth opening 147 to frictionally engage the flexible instrument to provide stability and retention of the instrument within the guide tube 140. The orifice may be an elastomeric ring configured to create friction with the flexible instrument.

[0077] Additionally or alternatively, a clamping mechanism may be arranged at the mouth opening 147 to clamp the flexible instrument and prevent further translation of the flexible instrument down the guide tube. In one example, a clamping mechanism, similar to a smaller version of clamp 124 may be included. Other examples may include c-clamps, screw clamps, etc.

[0078] FIG. 8 illustrates a perspective view of a surgical access assembly 100 having another example flexible instrument adapter 304 arranged on the outer sheath 102. In this example, the top surface 326 of the cap 322 may be angled inwardly from an outside radius of the wall member 128 towards the opening 119. The cap 322 may further include wall member 328 Such angle may aid to reflect light away from a camera 134 or light source 136. Further, surfaces that are not angled, may be coated or finished such that they may feature light absorbing properties or non-reflective

properties. Such surfaces may include any surface visible to an overhead camera such as the clamp 324 and non-included portions of the cap 322. As such, it can be said that the housing 129 includes a skirt portion that surrounds the opening 119 and the housing 129 includes a distal surface and a proximal surface, wherein the proximal surface is sloped at an angle from the skirt portion towards the opening 119 to control light reflections thereon.

[0079] The clamp 324 may be fixed to the cap 322. In the example shown in FIG. 8, the clamp 324 may define at least one slot (not labeled) configured to receive at least one projection 392 of the cap 322. This is similar to the arrangement described above with respect to FIG. 3, where the projection 392 may extend to a distal end 394 having a width wider than that of the projection 392. The distal end 394 may thus prevent vertical movement of the projection 392 within the slot and maintain the projection 392 within the slot, but still allowing lateral movement therein. Again, more than one slot and projection 392 may be appreciated.

[0080] FIG. 9 illustrates a side view of the surgical access assembly 100 of FIG. 8. In this example, the guide tubes 140a, 140b may be angled slightly with respect to the side walls of the outer sheath 102. The angle between the guide tubes 140a, 140b and the cap 122 may form an acute angle, or be less than 90 degrees. When a flexible instrument is not inserted into the guide tubes 140a,140b, the guide tubes 140a,140b may thus angle slightly towards the walls of the outer sheath 102. Such biasing may prevent a stiffness or strength of the flexible instrument from causing the guide tubes 140a, 140b to translate inward toward the center of the outer sheath 102 when the flexible instruments are installed in the guide tubes 140a, 140b. In the example show, the guide tubes 140a, 140b may form an 85 degree angle relative to the cap 122. However, other angles may be appreciated.

[0081] For example, the guide tube 140b may include a straight portion and a first bend portion 131 that extends from the straight portion at an angular offset (see angle α in Figure 11) from a distal end of the straight portion such that the flexible instrument inserted through the guide tube 140b is oriented to have a specific field of view at an open distal end 108 of the outer sheath 102.

[0082] FIG. 10 illustrates a perspective view of another example of a flexible instrument adapter 104 where at least one of the guide tubes 140 includes a keyway 330 defined at the mouth opening 147. The keyway 330, in one example, may include a notch or slot defined by the guide tube 140

configured to receive a respective projection, key 331, on the flexible instrument. This may allow the flexible instrument to maintain a certain orientation once placed down the guide tube 140. This may be relevant where the flexible instrument is a camera 134 and allows the orientation or view to be consistent or always "up" relative to the clinician's position. While a slot and notch arrangement are illustrated in FIG. 10, other keys may be considered.

[0083] FIG. 11 illustrates a cross-sectional view of a surgical access assembly 100 having a guide tube 140b with a first bent portion 131at the distal end thereof. The guide tube 140b may form a "kick out" or offset α at the distal end to allow for the flexible instrument to have an angle relative to the sides of the outer sheath 102. In the example where the flexible instrument is a camera 134, this offset may angle the distal end of the camera 134 to allow for a specific field of view. The offset α may, in one example, be fifteen degrees, though a greater or smaller offset may be realized. Such offset may center the field of view at the distal aspect of the outer sheath 102.

[0084] Fig. 12 shows perspective views of alternative flexible instrument adapter 404 coupled to an outer sheath 402, including a visualization instrument, depicted as a camera 434. The flexible instrument adapter 404 includes a first guide tube 440a disposed in the opening 419 as described above with the other implementations. The flexible instrument adapter 404 includes a cap 422 and a clamp 424. The cap 422 may include a housing 429, which may assume a ring-shaped configuration.

[0085] The camera 434 includes an alignment feature 460 to facilitate the positioning of the camera 434 relative to the cap 422. In the illustrated implementation, the alignment feature 460 of the camera 434 is configured to be positioned into an alignment channel 462 defined by the housing 429. By positioning the alignment feature 460 with the alignment channel 462 of the housing 429, the rotational orientation of the camera 434 can be fixed relative to the cap 422. Similarly, because the outer sheath 402 may include an indicia, the cap 422 can be secured to a known rotational orientation of the outer sheath 402 to ensure that the position of the camera 434 is knowable relative to the outer sheath 402. While these features are described with respect to a camera 434, it should be appreciated that the alignment feature 460 may be used on any other flexible instrument, such as a light source 136.

[0086] Referring now to Figure 13, where the cap 422 and clamp 424 are shown in phantom, an exemplary alignment feature 460 of the camera 434 is depicted. In this implementation, the alignment feature 460 is depicted as a guide block that has a trapezoidal cross-section shape. The guide block may be fixed to the outer surface of the camera 434. In the depicted version of the cap 422, the alignment channel 462 of includes a complementary shape such that the guide block can only be inserted in a single orientation to ensure that the camera 434 is in a known position and/or orientation relative to the outer sheath 402 as described above. It should be appreciated that the alignment feature 460 may assume shapes other than the trapezoidal cross-sectional shape described above. It is contemplated that the alignment feature 460 includes at least one axis of asymmetry such that the camera 434 can only be coupled to the alignment channel 462 in a single orientation. It should be appreciated that the alignment feature 460 may be simply feature of an outer profile of the flexible instrument, without any separate guide block attached thereto.

[0087] It is contemplated that the alignment feature 460, such as the guide block, attached to the camera 434 (or other flexible instrument) using a separate fixture during manufacturing to control the depth and rotational alignment. This ensures that the instrument assumes a known depth and rotational alignment relative to the outer sheath 402 when the flexible instrument adapter 404 is ultimately coupled.

[0088] Referring now to FIGS. 14-16, the flexible instrument adapter 404 may include clamp 424. The clamp 424 may function as a spring to selectively engage the rim portion 420 of the outer sheath 402 and secure the flexible instrument adapter 404 to the rim portion 420. Referring now to Fig. 15, similar to the clamp 124, the clamp 424 may include a first and second gripping portion 438a, 438b and an attachment portion 480 at each of the gripper portions 438a, 438b. The attachment portion 480 is configured to form a lip to engage a bottom side of the rim portion 420 when the flexible instrument adapter 404 is in an installed configuration. Similar to clamp 124, clamp 424 includes a pair of finger rests 482a, 482b. The clamp 424 includes arms 484, which have sufficient flexibility to allow it to deviate from its usual configuration so as to allow the gripping portions 438a, 438b to move apart from one another in response to the finger rests 482a, 482b being biased towards one another by a user. The clamp 424 may further include a ram member 485 which is contoured on its inner surface to engage an outer circumferential profile 487

of the rim portion 420 of the outer sheath 402. The ram member 485 may be coupled to the finger rests 482a, 482b by urging arms 489.

[0089] The clamp 424 is configured as a squeeze-to-open clamp. The clamp 424 is configured such in its resting position (when there is no force applied to the finger rests 482a, 482b), the clamp 424 can be coupled to the outer sheath 402. When the clamp 424 is coupled to the outer sheath 402, the ram member 485 applies a slight compression force on the rim portion 420 of the outer sheath 402. Furthermore, to release the clamp 424, a compression force applied to the finger rests 482a, 482b, which open the gripping portions 438a, 438b.

[0090] Referring again to Fig. 12 and Figure 17, it is contemplated that the first guide tube 440amay include one more relief cuts 463, 464 to enhance the ability for the flexible instrument to traverse these sections of the first guide tube 440a. For example, the first guide tube 440a may include a first relief cut 463 in a first bent portion 431 and second relief cut 464 in a second bent portion 450. It should be appreciated that any of the guide tubes described throughout the various flexible instrument adapter 404 designs may feature or more relief cuts 463, 464. The relief cuts 463, 464 may facilitate insertion of the flexible instrument through the first guide tube 440a.

[0091] It should be appreciated that various relief cut 463, 464 patterns are contemplated. Various methodologies for making these cuts are contemplated, including using laser cutting, saws, grinders, and the like. It should be appreciated that the relief cuts 463, 464 are not necessary in all configurations, and it is contemplated that only one of the bent portions 431, 450 may include the relief cuts 463, 464.

[0092] In Figure 12, the relief cut 464 is positioned at the distal end of the guide tube 440a and is cut on the inward facing surface of the guide tube 440a (the surface of the guide tube 440a facing the longitudinal axis of the outer sheath 102). The positioning of the relief cut 464 may further enhance the visibility of the surgeon using the visualization device, such as the camera 134, as portion of the guide tube 440a has been removed.

[0093] Figure 16 depicts the flexible instrument adapter 404 without the visualization device coupled thereto. As is contemplated elsewhere in this disclosure, the flexible instrument adapter

404 may be provided without the visualization device or the flexible instrument adapter 404 may be provided with the visualization device fixed thereto.

[0094] Referring now to FIGS. 18-20, an alternative flexible instrument adapter 504 is depicted. This flexible instrument adapter 504 includes a housing 529, which may be ring-shaped. The flexible instrument adapter 504 may include clamp 524. The clamp 524 may include a first wing 570 and a second wing 570, each of which extend from the housing 529. Each wing 570 includes a locking arm 572. The housing 529 may define a first proximal detent 578. The clamp 524 functions through application of force on the first and second wings 570 towards the housing 529, which causes the locking arms 572, 576 to engage their respective detent of the first and second detent 578, 581 to fix the flexible instrument adapter 504 to the outer sheath 502.

[0095] Referring now to FIGS. 18 and 19, the clamp 524 is more precisely described. Each wing 570 may include a first proximal locking arm 572 and one or more second distal locking arms 576. Furthermore, the housing 529 defines the first detent 578 on the proximal surface 575 of the ring-shaped housing 529 and additionally defines a second distal detent 581 on the distal surface 579 of the housing 529.

[0096] The clamp 524 slips on the outer sheath 502 is a loose fashion, and locks in place when the wings 570 are squeezed until the proximal locking arm 572 and the distal locking arm 576 engage the first proximal detent 578 and second distal detent 581. The distal locking arms 576 have a length sufficient to protrude past the rim portion 520 of the outer sheath 502 to thereby secure the outer sheath 502 in place.

[0097] It is contemplated that the flexible instrument adapter 504 may include the guide tube(s) 140 a, 140b, 440 and any of the other features described with respect to the other flexible instrument adapters 104, 204, 304, 404 described above. For example, the flexible instrument adapter 504 may include the alignment feature 460 on the flexible instrument and the housing 529 may define the alignment channel 462.

[0098] Although not shown, the distal end of the guide tube may include a diffuser. The diffuser may be configured to mitigate glare within the outer sheath 102 when light is delivered down the guide tube.

[0099] FIG. 21 shows a flow chart of an exemplary surgical method 2100 that may be used with the flexible instrument adapters described. The method 2100 may include positioning an outer sheath in a desired anatomic location sub-cortically, the outer sheath defining an access channel (step 2102). The method 2100 may include providing a flexible instrument adapter including a cap 122, 222, 322, 422 including a housing and a first guide member, and a visualization instrument, the housing defining an opening, the first guide member coupled to the housing, and wherein the visualization instrument is coupled to the guide member (step 2104). The method 2100 further includes attaching the flexible instrument adapter to the outer sheath after the outer sheath has been positioned in the sub-cortical location (step 2106). The method 2100 may include positioning a second instrument through the access channel defined by the outer sheath (step 2108). The second instrument may be a resection instrument. Alternatively, the second instrument may be selected from a group including a tissue removal instrument, a bipolar instrument, a monopolar instrument, an ablation instrument, a suction instrument, a light emitting instrument, a tissue interrogation instrument, a tissue acquisition instrument, or combinations thereof. In some implementation, the first guide member is further defined as a first guide tube and the method further comprises sliding a visualization instrument through a proximal end of the first guide tube until the visualization instrument defines a field of view that extends beyond a distal end of the first guide tube.

[0100] Various second instruments are described in U.S. Patent Nos. and Pub. Nos. 90285185, 9737648, US10398458B2, US8313501B2, US10342564B2, 10016209, 20240148252, 9615881, which are hereby incorporated herein by reference.

[0101] Throughout the disclosure, various flexible instrument adapters are described as including one or more guide tubes. However, it is also contemplated that the flexible instrument may be positioned as part of the adapter with configurations other than guide tubes. Such configurations are described as flexible instrument adapters that include a guide member. Exemplary guide members beyond the described guide tube include metallic or plastic components that define a recess that accommodates a portion of the flexible instrument. The recess may assume various shapes, such a U-shaped slot. The guide member may include one or more fasteners to secure the flexible instrument in the recess, such as one or more straps, clamps and the like. Alternative, an adhesive may be used to fix the flexible instrument into position in the recess of the guide member.

[0102] In still further alternatives, it is contemplated the flexible instrument adapters described throughout may be used without a guide tube or guide member. In such implementations, a rigid or semi-rigid instrument may be directly attached to the caps or clamps described throughout the various implementations.

[0103] Furthermore, various clamp mechanisms are described to secure the flexible instrument adapter to the outer sheath. It should be appreciated that any of the clamps described herein can be used with of the variations regarding the configuration of the guide tube(s), guide member, flexible instruments, and the like. In addition, throughout this disclosure, the recitation of the clamp can be replaced with the term securing member. Thus, the term securing member can not only refer to any of the clamps described above, but also clamp alternatives, such as a fastener, a bracket, a clip, an adhesive, or combinations thereof.

[0104] While the cap may be referred to as being ring-shaped in certain aspects of the description, other shapes are contemplated.

[0105] It will be appreciated that the surgical access system and methods described herein have broad applications. The foregoing embodiments were chosen and described in order to illustrate principles of the methods and apparatuses as well as some practical applications. The preceding description enables others skilled in the art to utilize methods and apparatuses in various embodiments and with various modifications as are suited to the particular use contemplated. In accordance with the provisions of the patent statutes, the principles and modes of operation of this disclosure have been explained and illustrated in exemplary embodiments.

[0106] It is intended that the scope of the present methods and apparatuses be defined by the following claims. However, it must be understood that this disclosure may be practiced otherwise than is specifically explained and illustrated without departing from its spirit or scope. It should be understood by those skilled in the art that various alternatives to the embodiments described herein may be employed in practicing the claims without departing from the spirit and scope as defined in the following claims. The scope of the disclosure should be determined, not with reference to the above description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. It is anticipated and intended that future developments will occur in the arts discussed herein, and that the disclosed

systems and methods will be incorporated into such future examples. Furthermore, all terms used in the claims are intended to be given their broadest reasonable constructions and their ordinary meanings as understood by those skilled in the art unless an explicit indication to the contrary is made herein. In particular, use of the singular articles such as "a," "the," "said," etc. should be read to recite one or more of the indicated elements unless a claim recites an explicit limitation to the contrary. It is intended that the following claims define the scope of the invention and that the method and apparatus within the scope of these claims and their equivalents be covered thereby. In sum, it should be understood that the invention is capable of modification and variation and is limited only by the following claims.

WHAT IS CLAIMED IS:

1. A neurosurgical access assembly for guiding a flexible instrument, comprising

an outer sheath defined by an open distal end and an open proximal end and including a hollow body portion therebetween and a rim portion arranged at the proximal end of the outer sheath, and

a flexible instrument adapter including a cap and a securing member coupled to the cap,

the cap including a housing and a first guide tube,

the housing defining an opening,

the first guide tube coupled to the housing and positioned within the opening, the guide tube being configured to extend at least partially into the outer sheath to receive a flexible instrument and guide the flexible instrument proximate to a tissue in the hollow body portion, and

the securing member configured to selectively secure the cap to the rim portion of the outer sheath.

2. The neurosurgical access assembly of claim 1, wherein the first guide tube includes a straight portion and a first bent portion that extends from the straight portion at an angle from a distal end of the straight portion such that the flexible instrument inserted through the first guide tube is oriented to have a specific field of view at the open distal end of the outer sheath.

3. The neurosurgical access assembly of claim 2, wherein the first guide tube includes a second bent portion than extends from the straight portion at an angle from a proximal end of the straight portion, the second bent portion being configured to receive the flexible instrument at an angle relative to a top surface of the housing of the cap and allow the flexible instrument to translate through the second bent portion and extend into the proximal end of the outer sheath without obscuring the open proximal end.

4. The neurosurgical access assembly of claim 3, wherein the neurosurgical access assembly is configured such that when the flexible instrument adapter is coupled to the outer sheath, the straight portion of the guide tube extends at an angle that is oblique to a wall of the hollow body portion.

5. The neurosurgical access assembly of claim 4, wherein the first guide tube defines a mouth opening at the proximal end of the first guide tube, and the mouth opening defines a keyway

configured to receive a respective key of the flexible instrument to maintain an orientation of the flexible instrument relative to the first guide tube when the flexible instrument is positioned within the first guide tube.

6. The neurosurgical access assembly of claim 5, wherein the mouth opening has a first diameter, and a distal end of the guide tube defines a second diameter, wherein the first diameter is greater than the second diameter.

7. The neurosurgical access assembly of claim 6, wherein the first guide tube defines a lumen, and comprises a frictional insert, the frictional insert is disposed within the lumen of the first guide tube to engage the flexible instrument when inserted through the lumen to provide stability and retention of the flexible instrument within the first guide tube.

8. The neurosurgical access assembly of claim 1, wherein the guide tube defines a lumen defining an interior surface, wherein the interior surface is non-reflective.

9. The neurosurgical access assembly of claim 8, wherein the interior surface is formed with a material selected from a group of a first material having light absorbing priorities and a second material being non-reflective.

10. The neurosurgical access assembly of claim 9, wherein the first material having light-absorbing properties is an oxidized stainless steel and wherein the second material being non-reflective is a enamel coating.

11. The neurosurgical access assembly of claim 1, wherein the guide tube includes an exterior surface, wherein the exterior surface is formed with a material selected from a group of a first material having light absorbing priorities and a second material being non-reflective.

12. The neurosurgical access assembly of claim 1, wherein the housing is further defined as a ring-shaped housing.

13. The neurosurgical access assembly of claim 1, wherein the cap further comprises a second guide tube.

14. The neurosurgical access assembly of claim 13, wherein the first guide tube is adjacent to the second guide tube.

15. The neurosurgical access assembly of claim 13, wherein the first and second guide tubes are equidistantly spaced from one another around a circumference of the opening of the cap.

16. The neurosurgical access assembly of claim 1, wherein the housing includes a skirt portion that surrounds the opening and the housing includes a distal surface and a proximal surface,

wherein the proximal surface is sloped at an angle from the skirt portion towards the opening to control light reflections thereon.

17. The neurosurgical access assembly of claim 1, wherein the securing member is further defined as a clamp.

18. The neurosurgical access assembly of claim 17, wherein the clamp includes a gripper portion configured to engage with the rim portion to secure the cap to the rim portion when the cap is coupled to the outer sheath in an installed state.

19. The neurosurgical access assembly of claim 18, wherein the clamp defines a finger rest and an arm, wherein the finger rests are connected to the gripper portion via the arm, wherein the clamp is configured such that the arm is configured to bend in response to force being applied to the finger rest.

20. The neurosurgical access assembly of claim 19, wherein the clamp includes a plurality of gripper portions configured to engage with the rim portion to secure the cap to the rim portion when the cap is coupled to the outer sheath in an installed state.

21. The neurosurgical access assembly of claim 20, wherein the clamp defines a pair of finger rests,

wherein one of each of the pair of finger rests is arranged in between each side of the plurality of gripper portions and connected to at least one of plurality gripper portions.

22. The neurosurgical access assembly of claim 19, wherein the clamp defines a slot adjacent the gripper portion, wherein the cap includes a projection configured to be received by the slot, wherein the projection is slidably disposed within the slot to accommodate the bending of the arm during compression of the finger rest while maintaining the clamp is coupled to the cap.

23. The neurosurgical access assembly of claim 2, wherein the guide tube includes a relief cut in the first bent portion.

24. The neurosurgical access assembly of claim 1, further comprising a flexible instrument, wherein an outer profile of the flexible instrument defines an alignment feature, and wherein the housing defines an alignment channel, wherein the alignment feature of the flexible instrument is positioned within the alignment channel of the housing.

25. The neurosurgical access assembly of claim 24, wherein the flexible instrument includes a guide block fixed to the outer surface of the flexible instrument, wherein the guide block defines the alignment feature.

26. A flexible instrument adapter for a surgical access system, comprising:

a ring cap having a ring-shaped housing that defines an opening at the center thereof, the ring cap including a first guide tube coupled to the housing and disposed within the opening, and

a clamp coupled to the ring cap and configured to selectively secure the ring cap to a rim portion of an outer sheath.

27. The flexible instrument adapter of claim 26, wherein the clamp defines a slot, wherein the ring cap defines a projection slidably disposed within the slot to allow for lateral movement within the slot to accommodate for bending of the clamp during installation of the ring cap to the rim portion.

28. The flexible instrument adapter of claim 27, wherein the projection extends to a distal end having a greater width than that of the slot to maintain the projection in the slot and fix the ring cap to the clamp.

29. The flexible instrument adapter of claim 28, wherein the clamp includes a lip configured to engage with a portion of an underside of the rim portion to maintain the ring cap on the rim portion in an installed state.

30. The flexible instrument adapter of claim 26, wherein the clamp comprises a first wing extending from the ring-shaped housing, wherein the first wing includes a locking arm, and wherein the ring-shaped housing defines a first detent, wherein compression of the first wings toward the ring-shaped housing causes the locking arm to engage the first detent to fix the clamp to the outer sheath.

31. The flexible instrument adapter of claim 26, wherein the clamp comprises a first wing and a second wing, each of which extend from the ring-shaped housing, wherein each wing includes a locking arm, and wherein the ring-shaped housing defines a first detent and a second detent, wherein compression of the first and second wings towards the ring-shaped housing causes the locking arms to engage their respective detent of the first and second detent to fix the clamp to the outer sheath.

32. The flexible instrument adapter of claim 30, wherein each wing includes a first proximal locking arm and a second distal locking arm, and wherein the ring-shaped housing defines the first detent on the proximal surface of the ring-shaped housing.

33. The flexible instrument adapter of claim 26, further comprising a flexible instrument, wherein an outer profile of the flexible instrument defines an alignment feature, and wherein housing

defines an alignment channel, wherein the alignment feature of the flexible instrument is positioned within the alignment channel.

34. The flexible instrument adapter of claim 33, wherein the flexible instrument includes a guide block fixed to the outer surface of the flexible instrument, wherein the guide block defines the alignment feature.

35. The flexible instrument adapter of claim 26, wherein the first guide tube includes a straight portion and a first bent portion that extends from the straight portion at an angular offset from a distal end of the straight portion such that the flexible instrument inserted through the first guide tube is oriented to have a specific field of view at an open distal end of the outer sheath.

36. The flexible instrument adapter of claim 35, wherein the first guide tube includes a second bent portion than extends from the straight portion at an angular offset from a proximal end of the straight portion, the second bent portion being configured to receive the flexible instrument at an angle relative to a top surface of the ring-shaped housing of the ring cap and allow the flexible instrument to translate through the second bent portion.

37. The flexible instrument adapter of claim 35, wherein the first guide tube includes a relief cut in the first bent portion.

38. The flexible instrument adapter of claim 26, wherein the first guide tube defines a mouth opening at a proximal end thereof, and the mouth opening defines a keyway configured to receive a respective key of the flexible instrument to maintain an orientation of the flexible instrument relative to the first guide tube.1

39. The flexible instrument adapter of claim 38, wherein the mouth opening has a first diameter, and a distal end of the first guide tube defines a second diameter, wherein the first diameter is greater than the second diameter.

40. The flexible instrument adapter of claim 39, wherein defines a lumen, and a frictional insert disposed within the lumen to engage a flexible instrument when inserted through the lumen to provide stability and retention of the flexible instrument within the first guide tube.

41. The flexible instrument adapter of claim 26, wherein the first guide tube defines a lumen defining an interior surface, wherein the interior surface is non-reflective.

42. The flexible instrument adapter of claim 41, wherein the interior surface is formed with a material having light absorbing priorities.

43. An adapter for a surgical access system, comprising:

a ring cap having a ring-shaped housing that defines an opening at the center thereof,

a clamp fixed to the ring cap and configured to selectively secure the ring cap to a rim portion of an outer sheath, wherein the clamp comprises a first wing and a second wing, each of which extend from the ring-shaped housing, wherein each wing includes a locking arm, and wherein the ring-shaped housing defines a first detent and a second detent, wherein compression of the first and second wings towards the ring-shaped housing causes the locking arms to engage their respective detent of the first and second detent to fix the clamp to the outer sheath.

44. An adapter for coupling to an outer sheath that includes a rim portion to form a surgical access system, comprising:

a ring cap having a ring-shaped housing that defines an opening at the center thereof,

a clamp fixed to the ring cap and including includes a gripper portion configured to engage with the rim portion to secure the cap to the rim portion when the cap is coupled to the outer sheath in an installed state,

wherein the clamp defines a finger rest and an arm, wherein the finger rests are connected to the gripper portion via the arm, wherein the clamp is configured such that the arm is configured to bend in response to force being applied to the finger rest.

45. A method of providing access to a desired anatomical location, comprising:

positioning an outer sheath in a desired location in sub-cortical anatomy, the outer sheath defining an access channel;

providing a flexible instrument adapter including a cap including a housing and a first guide member, and a visualization instrument, the housing defining an opening, the first guide member coupled to the housing, and wherein the visualization instrument is coupled to the guide member;

attaching the flexible instrument adapter to the outer sheath after the outer sheath has been positioned in the sub-cortical location; and

positioning a second instrument through the access channel defined by the outer sheath.

46. The method of claim 45, wherein the second instrument is a resection instrument.

47. The method of claim 45, wherein the second instrument is selected from a group including a tissue removal instrument, a bipolar instrument, a monopolar instrument, an ablation instrument,

a suction instrument, a light emitting instrument, a tissue interrogation instrument, a tissue acquisition instrument, or combinations thereof.

48. The method of claim 45, wherein the visualization instrument is selected from a group comprising a light source, a camera, or combinations thereof.

49. The method of claim 45, wherein the first guide member is further defined as a first guide tube, wherein the method further comprises sliding a visualization instrument through a proximal end of the first guide tube until the visualization instrument defines a field of view that extends beyond a distal end of the first guide tube.

50. A neurosurgical access assembly for guiding a flexible instrument, comprising

an outer sheath defined by an open distal end and an open proximal end and including a hollow body portion therebetween and a rim portion arranged at the proximal end of the outer sheath, and

a flexible instrument adapter including a cap and a securing member coupled to the cap,

the cap including a housing and a visualization instrument,

the housing defining an opening,

the visualization instrument coupled to the housing and positioned within the opening, the visualization instrument being configured to extend at least partially into the outer sheath, and

the securing member configured to selectively secure the cap to the rim portion of the outer sheath.

51. A neurosurgical access assembly for guiding a flexible instrument, comprising

an outer sheath defined by an open distal end and an open proximal end and including a hollow body portion therebetween and a rim portion arranged at the proximal end of the outer sheath, and

a flexible instrument adapter including a cap and a securing member coupled to the cap,

the cap including a housing and a first guide member,

the housing defining an opening,

the first member coupled to the housing and positioned within the opening, the guide member being configured to extend at least partially into the outer sheath to receive a flexible instrument and guide the flexible instrument proximate to a tissue in the hollow body portion, and

the securing member configured to selectively secure the cap to the rim portion of the outer sheath.

FIG. 1A

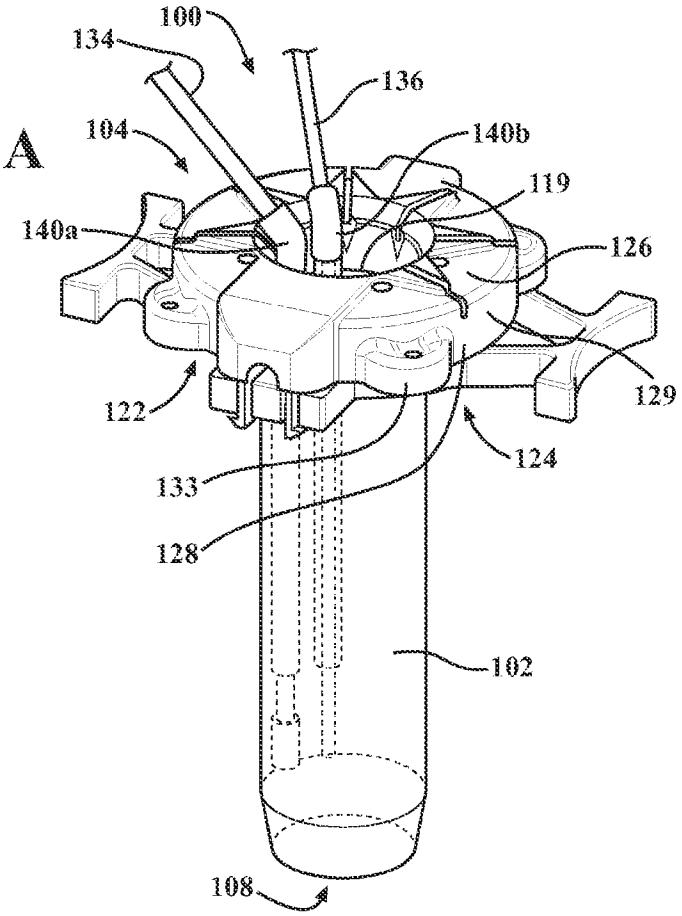

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FIG. 1B

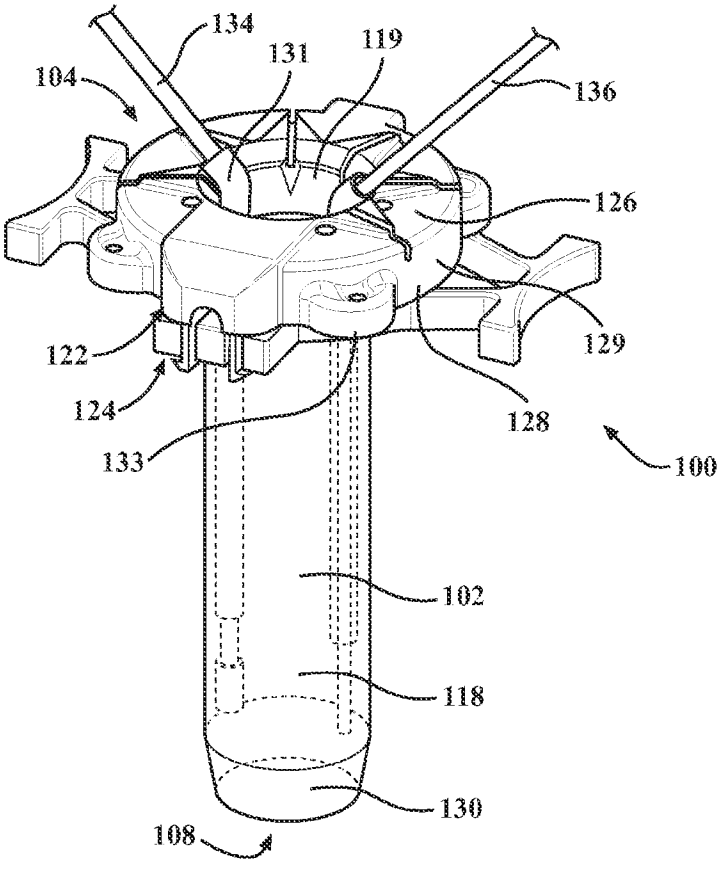
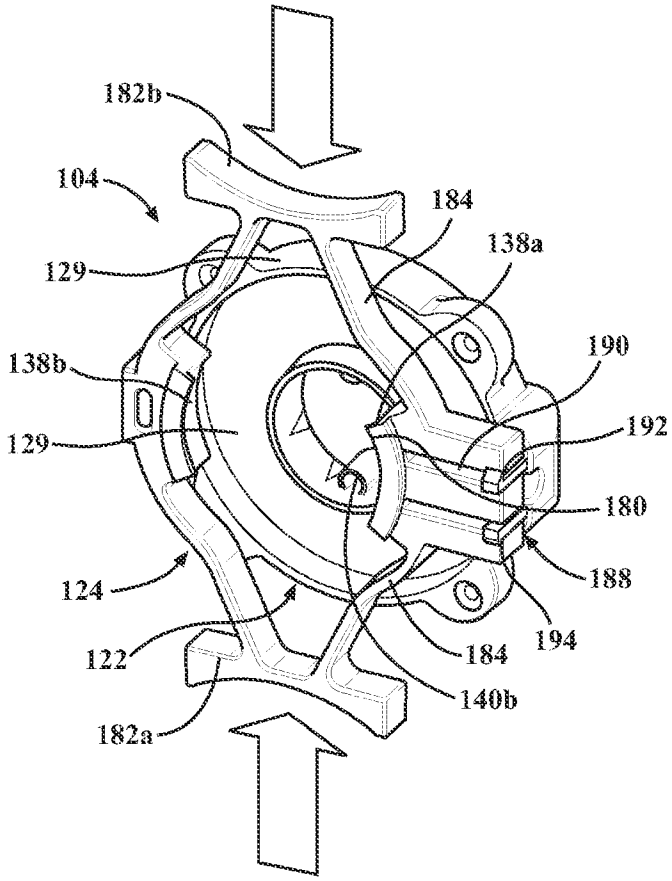

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FIG. 2


182b
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140b
182a

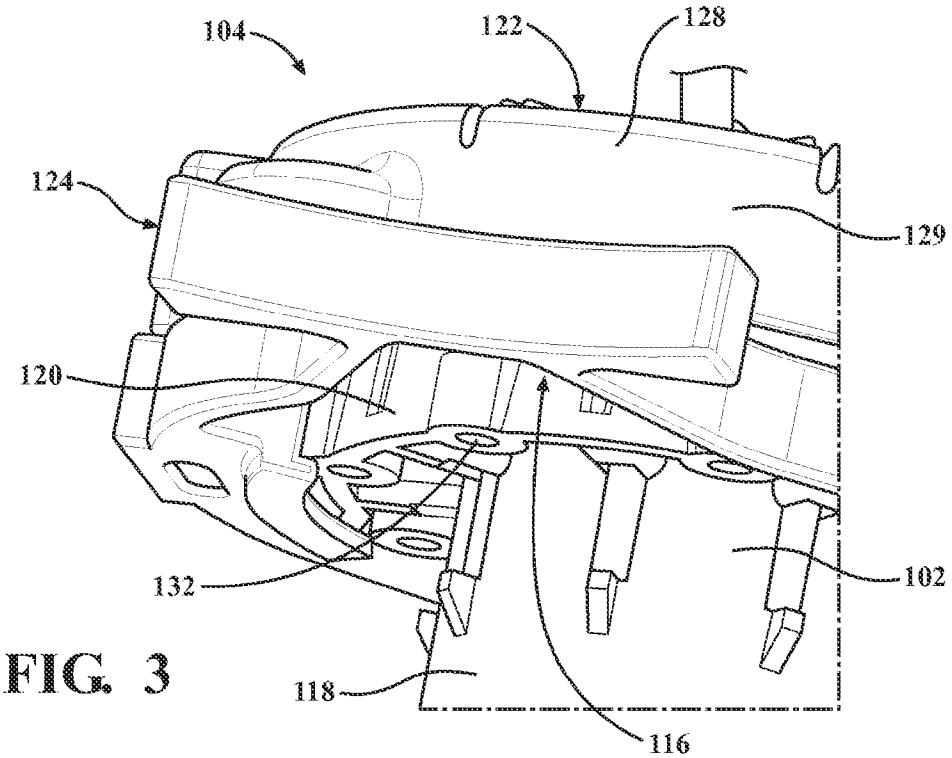

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FIG. 3

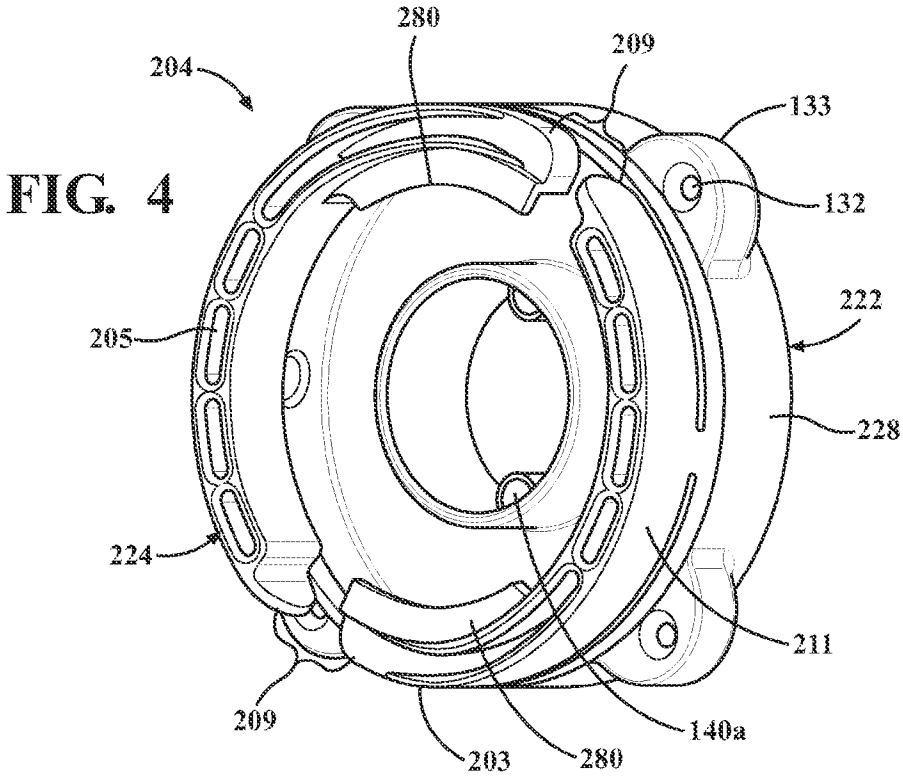

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140a
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FIG. 4

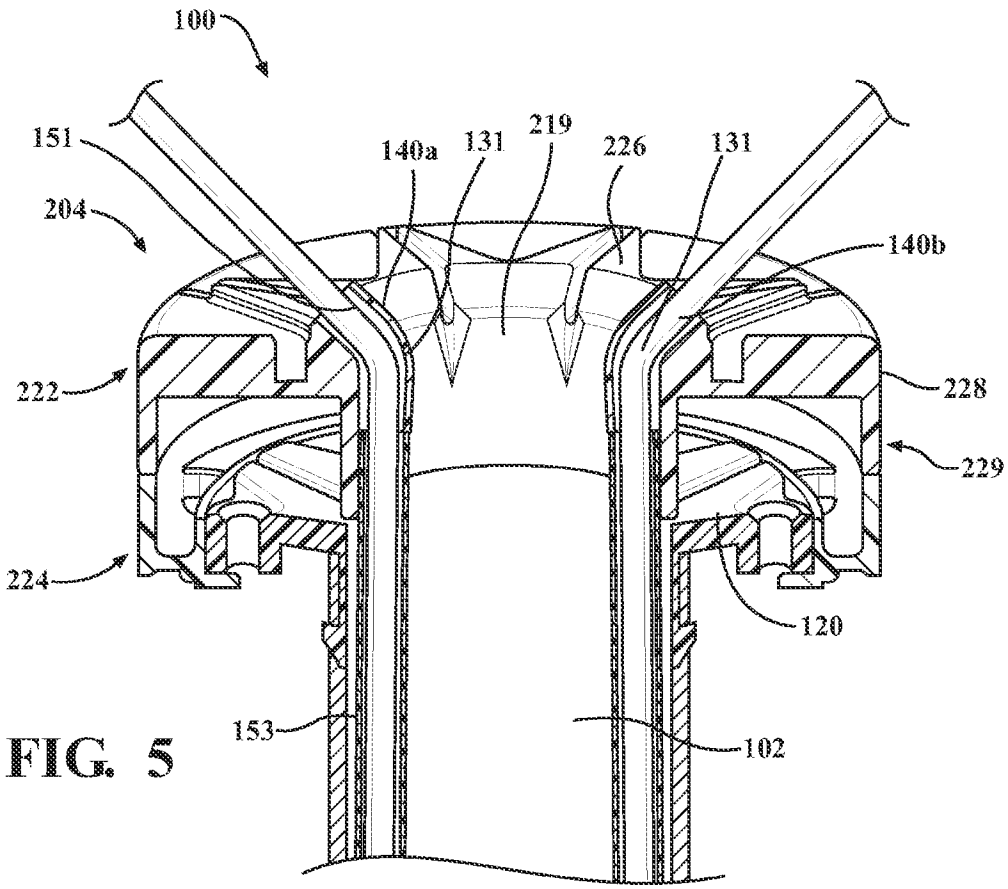

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FIG. 5

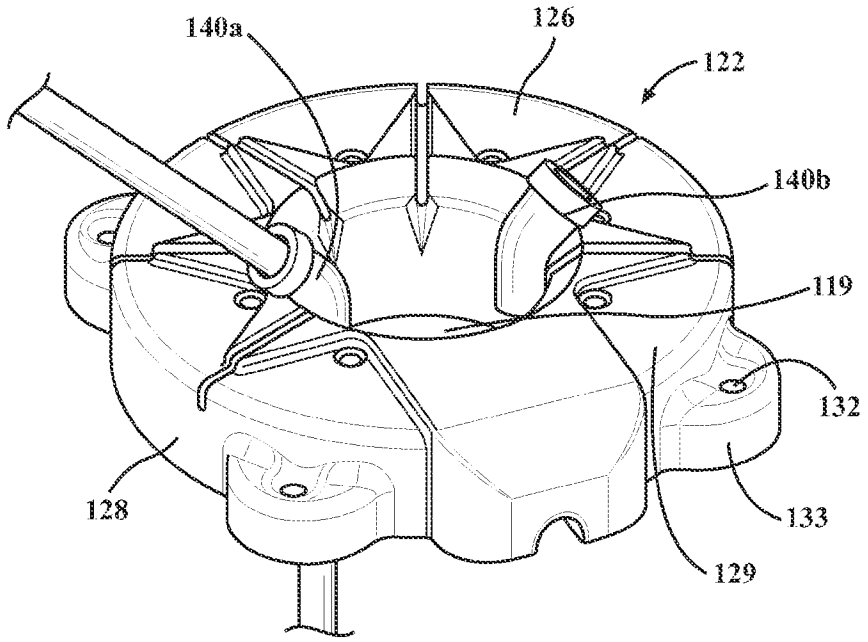

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FIG. 6

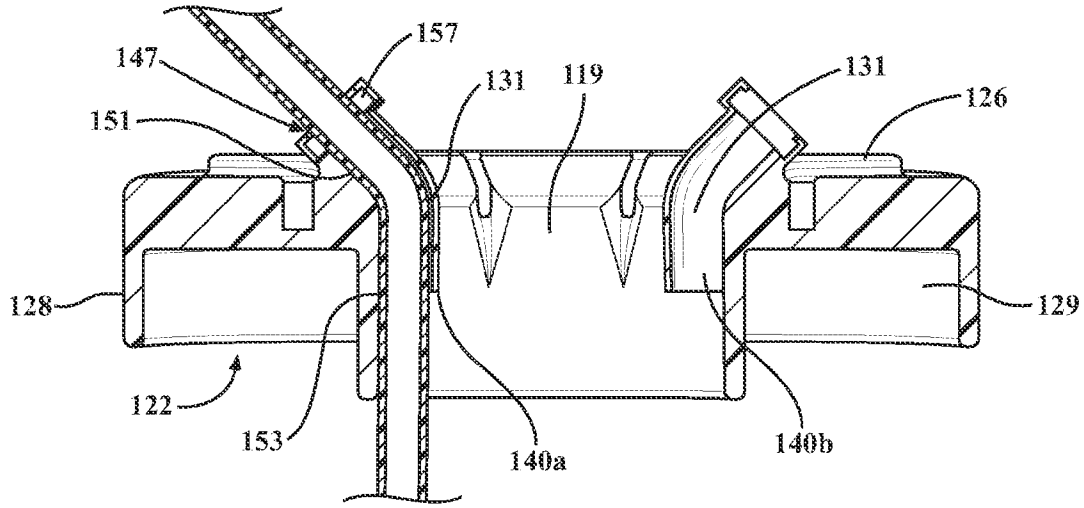

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FIG. 7

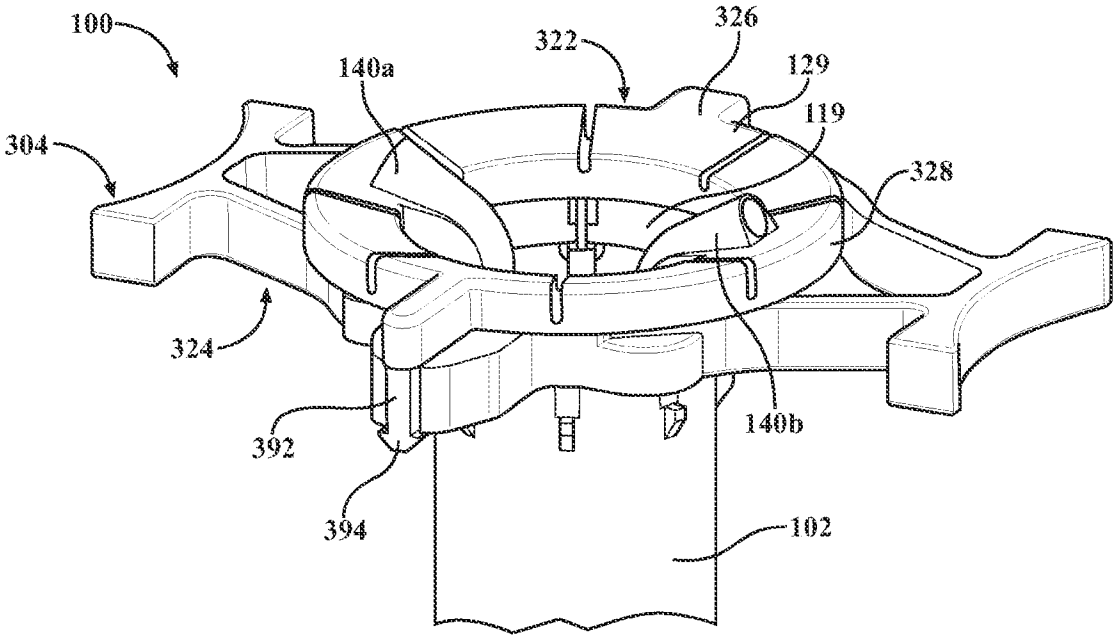

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FIG. 8

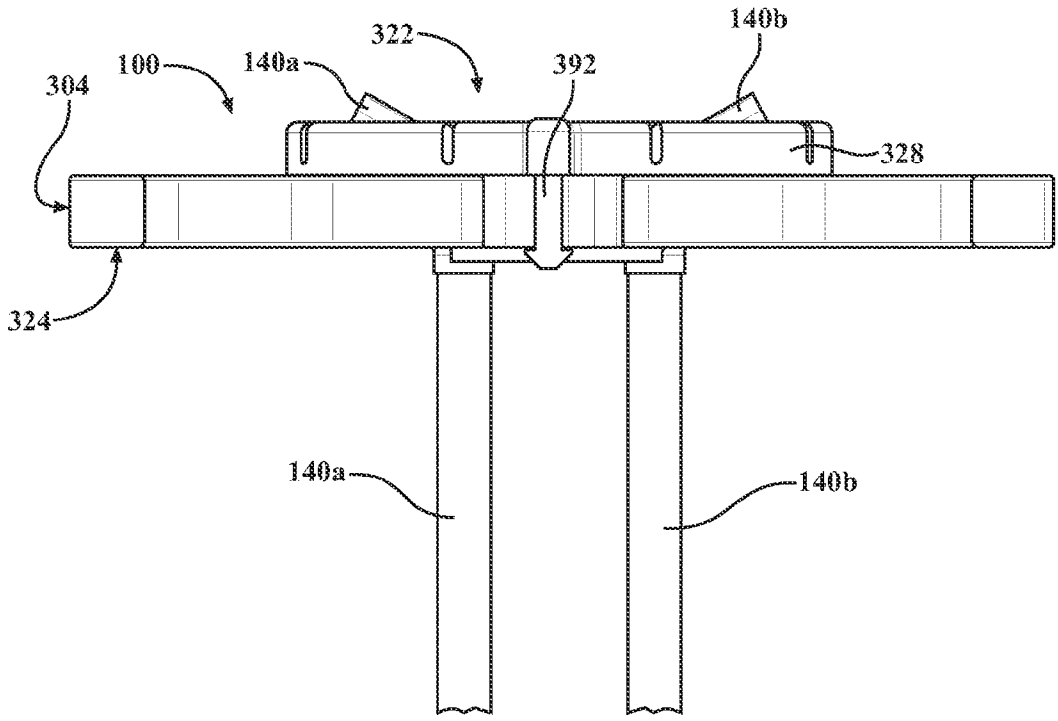

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FIG. 9

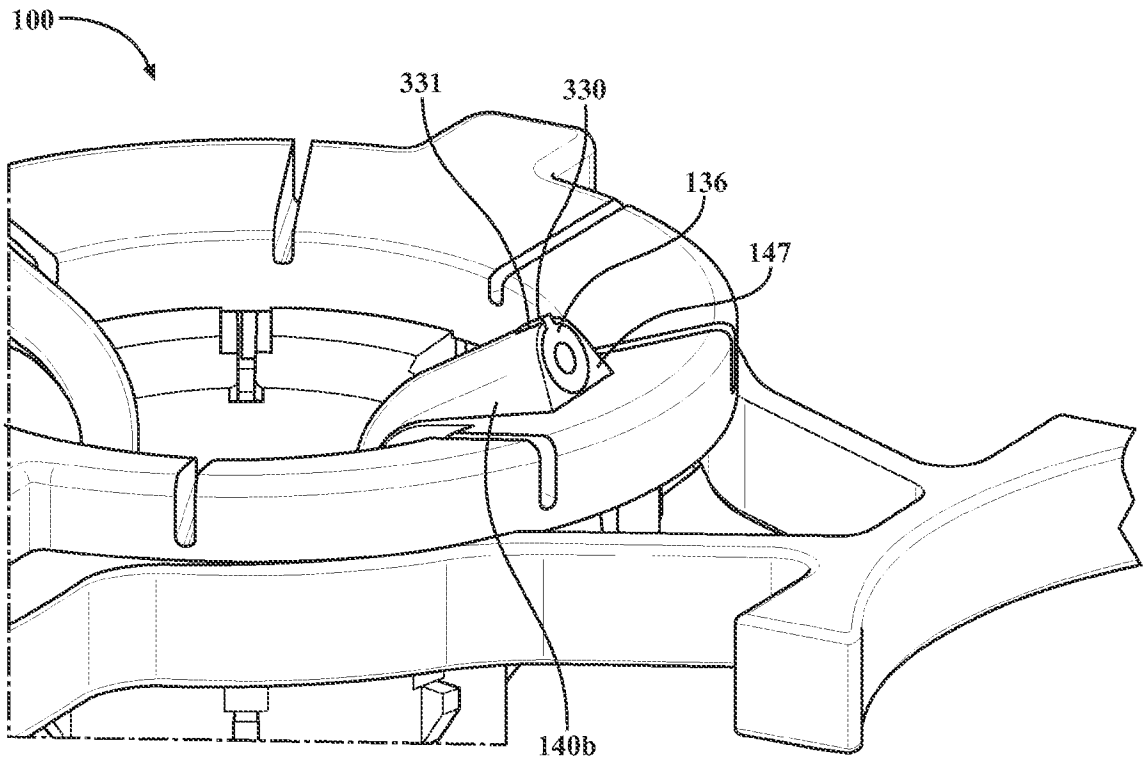
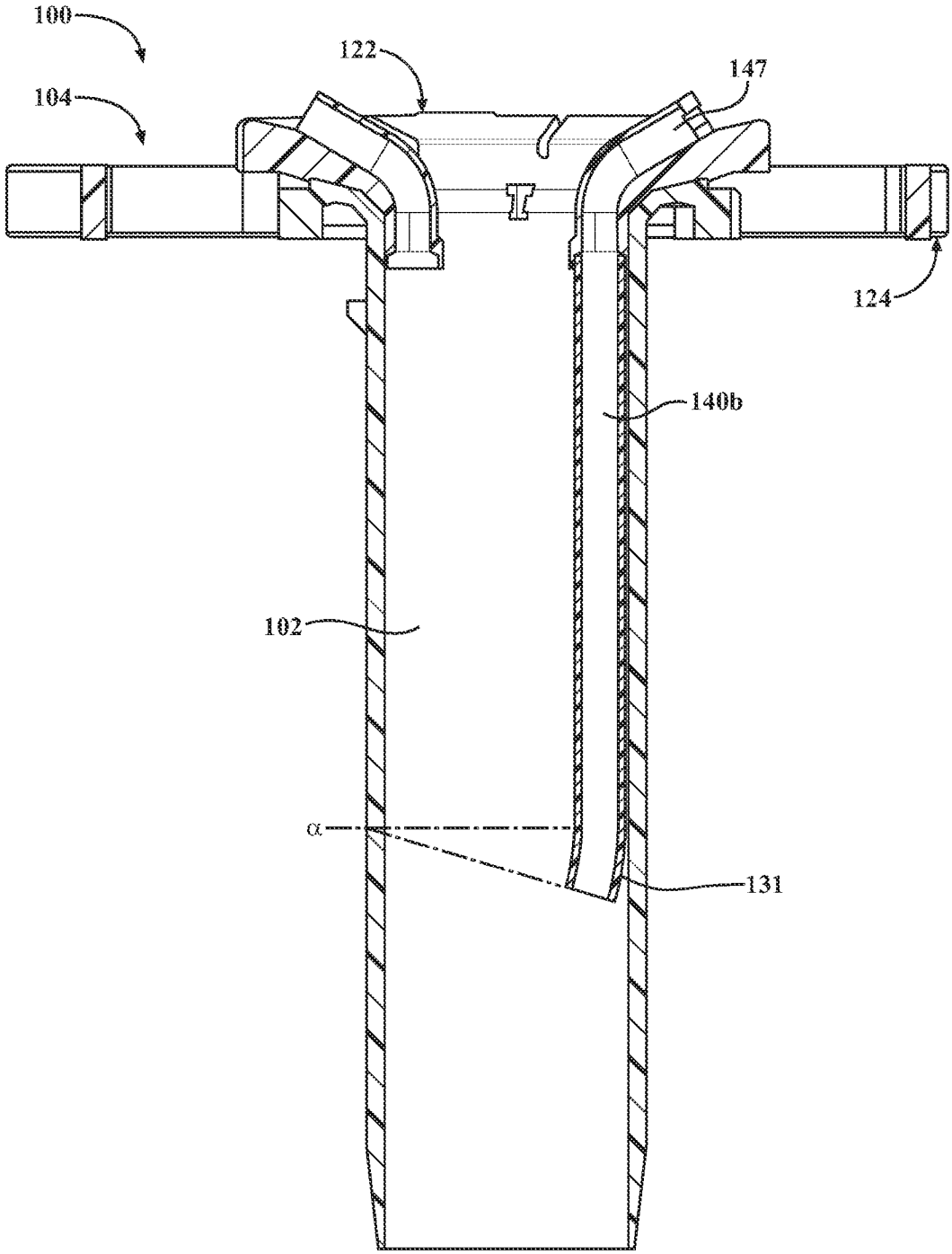


FIG. 10

FIG. 11



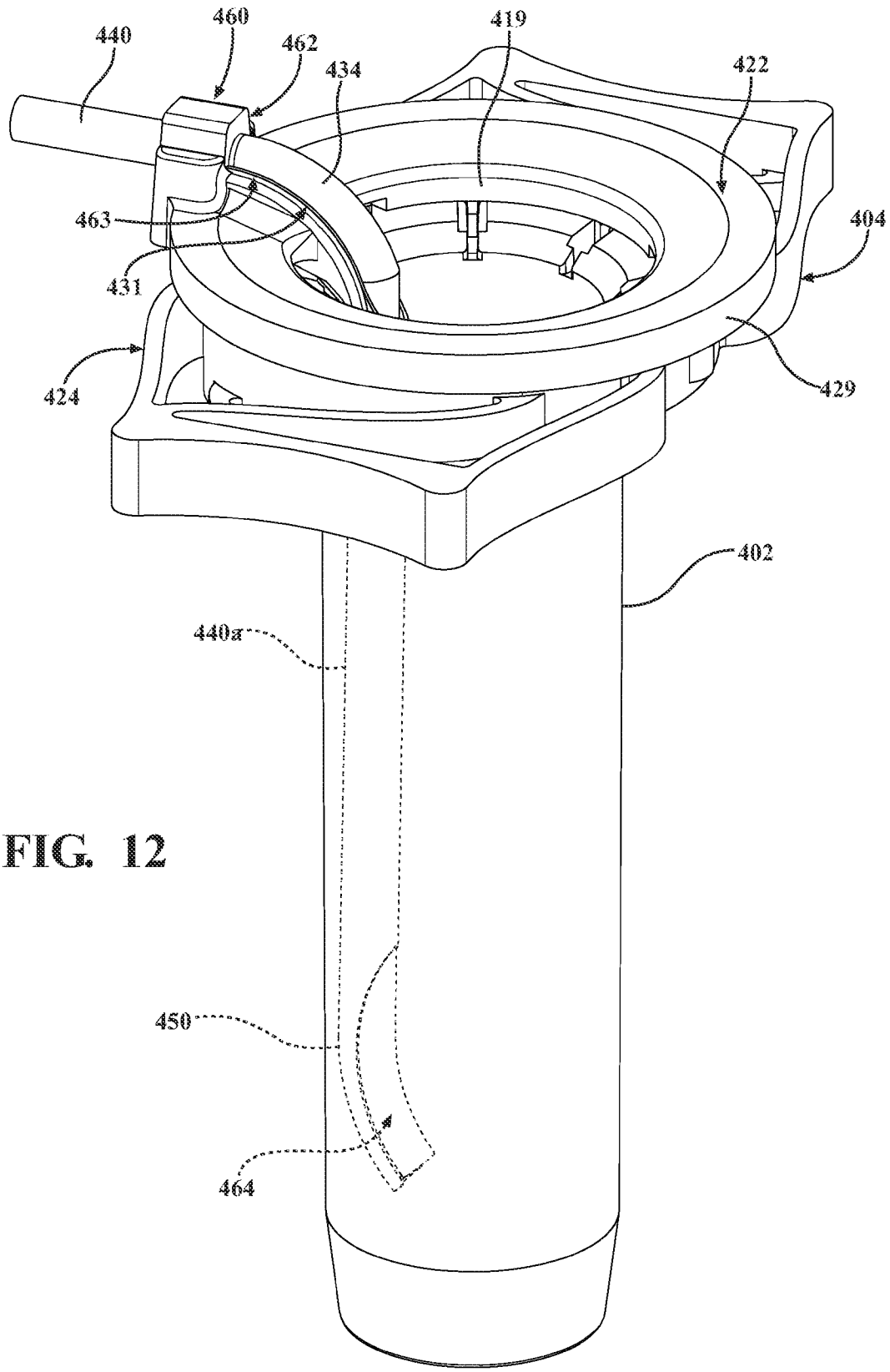


FIG. 12

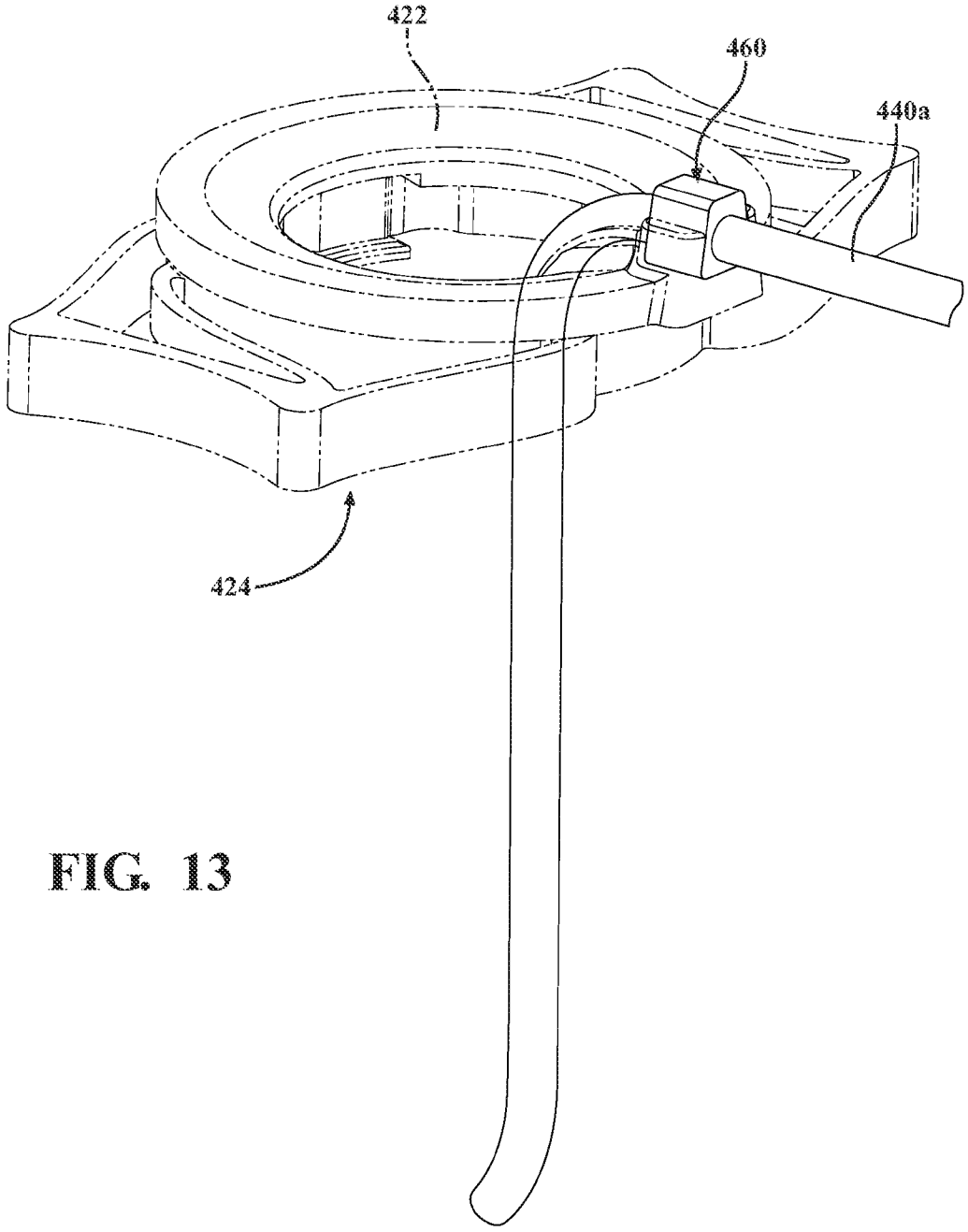


FIG. 13

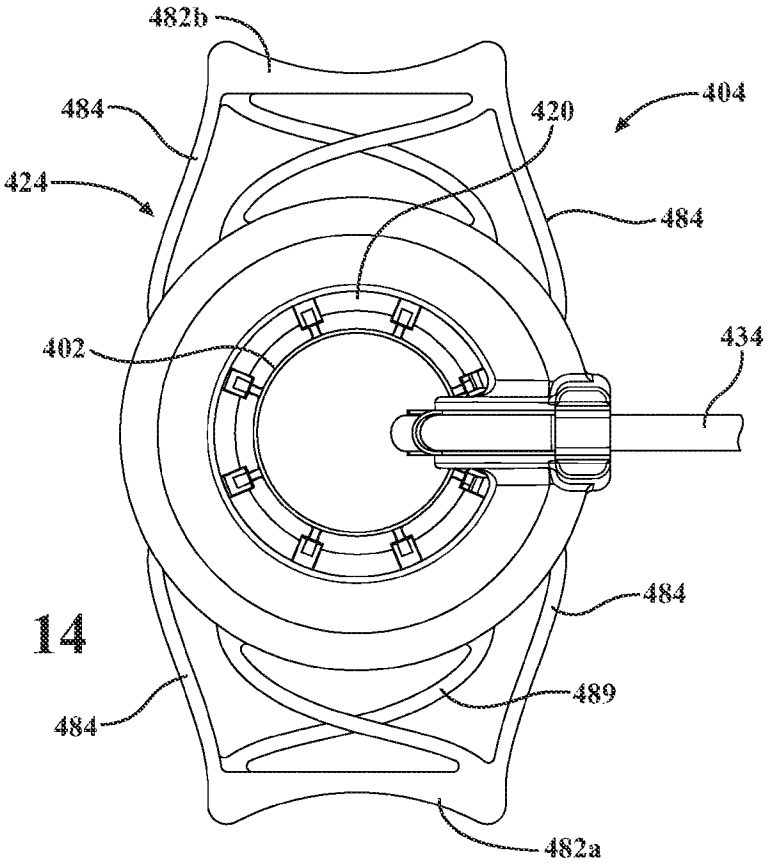

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FIG. 14

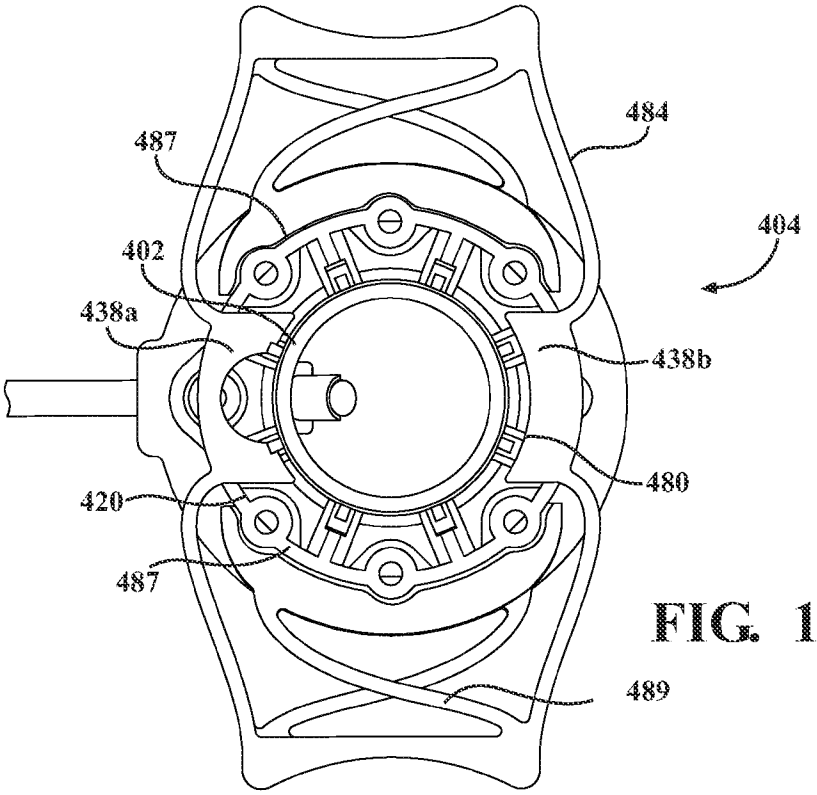

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FIG. 15

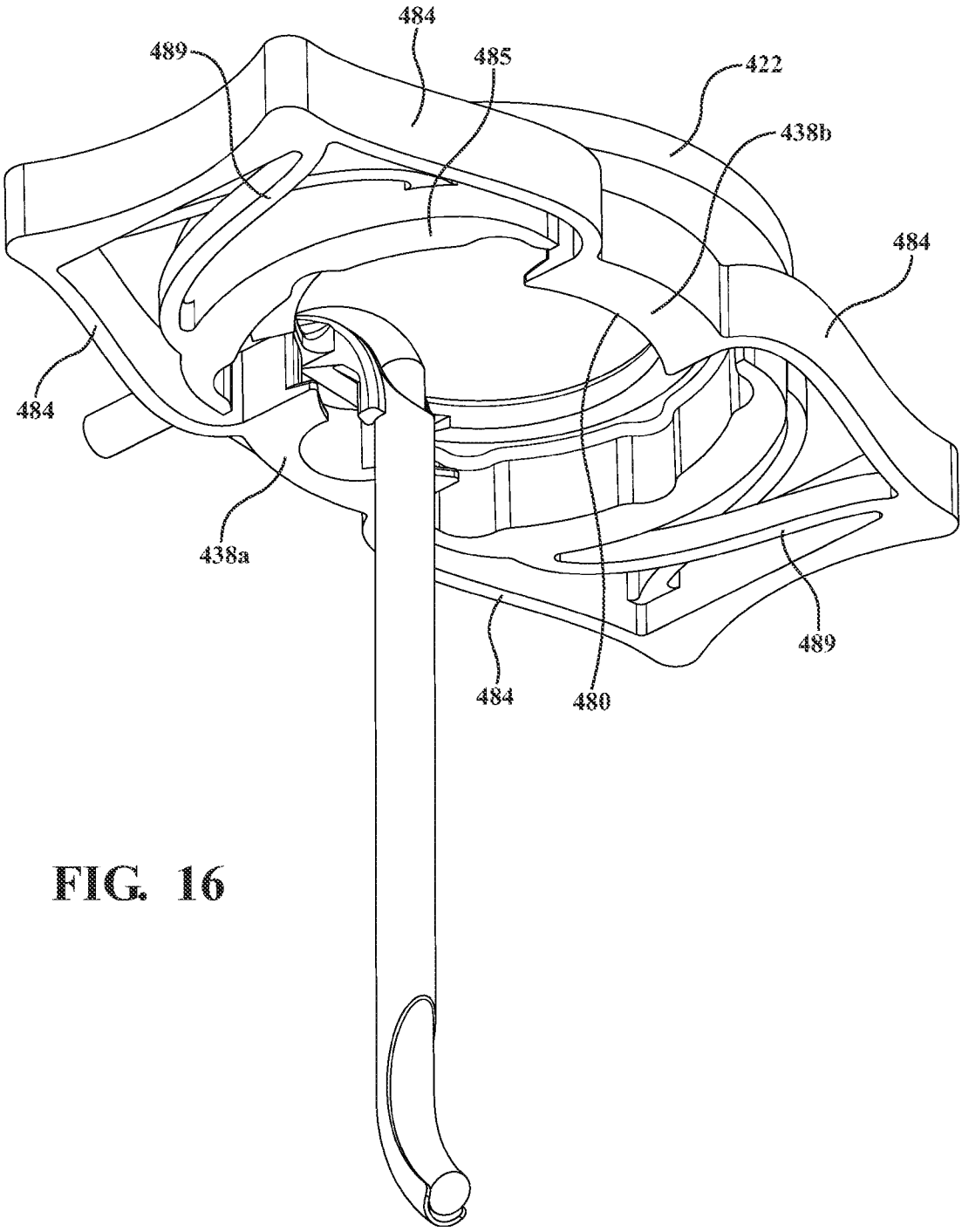


FIG. 16

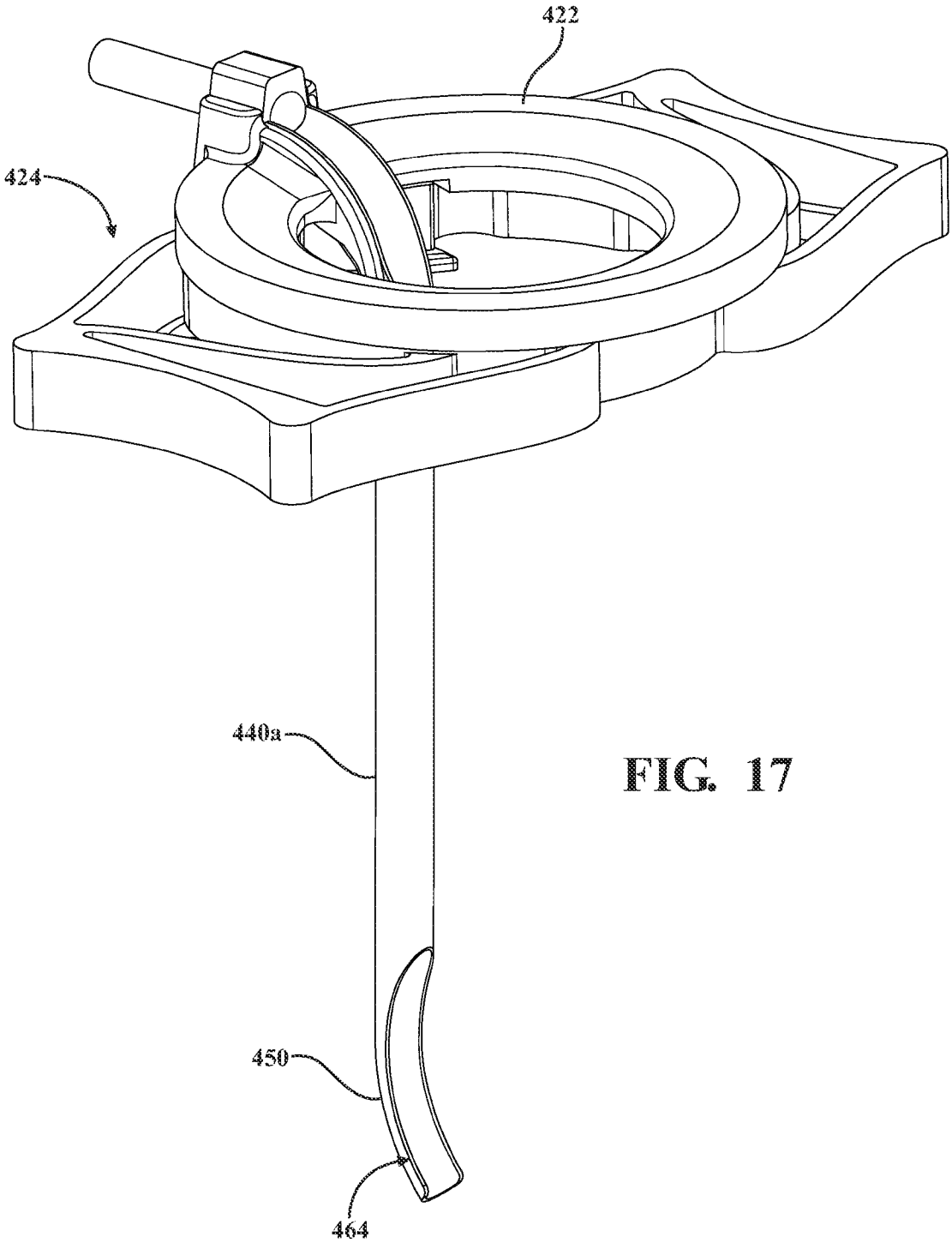


FIG. 17

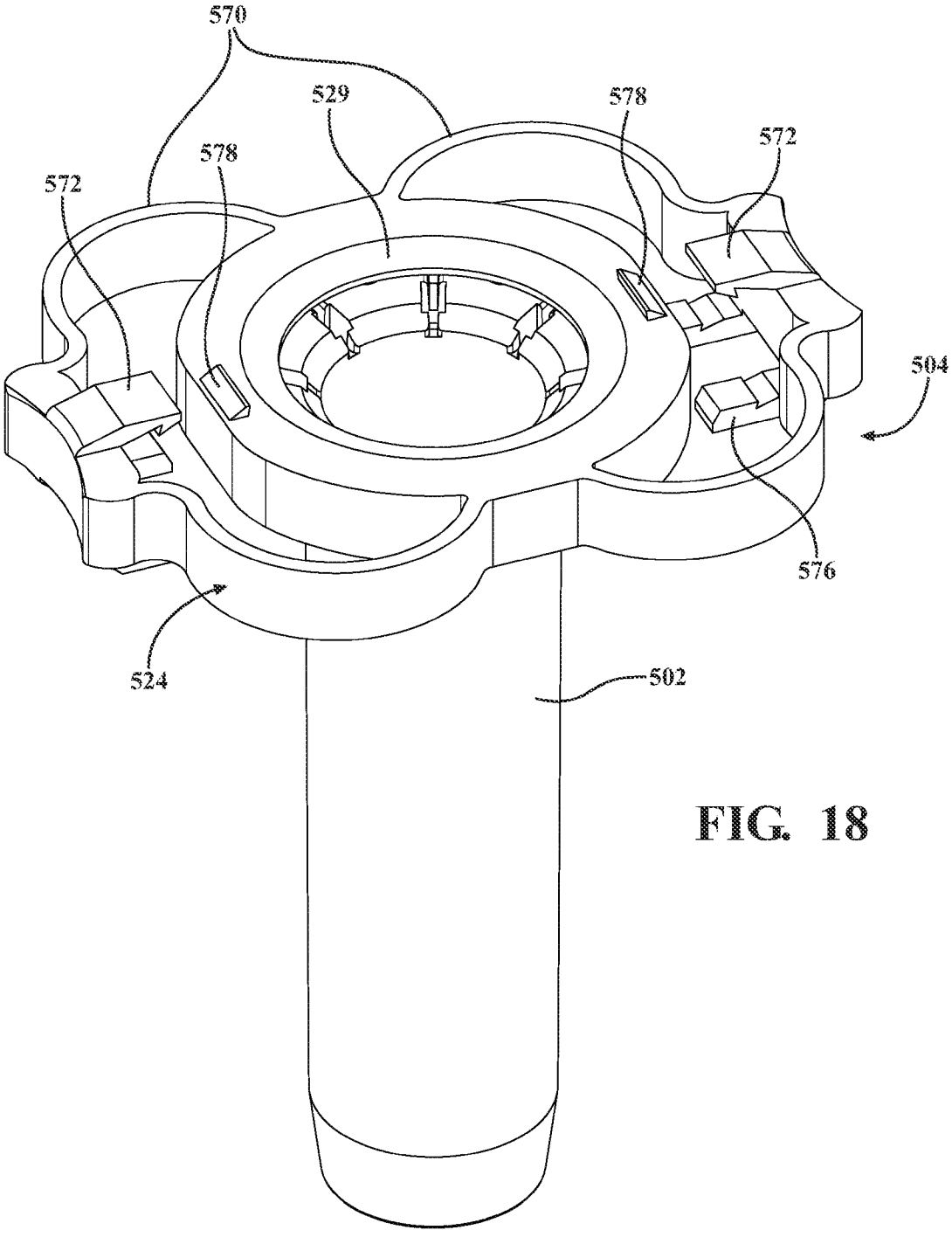


FIG. 18

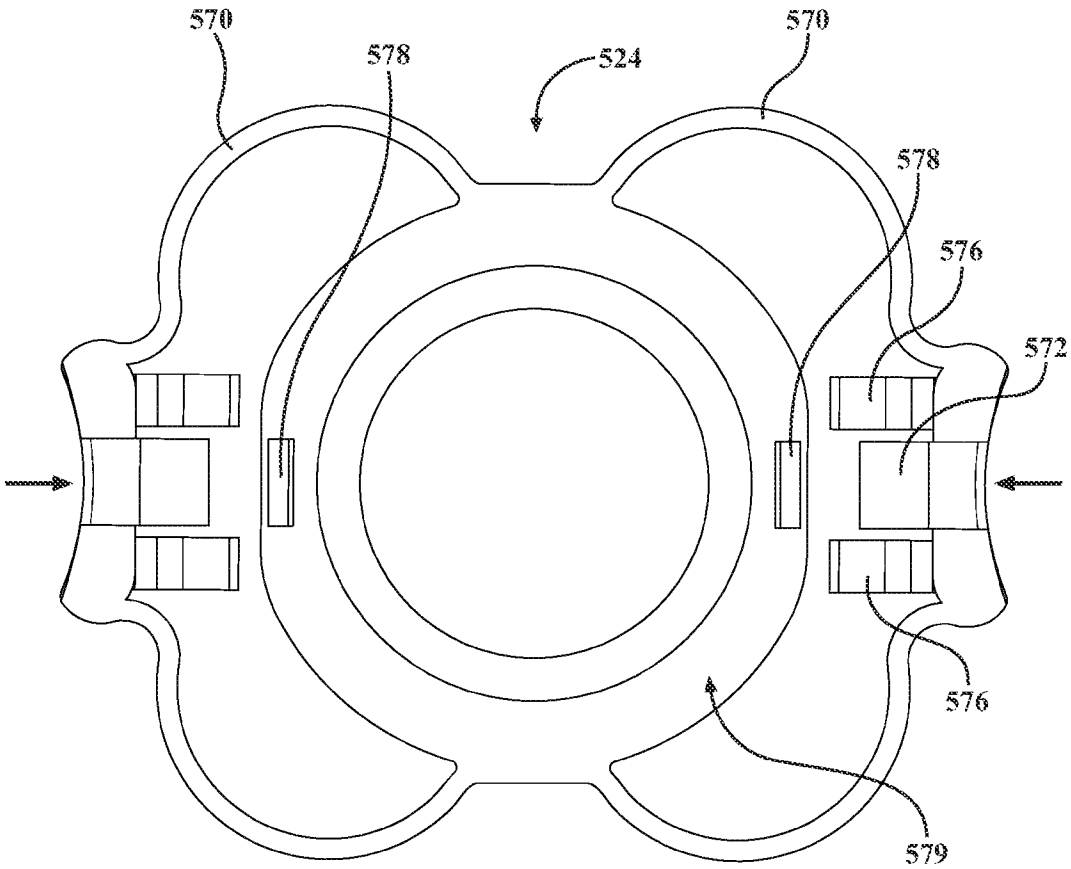


FIG. 19

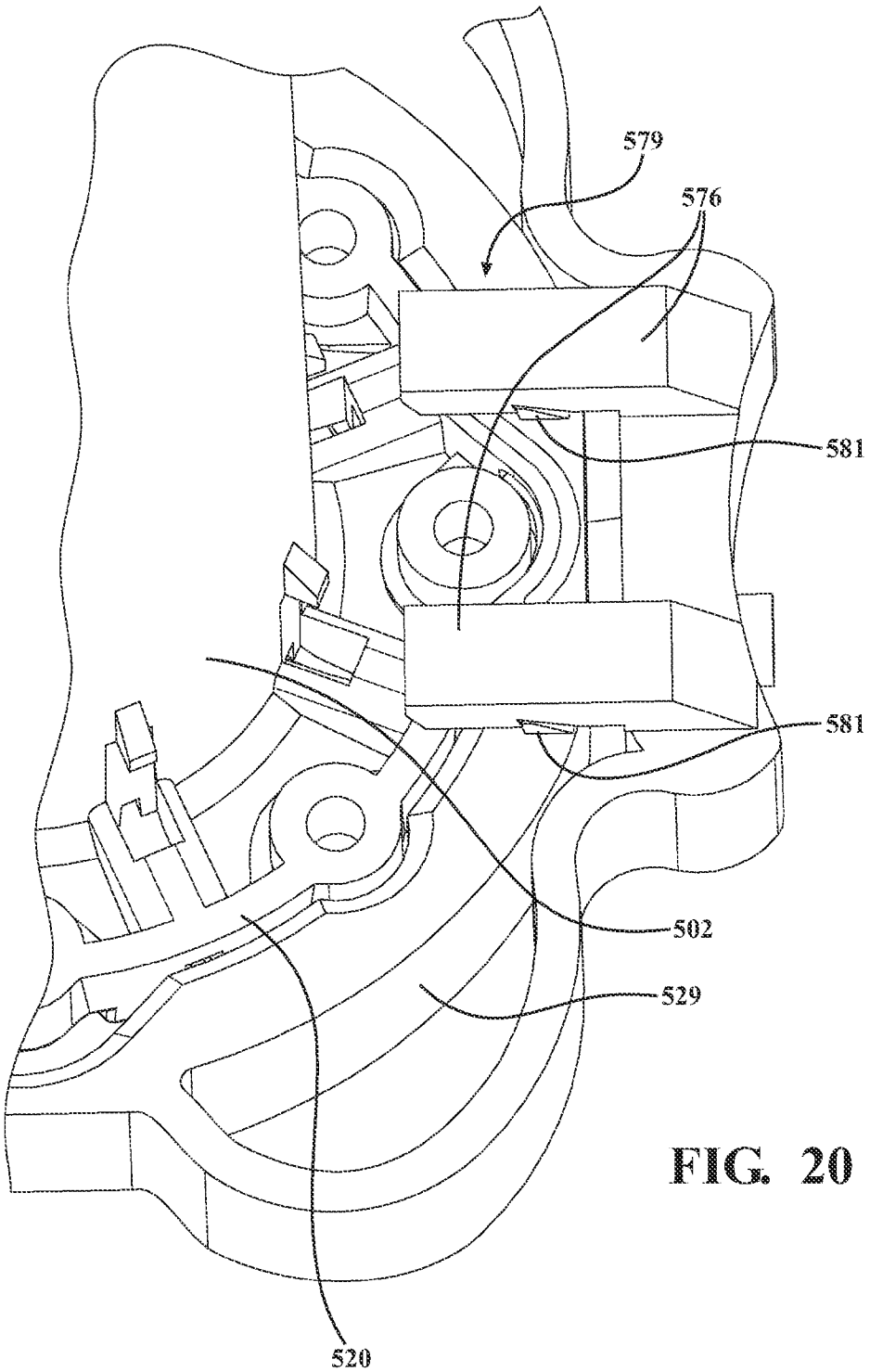


FIG. 20

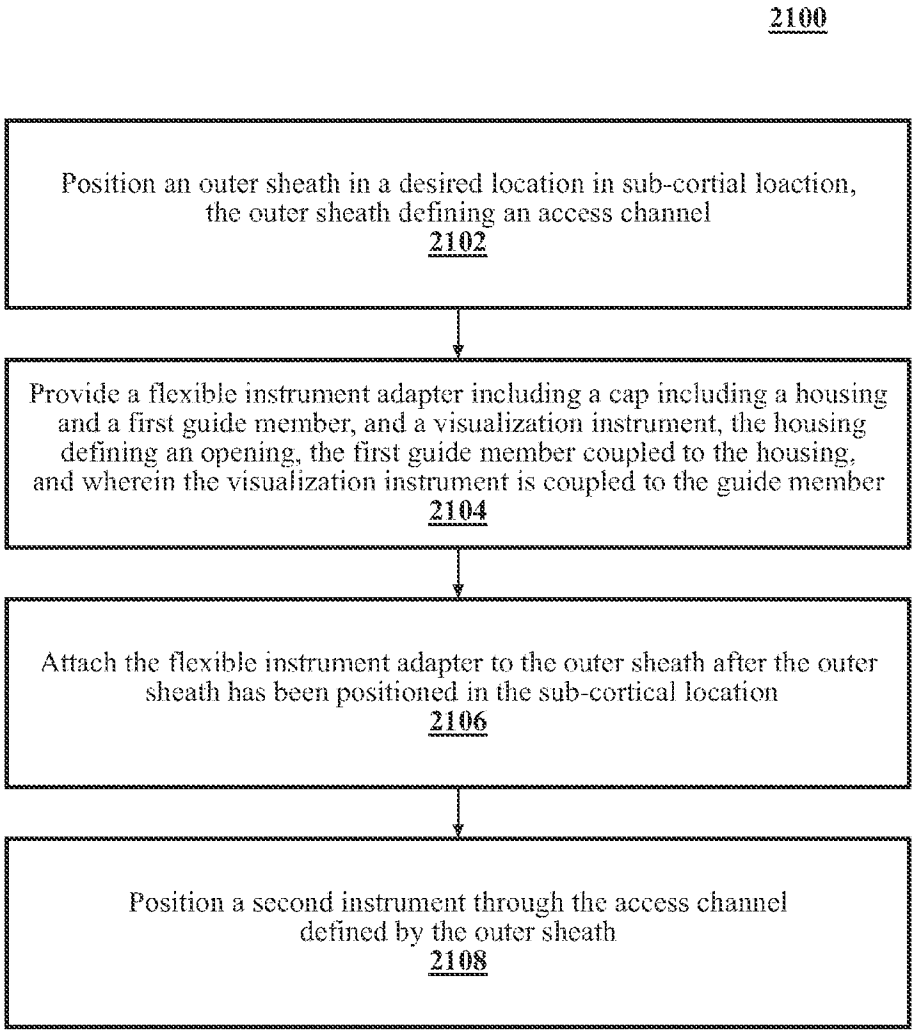

2100
Position an outer sheath in a desired location in sub-cortial loaction, the outer sheath defining an access channel
2102
Provide a flexible instrument adapter including a cap including a housing and a first guide member, and a visualization instrument, the housing defining an opening, the first guide member coupled to the housing, and wherein the visualization instrument is coupled to the guide member
2104
Attach the flexible instrument adapter to the outer sheath after the outer sheath has been positioned in the sub-cortical location
2106
Position a second instrument through the access channel defined by the outer sheath
2108

FIG. 21

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/054927

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/34 A61B90/10
ADD. A61B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

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 2010/041900 A2 (JEONG CHANG WOOK [KR]) 15 April 2010 (2010-04-15) abstract; figures 6, 10-14 paragraphs [0002], [0054]	1
Y	US 2015/374222 A1 (MARK JOSEPH L [US] ET AL) 31 December 2015 (2015-12-31)	1,2, 8-22,24, 25
A	abstract; figures 22-41 paragraphs [0003], [0181], [0190], [0193], [0200] - [0201]	3-7,23
Y	US 2023/011661 A1 (MARK JOSEPH L [US] ET AL) 12 January 2023 (2023-01-12)	1,2, 8-22,24, 25
A	abstract; figures 1-7 paragraphs [0003], [0006] - [0008], [0029], [0038], [0045]	3-7,23

-/--

[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 2025	10/03/2025

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Macaire, Stéphane

2

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/054927

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2023/329824 A1 (DOUGHERTY BRIAN C [US] ET AL) 19 October 2023 (2023-10-19) abstract; figures 2-3, 8-9 paragraphs [0003] - [0004], [0030]	1
A	WO 03/066124 A2 (CLEVELAND CLINIC FOUNDATION [US]; REZAI ALI R [US] ET AL.) 14 August 2003 (2003-08-14) abstract; figure 5	1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/054927

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. [X] Claims Nos.: 45-49
because they relate to subject matter not required to be searched by this Authority, namely:
Pursuant to Article 17(2)(a)(i) and Rule 39.1 (iv) PCT, the subject-matter of claims 45-49 has not been searched, since it is directed to a method for treatment of the human body by surgery (e.g. step of positioning the outer sheath in a desired location in sub-cortical anatomy).

2. [X] Claims Nos.: 26-44, 50, 51
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:
see FURTHER INFORMATION sheet PCT/ISA/210

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:

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.:

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

Continuation of Box II.1

Claims Nos.: 45-49

Pursuant to Article 17(2)(a)(i) and Rule 39.1 (iv) PCT, the subject-matter of claims 45-49 has not been searched, since it is directed to a method for treatment of the human body by surgery (e.g. step of positioning the outer sheath in a desired location in sub-cortical anatomy).

Continuation of Box II.2

Claims Nos.: 26-44, 50, 51

The application comprises 6 independent apparatus claims:

Independent apparatus claims 1, 26, 43, 44, 50 and 51.

There is no clear distinction between the independent claims because of overlapping scope. There are so many independent claims, and they are drafted in such a way that the claims as a whole are not in compliance with the provisions of clarity and conciseness of Article 6 PCT, as it is particularly burdensome for a skilled person to establish the subject-matter for which protection is sought (PCT Guidelines 9.30 and 9.34).
The applicant did not reply to the information to provide informal clarification sent on 22.01.2025.
The search as therefore been restricted to the first independent claims and the corresponding dependent claims. Claims 26-44, 50-51 have therefore not been searched.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.3), should the problems which led to the Article 17(2) PCT declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2024/054927

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010041900 A2	15-04-2010	KR 20100040633 A	20-04-2010
		WO 2010041900 A2	15-04-2010
US 2015374222 A1	31-12-2015	US 2013204095 A1	08-08-2013
		US 2015374222 A1	31-12-2015
		US 2019099070 A1	04-04-2019
		US 2023045431 A1	09-02-2023
US 2023011661 A1	12-01-2023	CA 3167032 A1	07-01-2023
		EP 4115792 A1	11-01-2023
		JP 2023010634 A	20-01-2023
		US 2023011661 A1	12-01-2023
US 2023329824 A1	19-10-2023	NONE	
WO 03066124 A2	14-08-2003	AU 2003208906 A1	02-09-2003
		US 2005245944 A1	03-11-2005
		WO 03066124 A2	14-08-2003