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(71) Applicant: **PSIP2 LLC** [US/US]; Brady-Sullivan Tower, 6th Floor, 1750 Elm Street, Manchester, New Hampshire 03104 (US).

(72) Inventor: **KOUBI, Rom**; 3 Augusta Crt., Skillman, New Jersey 08558 (US).

(74) Agent: **BOUNDY, David**; Potomac Law Group PLLC, 8229 Boone Boulevard, Suite 430, Vienna, VA 22182 (US).

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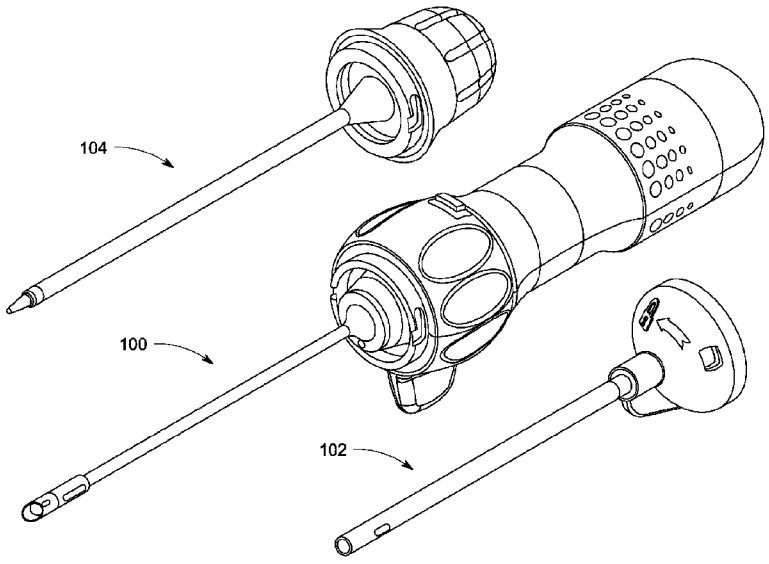

FIG. 1A

(57) Abstract: An endoscope, cannula, and obturator. The endoscope has a handle and an insertion shaft. The insertion shaft has a solid state camera. The handle contains a circuit board with circuitry for control of and receipt of signals from the camera. The handle and its components are formed of biocompatible materials. The handle is formed of inner and outer shells concentric with each other, rotation of the shells relative to each other controlled via one or more resilient components frictionally engaged between the respective shells. The handle has no metal fasteners, no adhesives, and no detachable parts small enough to travel though fluid passages of the insertion shaft, except those encapsulated by overmolding or melt-fusing to prevent dislodgement. The cannula has a connector and locking feature designed to engage with mating connectors and locking features of the obturator and the endoscope, both successively.

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[Continued on next page]

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

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Endoscope

BACKGROUND

[0001] This application claims priority from U.S. App. Ser. No. 17/824,857, filed May 25, 2022, titled Endoscope, U.S. Prov. App. Ser. No. 63/249,479, filed Sept. 28, 2021, titled Endoscope, and U.S. Prov. App. Ser. No. 63/237,906, filed Aug. 27, 2021, titled Endoscope. These applications are incorporated by reference.

[0002] This application relates to endoscopes, laparoscopes, arthroscopes, colonoscopes, and similar surgical devices or appliances specially adapted or intended to be used for evaluating, examining, measuring, monitoring, studying, or testing living or dead human and animal bodies for medical purposes, or for use in operative surgery upon the body or in preparation for operative surgery, together with devices designed to assist in operative surgery.

SUMMARY

[0003] In general, in a first aspect, the invention features an endoscope. The endoscope has a handle and an insertion shaft. The insertion shaft has at its distal end a solid state camera. The handle has retained within a circuit board with circuitry for control of and receipt of signals from the camera. The handle and its components are formed of biocompatible materials, and designed with no metal fasteners, no adhesives, and no detachable parts small enough to travel though fluid passages of the insertion shaft, except those encapsulated by overmolding or melt-fusing to prevent dislodgement. The handle is formed of inner and outer shells concentric with each other, rotation of the shells relative to each other controlled via one or more resilient components frictionally engaged between the respective shells.

[0004] In general, in a second aspect, the invention features an endoscope. The endoscope has a handle and an insertion shaft. The insertion shaft has at its distal end a solid state camera. The handle has retained within a circuit board with circuitry for control of and receipt of signals from the camera. The handle is formed of inner and outer shells concentric with each other. Rotation of the shells relative to each other is controlled via one or more resilient components frictionally engaged between the respective shells.

[0005] In general, in a thrid aspect, the invention features an endoscope set, having an endoscope, cannula, and obturator. The endoscope has a handle and an insertion shaft. The insertion shaft has at its distal end a solid state camera. The handle has retained within a circuit board with circuitry for control of and receipt of signals from the camera. The obturator is designed to pierce tissue for introduction of the endoscope. The cannula is a tube designed to accept passage of the

endoscope insertion shaft and to offer structural protection to the insertion shaft. The cannula has a connector and locking feature designed to engage with mating connectors and locking features of the obturator and the endoscope, both successively.

[0006] Embodiments of the invention may include one or more of the following features. The inner and outer shells of the handle may be formed of plastic components. The components may have resilient clips designed to held the components to each other before joining into unitary structure via melting. One or more control buttons of the endoscope may be molded with projections that function as return springs. The projections may be adhered into the endoscope handle via melting. The circuit board may be overmolded by plastic that encapsulates the circuit board from contact with water. Components of the handle may be joined to each other into a unitary structure via melting. The resilient components may include O-rings. The outer shell of the handle may have an overmolded layer of a high-friction elastomer. Locking features of the obturator and endoscope may be engageable by twisting of the endoscope relative to the cannula. Connectors of the endoscope and cannula may be watertight. The connectors may be molded for an interference seal without O-rings. The connectors may be formed as two frusta of cones in interference fit.

DESCRIPTION OF THE DRAWINGS

[0007] FIGS. 1A to 1H, 2A to 2Q, and 3A to 3G, 4C, 4E to 4H, 4N to 4W, 5A, 5G to 5J, and 5N to 5Z, 7B, 7C, 7G, and 7J are perspective views of endoscopes and/or endoscope related apparatus.

[0008] FIGS. 4A, 5B, 5D, 6A to 6E, 7C, 7E to 7I are plan section views of endoscopes and/or endoscope related apparatus.

[0009] FIGS. 4B, 4I, 4M, 5M, are exploded views of endoscopes and/or endoscope related apparatus.

[0010] FIGS. 4D, 4J, 4K, 4L, 5C, 5E, 5F, 5K, 5L, 6F, 7A, 7D are perspective section or cutaway views of endoscopes and/or endoscope related apparatus.

[0011] FIGS. 7K and 7L are plan views of endoscopes and/or endoscope related apparatus.

DESCRIPTION

[0012] The Description is organized as follows.

I. Overview

II. An endoscope that is partially-reusable, partially disposable/replaceable, and a coupling joint between

III. Extendable, bendable, or articulated camera tip

I. Overview

[0013] Referring to FIG. 1A, endoscope 100 (such as an arthroscope, laparoscope, or other), trocar 102, and obturator 104 may be used for joint surgery, joint access, or other minimally-invasive surgery. A minimally-invasive surgery generally begins with penetration to the surgical site using a pointed instrument such as trocar 102 or obturator 104. Trocar 102 is a hollow tube used to pierce from the skin to the surgical site; trocar 102 will remain in place during the surgery to maintain an access port. During piercing, trocar 102 may have obturator 104 inserted through the lumen. Obturator 104 and/or trocar 102 may have sharp points for piercing into the tissue of a joint, abdominal cavity, or other surgical site to create an access portal. Obturator 104 may be inserted into trocar 102, used as a unit to pierce skin and other tissues, and once the space of interest is accessed, obturator 104 may be pulled out, leaving the "trocar cannula." The scope may be placed through the cannula for visualization of the surgical site. The endoscope may be a "chip on a tip" scope, having an illumination source and a camera. After an access portal is cut via obturator 104 and trocar 102,

the endoscope may be inserted through trocar 102 to the surgical site, to provide the visual access to a surgeon who performs the surgery with other instruments. Other trocars may placed for access by other instruments, such as laparoscopic scalpels, shavers, staplers, suture machines, and the like.

[0014] In some cases, endoscope 100 may be inserted down the inner lumen of obturator 104, and the point of obturator 104 may be transparent. The endoscope-within-obturator configuration may provide visual guidance to guide obturator 104 or trocar 102 to the correct surgical site. In other cases, trocar 102 may have a sharp point, and the endoscope may be inserted down the inner lumen of trocar 102, to guide trocar 102.

[0015] Referring to FIG. 1B, endoscope 100 may have a number of features that ensure reliability, reduce manufacturing costs to the point that the entire endoscope, or portions thereof, may be disposable. Resterilization of endoscopes is costly, and always imperfect, which increases risk of cross-infection. Also, as endoscope 100 is reused, the optics become scratched and clouded, reducing the precision of the view available to the surgeon. Sections II to VIII will discuss multiple features of the endoscope that provide such cost reduction and disposability.

[0016] Referring to FIG. 1C, obturator 104 may be locked into the outer sheath or trocar 102 via a twist lock 940, 942.

[0017] Referring to FIG. 1D, obturator 104 and trocar 102 may be used to pierce into the surgical site, for example, a region of a knee behind the patella.

[0018] Referring to FIGS. 1E and 1F, obturator 104 may be unlocked from outer sheath/trocar 102. Obturator 104 and endoscope may be withdrawn, leaving hollow trocar 102 as a port to the site.

[0019] Referring to FIG. 1G, instruments, such as endoscope 100, etc. may be inserted through the outer sheath/trocar 102 to perform the surgery.

[0020] Referring to FIG. 1H, trocar/sheath 102 may be locked to the endoscope via the same twist lock motion as was used to hold the outer sheath/trocar 102 to obturator 104.

[0021] The various endoscope tip designs (FIGS. 2F-2M, 4A-4K, 4M-4W, 4X-4OO), may have the following properties. The overall tip may be small enough to meet the dimensions of the endoscope, typically the dimensions in the table of paragraph [0028] above. In some cases, the tip may be slightly larger or smaller in diameter than shaft The tip may hold a camera, illumination, fluid injection or evacuation ports, procedural tools, etc. mechanically stable, within that diameter. The tip may seal against elevated pressures that are typically used to distract tissues out of the view of the scope, to prevent intrusion of bodily tissues and fluids and insufflation fluid. The tip may deliver or allow delivery of illumination light, either via an LED mounted in the tip, or using fiber optics to convey light from the handle or a controller. Opaque parts of the tip assembly may exclude stray

light, both from the illumination fibers/LEDs/light guides, and reflected light from the surgical cavity. The tip may be manufacturable at desired quantities and cost. The tip may have a configuration that is atraumatic to surrounding tissue, for instance, without sharp points or edges. In some cases, the tip may have a piercing point for an initial entry. The tip may be designed to resist fogging or fouling. The tip may permit cleaning, preferably while *in situ* the surgical site.

II. An endoscope that is partially-reusable, partially disposable/replaceable, and a coupling joint between

[0022] Referring to FIGS. 2A, 2B, 2C, 2D, and 2E, a surgical endoscope 100 may be structured to permit detachment of a shaft 110 portion from the endoscope's handle 112, 114. A camera or image sensor at tip 116 of the shaft, any panning mechanism, illumination, power and signal connectors, and fluid flow channels may be in the disposable shaft 110. Handle 112, 114 may be designed to be reusable (which implies that handle 112, 114 may be sterilizeable, for example in an autoclave or other sterilization device, or protectable by a disposable sterility sleeve). Joint 130 between the detachable shaft and the reusable parts of handle 112, 114 may be generally distal in the handle (but not necessarily at the distal-most end). The replaceable shaft portion 110 may be disposable, along with a disposable portion 120 of the handle that is disposable with shaft 110.

[0023] Referring to FIGS. 2A and 2B, the handle of the endoscope 100 may include three principal components:

- The disposable cap 120. This distal-most portion of the handle may serve as a mounting base for shaft 110, and may disconnect from the remainder 112, 114 of the handle. This disposable cap portion 120 (along with shaft 110 and componentry inside) may be disposable.
- Rotation collar 112 may have surface features 302, 304 to allow a surgeon to rotate the rotation collar 120 about the central axis of the handle, that is, about the roll axis 126 of shaft 110. During surgery, insertion shaft 110, disposable cap 120 and rotation collar 112 may be locked to rotate with each other, so that rotating the rotation collar effects rotation 126 of the disposable cap 120 and shaft 110.
- Proximal stationary handle 114 has a shell surrounding componentry within the handle. The outer diameter and outer surface of handle 114 may be designed to provide an easy and low-slip grip for a surgeon's hand. Joint 128 between the proximal handle and rotation collar may allow these two components to rotate relative to each other. In some cases, a circuit board and similar componentry inside proximal handle 114 may rotate with disposable cap 120 and rotation collar 112, inside proximal handle 114.

Disposable cap 120 and rotation collar 112 may be separable from each other at joint 130, so that disposable cap 120 and shaft 110 may be disposable, while handle 114 and rotation collar 112 (and componentry inside them) are reusable.

[0024] Referring to FIGS. 2A, 2B, 2C, 3A, and 3B, between the disposable cap 120 and rotation collar 112, three basic connections may be made:

- A rotation-locking coupling 140, 142 to hold the disposable portion 120 to the reusable handle 112, 114. Coupling 140, 142 may have sufficient strength to transmit insertion and withdrawal forces, roll, pitch, and yaw torques, lateral forces, and similar forces from the proximal reusable handle 112, 114 to the distal disposable portion 120 and shaft 100, thereby to allow a physician to aim the illumination and/or camera as needed. Joint 130 between disposable cap 120 and rotation collar 112 may lie generally toward the distal end of the handle. The disposable cap and rotation collar 112 may engage through flat force-transmittal surfaces 144 at the center of joint 130 and around the circumferences, so that these forces are supported around the circumference of separable joint 130. One or more release buttons 146 may be pressed or squeezed to cause one or more locking snaps 148 to disengage. The mechanical connection may include a rotatable locking ring or other release/fixation mechanisms.
- An electrical connection to supply power to the illumination source and camera, and to carry optical signals back from camera 410 to the processing board in handle 112, 114 and display system outside the endoscope. The disconnectable electrical connections for power and signal may be effected by a USB-C connector 150, 152, mini HDMI connector, or similar connector that can maintain signal integrity for high speed signals. If illumination is conveyed by optical fiber, joint 130 may include an optical connector.
- A disconnectable connection to any panning mechanism for camera 410 may be effected by a physical connector, such as a linkage.

[0025] In some cases, the camera/image sensor 410, LED, and electronic connections (and any mechanical connections for panning the camera/image sensor 410) may be removable from insertion shaft 110. Shaft 110 and cap 120 may be smooth and simple enough in shape to allow easy sterilization. Similarly, once the electronics are removed from interior of shaft 110, they may be sterilizeable as well. it may be cost-effective, especially in lower-labor-cost markets, to disassemble, sterilize, and reassemble the shaft and its interior components for reuse.

[0026] One or more fluid hoses 160 for irrigation liquid or inflation gas (or two hoses, one for fluid and one for gas) may enter through disposable cap 120, so that the entire set of fluid tubing for the irrigation/inflation channel may be disposable with the disposable shaft portion. In other cases (*e.g.*, FIGS. 3E and 3F), a fluid hose 162 may enter the proximal end of the scope, and disconnectable fluid connections within joint 130 for fluid inflow and outflow may be effected by gaskets, O rings, and the like. Alternatively, connectors for the hoses may be outboard of the endoscope itself, either near the endoscope (for applications where it may be desirable to allow "quick change" replacement of the insertion shaft 110 in the course of a single procedure), or far from the endoscope, typically at

the receptacle for waste fluid, to ease disposal of all hoses that are potentially contaminated by contact with the patient.

[0027] Disposable shaft 110, 120 may be designed to facilitate disposability of components that come into contact with bodily fluids. Because sterilization is often imperfect, patient safety may be improved by disposing of components that have come into contact with patient bodily fluids. To improve sterilizability, it may desirable to reduce componentry in the disposable component 110, 120 so that cost of the disposable component may be reduced, and to reduce surface features and crevices that may be difficult to sterilize. Thus, the lens, image sensor, LED, panning mechanism, and shaft 110 may be disposable. In addition, because shaft 110 is used for fluid inflow and outflow, and is disposable, sealing against bodily fluids may be unnecessary.

[0028] Referring to FIG. Referring to FIG. 2D, the replaceable/disposable shaft 110 and its mounting componentry 120 may be specialized to different types of surgery. For example, a purely diagnostic scope 172 may have an outer diameter of 1 to 3mm. A replaceable disposable cap / shaft unit 110, 120, 178 for laparoscopic thoracic surgery may have a shaft of 400 mm length and diameter of 10 mm. Replaceable components 176 for arthroscopic surgery of knees and hips may be 155 mm in length, and 5.5 mm or 4 mm in diameter. For small joints, a replaceable shaft 174 of 2.9 mm diameter or less may be preferred. A replaceable shaft/scope unit with an bendable end 200 may be dimensioned for laparoscopic surgery. Typical dimensions for various surgical specialties may be as follows (measured in millimeters):

		Cannula diameter		Scope diameter	
Scope Type	**Discipline**	**Min**	**Max**	**Min**	**Max**
Arthroscope (small joint)	Arthroscopy	2.8	4.0	1.9	2.9
Arthroscope (large joint)	Arthroscopy	4.7	6.0	2.9	5.3
Cytoscope	Cytoscopy			2.9	5.3
Encephaloscope	ENT			2.0	4.0
Hysteroscope	Gynecology	3.7	7.0	2.0	5.0
Laparoscope	Laparoscopy			2.0	10.0
Sinuscope	ENT			2.0	4.0
Thoracoscope	Pulmonary				10

[0029] Various replaceable components 110 may have different instruments at tip 116. For example, various replaceable shafts may have cameras oriented at 0° (directly on-axis), 30°, 45°, 70°, and 90°.

[0030] Referring to FIG. 2B, disposable shaft portion 110, 120 may in turn be separable into an outer cannula 132 for protection and strength, and an inner shaft portion 134 carrying various illumination, optical, and fluid-carrying componentry. The scope may be sold as a handle unit 112, 114 with a set of ten or twelve or twenty replaceable shaft/cap unit 110, 120.

[0031] U.S. App. Ser. No. 16/434,766, filed Jun. 7, 2019, and its formal drawings filed Aug. 13, 2019, are incorporated by reference.

III. Extendable, bendable, or articulated camera tip

[0032] Referring to FIGS. 2F and 2G, the camera tip 202 may be slideable within cannula shaft 132, to be extendable and retractable. When extended, the distal portion of camera stalk 202 may be bendable, for example, as rigid segments 210 joined at articulation joints. In FIGS. 2F and 2G, cone 204 shows the field of view of camera 410. The extendable/bendable portion of shaft 202 may be formed of a series of elements that are each essentially rigid in the longitudinal dimension, but articulated at each joint to permit bending or flexure. The articulation may all be in the same dimension, as shown in FIGS. 2F and 2G. Alternatively, as shown in FIGS. 2H and 2I, articulation pivots 212 may be at alternating 90° angles, so that the bending may be in two dimensions, which in combination, may yield 360° of bending angles. Alternatively, the bendable portion 202 may be formed of elastic material, with an internal stiffener that is relatively stiff and incompressible against longitudinal compression dimension, and flexible in lateral and/or inclination bending. Bendable portion 202 may include two or four cable channels spaced around an outer surface, so that tension cables may cause bending in a desired direction.

[0033] Referring to FIGS. 2H, 2I, 2J, 2K, 2L, and 2M, in some cases camera 410 may be pannable within endoscope tip 400. For example, camera 410 and its illumination LED may be mounted on one side of a substrate 220 formed as three rigid segments with two hinges 222, so that the two outer segments 224 may be moved relative to each other 226, and the center segment rotates in place, in the manner of a flexing parallelogram. The two outer segments 224 may be mounted in slide channels, and connected by cables 228 to controls at the handle. Referring to FIG. 2J, substrate 220 may be molded onto a flat flexible backing. The backing may contain folds 222 to create hinge points that allow the backing to fold into its parallelogram configuration (FIGS. 2K and 2L). Pivot points 230 may be molded into substrate 220. Referring to FIG. 2K, a flex circuit 232 may be laminated onto the substrate, and control tension cables 228 attached to the two ends. A camera, illumination LED, pressure sensor, temperature sensor, or other sensors may be affixed to substrate 220. Referring to FIG. 2L, substrate 220 may be folded into three sides of a parallelogram, and a fourth side may be formed by a linkage connected to hinge points. Further details are described in U.S. Pat. No. 9,375,139, incorporated herein by reference.

[0034] Longitudinal movement 226 of one face of the substrate relative to the other changes the angle of the center segment, and thus the angle of the image CCD or other camera, and any other sensor. This may provide an adjustable view angle over a range that may be as large as 90°. The

endoscope can also accommodate for a 180° or retrograde view where the endoscope has a flat top construction and a rotatable or living hinge rectangular endoscope architecture.

[0035] Passages and apertures for ingress and egress of irrigation, inflation, or other fluids may be provided in the tip. An aperture for irrigation fluid may be aimed to clear fouling from a window or lens over camera 410.

[0036] At least one of surfaces 224 may contain a metal strip bonded onto or into segment 224. The metal strip may be a spring steel or nickel-titanium alloy with a preformed radius of curvature. The metal alloy may alternatively be a malleable metal such as aluminum or may be a nickel-titanium (nitinol) alloy with a shape memory feature. The metal strip allows the elongated core to reliably bend in one plane of curvature. Where the memory substrate is spring-steel or nitinol, it may bend to a shape if malleable, or may be made steerable with a nitinol shape-memory component.

[0037] Referring to FIGS. 2N and 2O, lever 240 may be moved to advance/project or retract/withdraw camera 410 within insertion shaft (FIGS. 2F and 2G). Another switch/lever 242 (for example a paddle-shaped switch) may control cables or levers that flex the articulable tip by exerting tension on cables 228 that extend to the tip, to cause rotational articulation at joints 212 along the extendable portion 202 of shaft 110, thereby to control articulation of the camera tip to move in positive-y and negative-y directions. Another lever may be used to control camera panning (FIGS. 2H, 2I, 2J, 2K, 2L, and 2M).

[0038] Referring to FIGS. 2P and 2Q, a four-point control 244 may control four control cables 228 or rods or other load bearing components to the articulated or bendable portion of the extendable/retractable and/or articulated camera shaft 202, so that the camera tip may be articulated in positive-x, negative-x, positive-y, and negative-y directions.

[0039] Referring again to FIG. 2D and 2E, the extendable/retractable and/or articulated camera shaft 110, 200 may be used with a reusable handle, disposable tip configuration. The extendable/retractable and/or articulated camera shaft may be used with a reusable or single-use unibody scope configuration.

[0040] The articulated camera tip 200 may be especially useful in abdominal thoracic laparoscopy. Typically, during abdominal surgery, the abdominal cavity is inflated with carbon dioxide, to give the surgeon a large open field of view. This gives an extendable/retractable and/or articulated tip space to move. The extendable/retractable and/or articulated tip may be useful to provide a view behind an organ, such as the stomach or liver. If the surgeon only has a fixed view endoscope/laparoscope, the only way to obtain a view behind an organ would be to open another port from the opposite side of the body.

IV. Additional features of an endoscope

[0041] Referring to FIGS. 2A and 2B, disposable shaft portion 110, 120 may in turn be separable into an outer cannula 132 for protection and strength, and an inner shaft portion 134 carrying various illumination, optical, and fluid-carrying componentry. Illumination may be provided by an LED at or near the distal tip, or via fiber optics from an illumination source in the handle, or illumination at an external controller.

[0042] Referring again to FIG. 2A, the endoscope may have a handle 112, 114, 120, and a shaft 110 for insertion into a body. At or near distal tip 116 of the shaft 110 may be a camera, electronic image sensor, or other optical component. The camera's orientation may be fixed in the scope, or may be pannable. Camera 410 may be at tip 116, looking out from the shaft, or may be recessed a short distance behind the structural tip of the shaft. Also at or near the tip may be an illumination source, such as an LED. Tip 116 may have a rigid pointed tocar tip, or may have a spoon-shaped portion that reaches past the image sensor, or may be flexible (in the manner of the tip of a colonoscope), in each case extending a little beyond imaging camera to provide physical protection to the camera/image sensor 410 during insertion or to protect camera/image sensor 410 from a surgical cutting device.

[0043] Illumination may be in visible light, infrared, and/or ultraviolet. In some cases, an illumination LED (light emitting diode) or other illumination source may be placed in reusable handle 112, 114 or in a docking station/controller, and the disposable shaft may have fiber optics to transmit light to the tip, and joint 130 may have an optical coupler. In other cases, the illumination LED may be placed in tip 116 to illuminate the surgical cavity directly; in such cases, joint 130 may have a power connector. In some cases, the LED may be recessed from the tip, or placed somewhere in the shaft, or may be in an external controller, and optical fiber may carry illumination light to the tip. The optical fiber may be configured, for example, with a split, so that light will be arrayed in a desired pattern around the image sensor to better distribute the light into the surgical cavity around the image sensor.

[0044] The shaft 110 itself may be rigid, made of a nonbioreactive metal such as stainless steel or coated aluminum. In some cases, a surgical cavity around endoscope tip 400 may be insufflated by gas (typically carbon dioxide), or irrigated by saline solution. In either case, fluid inflow and outflow may be effected by channels through the shaft.

[0045] Shaft 110 may also carry power wires to the illumination LED and camera 410, and carry signal wires that carry an optical signal back from camera 410 to electronics in the reusable portion 112, 114 of the handle. Electrical power to camera 410 may be supplied over conductors in a flexible cable or on a printed circuit board (flexible or rigid), and insulated with a conformal and insulating coating such as parylene. This same flexible circuit board 416 may have signal conductors

for the video signal from camera 410. The video signal may be transmitted from camera 410 to the handle using any video signal protocol, for example, MIPI (Mobile Industry Processor Interface) or HDMI. Parylene may also improve biocompatibility.

[0046] Shaft 110 may also carry cables or other mechanical elements to control panning of camera 410.

[0047] Referring to FIG. 3A, 3C, and 3E, rotation collar may have various features that make rotation easy. For example, depressions 302 may provide a good grip for fingers for light roll torque. Fin 304 may provide greater leverage for greater roll torque, and may also provide a fixed rotational point of reference.

[0048] A button 310 may perform various functions, such as turning illumination LED on or off, taking pictures, starting and stopping video, and the like. A single button may perform all these functions based on the nature of the press. For example, press-and-hold for 3 seconds may turn the illumination LED on and off. A quick press may capture a single-frame still picture. A double-click may start and stop video recording.

[0049] If camera 410 at the tip 116 of shaft 110 is pannable or has other controllable features, there may be a control (for example, a lever, or a touch-slide panel, etc.) near button 310 to control that adjustment of camera 410.

[0050] One or more ultraviolet LEDs or other illumination source may be placed inside handle 112,114, inside shaft 110, or near tip 116 to assist with insuring sterility of the internal components of the device or of the water as it passes thru the device

[0051] Referring to FIGS. 3C, 3E, and 3F, irrigation/insufflation hose(s) 160, 162 may enter at various points through the handle. For example (FIG. 3C), irrigation/insufflation hose(s) 160, 162 may enter laterally, somewhere near the distal end of the handle, for example, through fin 304. Or, as shown in 3E and 3F, irrigation/insufflation fluid/gas hose(s) 160, 162 may enter through the proximal end of handle 114. This hose may then be disconnectable via a fluid disconnect joint 320 within joint 130. In cases where hose(s) 160 for insufflation fluid/gas enters through disposable cap 120 (FIG. 3C), various joints and strain relief features 340 may be used to hold hose(s) 160 in place.

[0052] Referring to FIG. 3B and FIG. 3F, electrical connectors 150, 152 such as USB-C or mini-HDMI connectors may be used to connect camera 410 to a circuit board interior to handle 114.

[0053] Referring to FIG. 3B, rotation-locking coupling 140, 142 may lock disposable cap 120 in rotational relationship to rotation collar 112. Various rigid and resilient features 144, 148 may lock them together for other forces and torques, and release buttons 146 may permit them to disengage to allow replacement of disposable cap 120. The coupling between cap portion 120 and

rotation-locking coupling 140, 142 may place much of the stress at the periphery of the joint, so that joint 130 may carry and transmit forces (especially torques) well.

[0054] Referring to FIG. 2A, 3C, and 3D, rotation between the handle's stationary portion 114 and rotation collar 112 may be provided via a rotational bearing at joint 128.

[0055] Referring to FIGS. 3C, 3D, and 3E, proximal handle 114 may contain a number of components, typically components that have only incidental patient contact (and therefore present less risk of cross-infection), are higher in cost (and therefore desirably reusable), and either sterilizeable or may be covered by a sterility sleeve. For example, proximal handle 114 may hold power transformers, signal amplifiers, controls for the illumination LED and camera, a mechanical control for panning camera 410, rotation sensors for righting of an image from camera 410, and the like. The handle may also include connections to external sources and destinations of power, signal, fluid, and the like.

[0056] Proximal handle 114 may include rotational sensors so that an angular orientation of camera 410 may be ascertained. For example, the inner surface of proximal handle 114 may mount one or more magnets 320, and printed circuit board 322 (which rotates with rotation collar 112 and disposable cap 120) may have Hall effect sensors 324 that detect the magnets. This may be used to compute a rotational orientation, which may in turn be used to "right" the image from camera 410 on a video display screen.

[0057] The distal tip of the shaft, camera 410 mounted therein, and the mounting of componentry within shaft 110 may be designed to be robust. Occasionally, during surgery, the tip of the endoscope may come into contact with a shaver, ablation probe, or cauterization probe, and it may be desirable to have the tip be robust to such contacts. To reduce risk that componentry may be dislodged and left in the patient, the disposable shaft and its componentry may be designed to avoid joints that are at high risk of mechanical failure. A disposable optical system may prevent the image degradation that occurs when nondisposable optics are reused in multiple surgical procedures.

[0058] Endoscopes as a genus include arthroscopes, laparoscopes, colonoscopes, and other specialized scopes for various body cavities. For an arthroscope for joint surgery, the shaft may be as small as 5mm, 5.5mm, or 6mm, and highly rigid. For other endoscopes, such as a colonoscope, the diameter may be larger, and the shaft may be flexible.

[0059] The endoscope may be delivered as a handle and multiple tips, each tip individually sealed for sterility.

[0060] Referring to FIG. 3F, hoses 160, 162 for irrigation/insufflation fluid/gas in, irrigation/insufflation fluid/gas out, and electrical connection cord 164 may be permanently affixed 340, 342 to disposable cap 120. This arrangement may allow that hose 162 that carries water out of

the surgical cavity, and which is therefore contaminated, may be disposable, and no fluid will come into contact with the reusable part 114 of the handle. Hoses and cord 160, 162 may be routed through channel 354 running the length of reusable handle 112, 114. Channel 344 may be of inner diameter large enough to permit easy passage of hoses and cord 160, 162, 164, and connectors 350, 352, and have a continuous smooth wall that permits easy sterilization, to permit ready replacement of the replaceable components. Channel 354 may be off the central axis, to allow printed circuit board 322 to lie on the central axis. Connectors 350, 352 at the end of hoses and cords 160, 162 may be small enough to pass through channel 354. Thus, replacement of shaft 110, cap 120, hoses and cords 160, 162 may be effected by threading connectors 350, 352 and hoses and cord 160, 162 through channel 344. Electrical cord 164 may have a connector 354 at or near joint 130, and hose(s) 160 for irrigation/insufflation fluid/gas flowing into the surgical cavity may likewise have a connector at joint 130 to allow this hose(s) to be reusable, or may be permanently affixed 340 to reduce possibility of leaking. Having hoses and cable 160, 162 roughly on-axis reduces undesirable cable flop as the scope is in use, and reduces undesirable torque on cap 120. Forming shaft 120, cap 120, and hoses 160, 162 as an integral unit for replacement reduces possibility of leaking, and improves sterility of the replacement operation.

[0061] Referring to FIG. 3G, reusable handles 112, 114 may be sterilized in a sterilizer 360. Preferably, hose(s) 160, 162 and all other portions of endoscope 100 that come into contact with the patient, or with fluids that have come into contact with the patient, are disposable, and the design for reusable portions 112, 114 ensures that contamination is minimized through avoiding contact with the patient's bodily fluids. Sterilizer 360 may be arranged to accept one or more reusable handles 112, 114, and irradiate them with ultraviolet light from ultraviolet LEDs 362. Rods 364 that pass through handle channel 344 may have ultraviolet LEDs 366 arranged along their lengths, to sterilize internal channels 344.

V. Endoscope tip

[0062] Components of endoscope tip 400 may be designed to permit a camera or vision sensor 410, a light source, an objective lens or window, and fluid management to be mounted within a confined space, such as an endoscope of 5 mm diameter or less.

[0063] Referring to FIGS. 4A and 4B, endoscope tip 400 may be formed of top brace 412, bottom brace 414, and flexible circuit board 416. Camera 410 may be mounted on one side of flexible circuit board 416, and an illumination LED on the other side. Clear window 420 may protect camera 410 from the outside environment, such as the tissues and bodily fluids of an endoscopic

procedure, and pressurized insufflation fluids. The entire assembly may be locked together via overmolding.

[0064] Referring to FIG. 4B, to assemble the components, one end of flexible circuit board 416, the end with the LED mounted thereon, may be slotted into a slot or channel in top brace part 412, which holds the LED into place. Then board 416 may be folded around a bend in top brace 412, so that camera 410 comes into place through its hole in top brace 412. The folding and rotation brings the LED close to the sensor, which permits the assembly to fit within the 5mm diameter of tip 400. Then bottom brace 414 may be brought into place, which holds top brace 412, bottom brace 414, circuit board 416, LED, and camera 410 in their positions of mutual alignment. A locking notch and clip, or ultrasonic welding may hold this assembly together for a time. Then an overmolding step may lock everything together.

[0065] Referring to FIGS. 4C, 4D, 4E, 4F, and 4G, transparent window 420 may cover camera 410 to protect it. Window 420 may be two thicknesses, a thicker region over camera 410, and a thinner region for the portions used for mounting and for the LED to shine through. A peripheral ridge of endoscope tip 400 may extend beyond window 420 by a small amount. Top brace 412 may include a wall that surrounds the LED. These shapes, alone or in combination, may offer one or more of the following advantages. First, these shapes may reduce stray light from the LED being internally reflected into camera 410. Second, the thickness of the window 420 on the lens side may reduce vignetting artifacts, when the edge of the field of view of a camera image is occluded or the lens gathers less light toward its edge. Likewise, the shape of the lens may be used to reduce distortions such as fisheye distortions. Third, the ridge may tend to keep tissues away from the lens, reducing obscuring and improving view.

[0066] Window 420 of FIGS. 4E and 4F may be placed over the surface of the assembly of circuit board 416 with LED and camera 410, top brace 412, bottom brace 414, and window 420 (FIGS. 4B, 4C). Then the assembly with window 420 may be locked together via overmolding of a covering sheath (FIGS. 4C, 4D, 4G). This overmolding may provide watertightness to the entire tip assembly. The overmolded assembly may then be fitted onto the tip of the endoscope's insertion shift.

[0067] Referring to FIGS. 4H, 4I, 4J, and 4K, in other cases, in an alternative, clear window 422 may be overmolded onto top brace 412, before circuit board 416, LED, camera 410, and bottom brace 414 are assembled. As window 422 is overmolded, a flat platen may be placed to project through camera 410 hole to provide a mold surface, to provide an optically smooth back surface of window 422. The mold may be flat (planar), or may have a desired curvature to form a convex or concave lens in overmolded window 422. As shown in FIG. 4K, the circumferential edges of top

brace 412 may be shaped to provide a secure lock that engages overmolded window 422. Then circuit board 416 with LED may be inserted into the slot, and folded around top brace 412, and then bottom brace 414 may be snapped into place and ultrasonically welded.

[0068] Referring again to FIG. 4A, at its top right and bottom right corners, and referring to FIG. 4B, at the top right corner of top brace 412 and the lower right corner of bottom brace 414, energy directors molded into top brace 412 and bottom brace 414 may improve ultrasonic welding. Ultrasonic welding may improve adhesion and watertightness among top brace 412, bottom brace 414, and flow director components. The energy directors may be molded as triangular-profile ridges on the inside surface of the top-brace-bottom-brace assembly. The inner diameter of the energy directors may be slightly smaller than the outer diameter of the flow director, so that ultrasonic welding causes the energy directors to melt and to form a seal.

[0069] Taken together, these features may provide an endoscope tip 400 of very small diameter, such as 4mm or less, 5mm or less, 4.5mm or less, or 4mm or less, or a tip 400 slightly larger than an endoscope shaft, with all components fitting inside that tip diameter. Mounting the LED and camera 410 on opposite sides of a flexible circuit board may assist in making the entire assembly more easily manufacturable. That manufacturing may involve inserting the end of a flexible circuit board 416 into a slot, and wrapping board 416 around a molded part or wrapping the board into a channel between molded parts to place various components in their preferred operating orientations. Components may be ultrasonically welded together. Overmolding may be used to structurally hold components together and to provide a watertight seal. Clear window 420, 422 may be overmolded onto a structural component, or the structural components may be overmolded over a clear window.

VI. Avoiding fasteners, springs, and other small components

[0070] Moving parts and structural components of endoscope 100 may be joined and affixed in place using techniques that avoid small components such as fasteners and springs. These manufacturing techniques may reduce costs of molding, reduce costs of assembly, reduce manufacturing steps, and reduce the likelihood that a separate component, for example, a steel spring or screw, may come loose and endanger patient safety. Likewise, assembly may be accomplished without adhesives or solvents that may be toxic.

VI.A. A button without springs

[0071] Referring to FIG 5A, a control button 710 for the endoscope may be formed as a single component with the button, its guide track, and its springs 712 molded as a single component.

[0072] This single component may be manufactured to simultaneously provide adequate stiffness so that a button press is transmitted from the top of the button to the bottom, and adequate

resilience in beam structures 712 to provide restoring force to return the button to its undepressed state. The loop beam structures 712 may be molded with flexible projections extending out from a united molded component. These extended flexible projections 712 may act in a combination of bending and torsion so that when button 710 is released, elastic memory of the materials will spring the button back into its initial position. FIGS. 5B and 5C show the button in its normally-up position, with the spring loops 712 in their originally-molded planar configuration. FIGS. 5D and 5E show the button depressed, and the spring loop 712 deformed in torsion.

[0073] The button with its springs may be molded of ABS plastic.

[0074] In some cases, the handle may have metal fasteners and other small metal parts, or assembly may use chemical adhesives and the like, but they may be encapsulated fully or partially within overmolding sufficiently to ensure no loosening , escape, or contact with fluids that flow into a patient.

VI.B. Overmolding of case over circuit board

[0075] Referring to FIGS. 5F and 5G, a circuit board 722 to be mounted within the handle, with its connecting cables that will feed forward into the insertion shaft, and its connecting cables that will feed backwards to the supporting power supply and computer driver, may be overmolded 720 using low pressure overmolding. Overmolding 720 may include through-holes that provide secure mechanical mounting points for mounting within the handle. Overmolding 720 may provide a covering that protects all sides and is resilient to protect circuit board 722 from mechanical insult during manufacturing and use. Overmolded case 720 may provide strain relief for the cables 724 at the two ends of circuit board 722, to reduce damage that might be caused by pulling on the cables 724. The overmolding 720 may provide a unified, no-seams covering to protect he circuit board 722 from water intrusion. Overmolding 720 may protect against fluid ingress to a level of IP65 under international standard EN 60529. Liquid-tight protection of overmolded case 720 over circuit board 722 (and any other liquid sensitive components within the handle) may allow the sterilization of the interior of the handle via flowing a sterilizing liquid or gas through the interior of the handle, and may provide dielectric protection to prevent electrical shock to the patient. These advantages may be achieved by reducing manufacturing to a single manufacturing step.

VI.C. Avoiding internal fasteners

[0076] Referring to FIG. 5H, the overmolded circuit board structure may be mounted within the handle via molded clips, heat staking, and similar techniques that result in a unitary structure, without separate small-part fasteners. In FIG. 5H, the inner shell of the handle may be molded in two parts 732, 734. Top half 732, shown turned upside-down in FIG. 5I, may be molded with several molded bosses 736. In FIG. 5H, the button has been turned upside-down and set in place; the looping

resilient projections are visible. In FIG. 5I, overmolded PC board 720 may be placed over bosses 736, so that bosses 736 project through the through-holes in the board casing. In FIG. 5J, heat and/or ultrasonic vibration may be used to melt the tips of bosses 736 into domes or heads 738 that hold the button and PC board in place.

[0077] By these techniques, endoscope 100 may be assembled into a structure that is strong, without small parts that require separate assembly steps or that can become dislodged, and without toxic adhesives or solvents.

VI.D. Rotational resistance via O-rings

[0078] Referring to FIG. 5K and 5L, inner shell 742 and outer handle shells 732, 734 rotate relative to each other, so that the surgeon may adjust field of view, using the magnetic Hall effect sensors 324 discussed above. The inner handle 742 rotates in unison with rotation collar 112. Inner handle 742 and rotation collar rotate relative to outer handle 114. The inner handle 742 and outer handle shells 732, 734 may be coupled via two silicone O-rings 740 that provide some friction to maintain their relative position, while allowing the surgeon to rotate the two handle components to adjust the arthroscope's field of view.

[0079] For assembly, the cylindrical inner handle may be fully assembled, and the O-rings 740 may be fitted over the end of inner handle 742 into their two retaining channels. Then the two halves of the outer handle shell 732, 734 may be brought together like buns over a hotdog, surrounding the inner shell and O-rings 740. Then the two halves of the outer shell 732, 734 may be ultrasonically welded to each other.

VI.E. Ultrasonic welding of the two halves of the outer handle shell

[0080] Referring to FIG. 5M and 5N, the two halves 732, 734 of the outer shell may be ultrasonically welded without adhesives or solvents. Referring to FIGS. 5O and 5P, the two outer shell halves may have locking clips or hooks that may snap together to hold them temporarily before ultrasonic welding begins.

[0081] Referring to FIGS. 5O, 5P, 5Q, 5R, 5S, 5T, 5U, 5V, 5W, and 5X, various energy directors and troughs may be designed to ensure high efficacy of ultrasonic welding. In each case, the height of the energy director is slightly higher than the depth of its mating trough, and the width of the energy director is slightly narrower than the trough. Ultrasonic vibration may cause the energy director to slightly melt and deform to fill the trough. The ultrasonically-welded seams may come very close to fully enclosing the cavity of the outer handle, to reduce the likelihood of any fluid intrusion from outside into the interior of the endoscope. Any fluid carries risk of pathogens. Sterilization of the interior of devices such as endoscopes is difficult, so exclusion of fluids is important for any components that may be reused.

VI.F. Thermoplastic elastomer coating handle

[0082] Referring to FIGS. 5Y and 5Z, a high friction surface 750 may be bonded to or overmolded onto the outer surface of the outer handle shell 732, 734, to provide a high-friction contact between a surgeon's gloved hand and the handle. During surgery, the surgeon's glove and/or the handle may become covered with bodily fluids and other liquids that may reduce friction, so that the surgeon could have trouble maintaining control of a solid endoscope. By covering the endoscope handle with a high-friction compound 750, such as thermoplastic elastomer (TPE), the handle becomes higher friction, which may improve the surgeon's control. If the cover is overmolded as a single unitary layer, it may provide additional sealing against fluid intrusion. One medical grade, biocompatible TPE is Medalist MD-34940 or MD-34950 from Teknor Apex of Pawtucket, RI.

VII. Liquid flow

VII.A. Liquid-tight seal

[0083] Referring to FIGS. 6A and 6B, the joint between the handle body and the outer sheath or insertion trocar 102 may be designed to provide a water tight seal between the endoscope and the outer sheath/trocar 102 without the use of an O-ring. An O-ring at this joint may be undesirable if it could fall off mid-surgery or be introduced into the patient when the endoscope is being locked into the outer sheath/trocar 102. In FIGS. 6A and 6B, the seating cup for the outer sheath/trocar 102 is shown in cutaway section, so that the male conical inner surface 810 of the seat can be seen, and the female mating cone 812 on the nose of the endoscope is shown in plan view, so that the mating between the outer surface of the male cone with the inner surface of the female cone in the cup of the outer sheath/trocar 102 can be seen.

[0084] FIG. 6C shows the two cones 810, 812 with some of the dimensions exaggerated. Male cone 810 may have a slightly sharper angle of conicity than female cone 812, by about ½°. The largest diameter of female cone 812 may be slightly smaller than the largest diameter at the base of the male cone 810, so that these two surfaces 810, 812 will form a watertight interference seal. The interference of diameters may be on the order of ½ mm, when the diameters of the two cones are in the range of 19 to 25 mm. The angle may be on the order of 15°, and the two cones may differ by about ½°. Likewise, at the small end of the cones, the outer diameter of the male cone 810 may be the same as the inner diameter of the female cone 812, but male cone 810 may have small ridge 814 at its circumference, which leads to a watertight interference seal at this end as well. The polymers of the parts may be chosen to provide an appropriate amount of resilience for the interference fit to appropriately seal the water.

[0085] FIG. 6D shows ridge 814 molded onto the small end of the male cone. The ridge on male cone 810 may form an interference seal with the small end, inner diameter of female cone 814 in the mounting cup of outer sheath/trocar 102. FIG. 6E shows the two parts mated.

[0086] In other alternatives, the seal between the endoscope and outer sheath/trocar cap may use O-rings. O-rings may be seated in channels on the surface of the inner male cone, so that the female cone engages to compress the O-ring into its channel before the contact begins to translate into lateral forces that would displace the O-ring. O-rings may be especially desirable at the large-diameter end of the male cone abutting the face of the chassis of the endoscope, so that the female surface of the outer sheath/trocar cap cannot displace the O-ring. In some cases, the angles of the cones may be flatter than 15°, so that the compression force against the O-rings created by the twist lock (see discussion of FIGS. 7J, 7K, and 7L, in section VIII.C) is increased relative to lengthwise frictional force that would tend to displace the O-rings.

VII.B. Inducing spiral flow

[0087] Referring to FIG. 6F, the chamber 820 between the fluid indeed tube and the fluid flow annulus of outer sheath/trocar 102 may be designed as a squeezing cone to impart spiral flow to water or similar irrigation fluid. Spiral flow 822 may be induced via the Bernoulli effect and Venturi effect as the water flows through the narrowing conical passage. Spiral vanes on the two conical surfaces may further accelerate the spiral flow.

[0088] This flow pattern may have several advantages. Spiraling flow 822 may increase pressure and water velocity as the water emerges from the flow director holes at the tip of the endoscope. Spiraling motion 822 may help clean any debris that accumulates on the front window in front of camera 410.

VIII. Molding and Joining

VIII.A. Diagonal slots to connect dissimilar materials

[0089] Referring to FIGS. 7A, 7B, 7C, and 7D, parts made of stainless steel may be connected to parts made of plastics such as ABS without using adhesive. One such technique is to cut holes 910 in the stainless steel and to overmold with ABS. Holes 910 may be shaped as slots, and the slots may be diagonal to the basic thrust and rotational forces. Diagonal slots 910 may provide additional securing in multiple dimensions. ABS has a shrinkage ratio, so a technique for confining play between the ABS and stainless steel may be advantageous. Joining slots 910 may be used at multiple points, for example at the base of outer sheath/trocar 102 where the base cup of outer sheath/trocar 102 mounts to it, at the base of the endoscope insertion shaft/inner sheath/cannula

mounts in the nose of the endoscope, and to join the endoscope flow director onto the distal end of the insertion shaft.

VIII.B. Joining component parts of obturator

[0090] Referring to FIGS. 7F, 7G, 7H, and 7I, the handle/cap of obturator 104 may be hollow, to reduce weight and to reduce material costs. The shaft of obturator 104 may be made of solid stainless steel, because it is used to force a piercing access portal into the patient's tissues. As shown in FIG. 7E, a circumferential groove 930 may be lathed into the handle/proximal end of the obturator shaft, or two parallel cuts 930 may be milled. Base 932 of the obturator cap may then be overmolded onto this proximal end. Then the shell 934 of the handle may be ultrasonically welded 936 onto the base part. Advantages include reducing use of material, which reduces weight and cost. The ultrasonic welding may joint the outer shell to the inner base of the handle without small metal parts that may become dislodged into the patient, without adhesives that may be toxic.

[0091] FIG. 7H shows the male energy director, and FIG. 7G shows the female trough. After ultrasonic welding 936, the two parts are melted together, as shown in FIG. 7I.

VIII.C. Twist-locking the parts together

[0092] Referring to FIGS. 1C, 7J, 7K, and 7L, keyway 940 on a bayonet of the obturator handle may accept a key 942 on the inside of the mounting cap for outer sheath/trocar 102, which locks the two together during the piercing step. Slope 944 may be on the order of 3° in order to draw the parts together. Likewise, one or more keyways on a bayonet on the nose of the endoscope may engage one or more pins on the inside of the mounting cap of outer sheath/trocar 102, to lock them together during observational use of the endoscope. The key and keyways of the three components may be designed to be mutually compatible and interchangeable. This may reduce manufacturing costs, and may reduce handling during surgery.

IX. Embodiments

[0093] Embodiments of the invention may include any one or more of the following features, singly or in any combination.

[0094] Endoscope 100 may have a handle, and an insertion shaft, the insertion shaft having at its distal end a solid state camera. The insertion shaft may have solid state illumination and imaging circuitry at or near a tip designed to provide illumination and imaging of the interior of a body cavity for a surgeon during surgery. The proximal portion of the handle may have electronics for drive of the illumination circuitry and to receive imaging signal from the imaging circuitry. The proximal handle portion may be designed to permit sterilization between uses. A joint between the proximal handle portion and the insertion shaft may designed to separably connect the insertion shaft

to the proximal handle portion. When it is separated, the joint may permit removal of the insertion shaft for disposal and replacement. The joint may be designed so that, when connected, the joint can transfer mechanical force from a surgeon's hand to the insertion shaft, and provides electrical connectivity between the proximal handle circuitry and the illumination and imaging circuitry. The handle may have proximal and distal portions. The distal portion may lie between the insertion shaft and proximal handle portion. The insertion shaft may be rigidly affixed to the distal handle portion. The joint may be disposed to connect and disconnect the distal and proximal portions of the handle. The distal handle portion may be designed to indirectly transfer mechanical force between a surgeon's hand to the insertion shaft, and provide indirect electrical connectivity between the proximal handle circuitry and the illumination and imaging circuitry. The handle may have a rotation collar having surface features designed to assist the surgeon in rotating the insertion shaft in the roll dimension about the axis of the insertion shaft relative to the proximal handle portion. The electronics inside the proximal handle portion may be designed to sense roll of the insertion shaft, and provide an angular rotation signal designed to permit righting of a displayed image received from the imaging circuitry. A mounting for the image sensor may be designed to permit panning of the image sensor about a pitch or yaw axis perpendicular to the central axis of the insertion shaft. One or more ultraviolet LEDs internal to the endoscope may be designed to sterilize a region of the interior of the endoscope. Hoses for insufflation fluid or gas may be designed on lie on or near a central axis of proximal handle portion. Two or more insertion shafts each having dimensions different than the others, may each be connectable to the proximal handle portion at the joint, to permit use of the proximal handle in surgery with different requirements for insertion shaft. A sterilization cabinet may be designed to sterilize components of the endoscope. An insertion shaft of an endoscope tip has a rigid proximal portion and a distal portion. The distal portion is bendable to direct a field of view of imaging circuitry in a desired direction. An illuminator and solid state imaging circuitry are at or near a distal tip of the articulable distal portion. The illuminator is designed to illuminate, and the imaging circuitry being designed to capture imaging of, an interior of a body cavity for a surgeon during surgery. A coupling of the replaceable endoscope tip is designed to separably connect the insertion shaft at a joint to a handle portion, and to disconnect the joint. The coupling has mechanical connectors. When the joint is separated, the mechanical connectors permit removal of the insertion shaft from the handle for disposal and replacement. When the joint is connected, the joint is designed to provide mechanical force transfer between a surgeon's hand to the insertion shaft. Electrical connectors are designed to connect the insertion shaft to electronics in the handle. The handle electronics are designed for drive of the illuminator and to receive imaging signal from the imaging circuitry, the handle being designed to permit sterilization between uses. Control force transfer

elements are designed to permit a surgeon to direct a direction of the imaging circuitry by transfer of mechanical force directed by a surgeon to the articulable distal portion. The distal bendable portion includes a series of articulated rigid segments. A sheath or cover over the articulated rigid segments is designed to reduce intrusion or pinching. The distal bendable portion is formed of a solid component, bendable in its lateral and elevation dimensions, and relatively incompressible in compression in its longitudinal dimension. The distal bendable portion is extendable from and retractable into a solid sheath. The distal bendable portion is bendable in one dimension. The distal bendable portion is bendable in two orthogonal dimensions. The imaging circuitry is mounted within at or near a distal tip of the articulable distal portion via a pannable mounting. The pannable mounting is designed as two sides of a parallelogram. The imaging circuitry is mounted on a structural segment hinged to the two parallelogram sides. Passages and apertures are designed to pass irrigation fluid to improve view from a lens or window over the imaging circuitry. Passages and apertures are designed to pass inflation fluid to enlarge a cavity for surgery. Mechanical connectors of the coupling include a twist-lock designed to affix the endoscope insertion shaft to the handle portion. A plurality of the endoscope tips are bundled and packaged together with a handle. The handle has electronics designed for drive of the illuminator and to receive imaging signal from the imaging circuitry. The plurality of tips and handle are packaged for integrated shipment and sale. The illuminator is an illumination LED mounted at or near the distal tip. The illuminator is an emission end of a fiber optic fiber driven by an illumination source in the handle. Camera 410 may be enclosed within a plastic casing. The plastic casing may be formed as an overmolded jacket that is designed to protect camera 410 from bodily fluids and to structurally hold components of the tip in an operating configuration. The overmolded jacket may be designed to retain a transparent window in operating configuration with camera 410. The overmolded component may be formed of transparent plastic. The overmolded component may be designed to function as a lens for camera 410. Camera 410 may be mounted on a flexible circuit board. Flexible circuit board 416 may mount an illumination LED. The LED and camera may be mounted on opposite sides of flexible circuit board 416. Camera 410 may be protected behind a transparent window. The window may be molded in two thicknesses, a thinner portion designed for mounting and to allow passage of illumination light, a thicker portion over camera 410. The handle may contain a circuit board with circuitry for control of and receipt of signals from camera 410. The handle and its components may be designed with no metal fasteners, and no adhesives, except those captured by overmolding. Control buttons of the endoscope may be molded with projections that function as return springs. The projections may be adhered into the endoscope handle via melting. The circuit board may be overmolded by plastic that encapsulate the circuit board from contact with water. The circuit board may be mounted into the

handle via melting. Components of the handle may be joined to each other into a unitary structure via melting. Components of the handle may be joined by resilient clips designed to held the two components to each other before joining into unitary structure via melting. The handle may be formed of two shells concentric with each other. Rotation of the two shells relative to each other may be controlled via one or more O-rings frictionally engaged with the two respective shells. The handle may have overmolded a layer of a high-friction elastomer. The insertion shaft may be connected to the handle via a separable joint. A water joint of the separable joint may be molded for an interference seal without O-rings. A water cavity of the separable joint may be designed to impart swirl to water flowing from the handle to the insertion shaft. The insertion shaft may be formed of stainless steel and connected to the handle via a separable joint. Plastic components of the endoscope may be joined to the insertion shaft via overmolding of plastic into slots aligned at an oblique angle in the wall of the insertion shaft, without adhesives. The water joint may be formed as two cones in interference fit. The cones may interfere at a large diameter. The cones may interfere via a ridge raised on a lip of the inner male cone. Obturator 104 may be designed to pierce tissue for introduction of the endoscope. Features for twist-locking obturator 104 into trocar 102 may be compatible with features for twist-locking the endoscope into trocar.

[0095] An endoscope may have a handle and an insertion shaft. The insertion shaft has solid state illumination and imaging circuitry at or near a tip designed to provide illumination and imaging of the interior of a body cavity for a surgeon during surgery. The proximal portion of the handle has electronics for drive of the illumination circuitry and to receive imaging signal from the imaging circuitry, the proximal handle portion being designed to permit sterilization between uses. A joint between the proximal handle portion and the insertion shaft is designed to separably connect the insertion shaft to the proximal handle portion. When it is separated, the joint permits removal of the insertion shaft for disposal and replacement. The joint is designed so that, when connected, the joint can transfer mechanical force from a surgeon's hand to the insertion shaft, and provides electrical connectivity between the proximal handle circuitry and the illumination and imaging circuitry.

[0096] An endoscope may have a handle and an insertion shaft, the insertion shaft having solid state illumination and imaging circuitry at or near a tip designed to provide illumination and imaging of the interior of a body cavity for a surgeon during surgery, and the proximal portion of the handle having electronics for drive of the illumination circuitry and to receive imaging signal from the imaging circuitry, the proximal handle portion being designed to permit sterilization between uses; and a joint between the proximal handle portion and the insertion shaft designed to separably connect the insertion shaft to the proximal handle portion. The joint is separated to permit removal of the insertion shaft for disposal and replacement. The joint is reconnected with a new insertion shaft, the

connection designed to provide mechanical force transfer between a surgeon's hand to the insertion shaft, and electrical connectivity between the proximal handle circuitry and the illumination and imaging circuitry.

[0097] Embodiments of the invention may include one or more of the following features. The handle may have proximal and distal portions. The distal portion may lie between the insertion shaft and proximal handle portion. The insertion shaft may be rigidly affixed to the distal handle portion. The joint may be disposed to connect and disconnect the distal and proximal portions of the handle. The distal handle portion may be designed to indirectly transfer mechanical force between a surgeon's hand to the insertion shaft, and provide indirect electrical connectivity between the proximal handle circuitry and the illumination and imaging circuitry. The handle may have a rotation collar having surface features designed to assist the surgeon in rotating the insertion shaft in the roll dimension about the axis of the insertion shaft relative to the proximal handle portion. The electronics inside the proximal handle portion may be designed to sense roll of the insertion shaft, and provide an angular rotation signal designed to permit righting of a displayed image received from the imaging circuitry. A mounting for the image sensor may be designed to permit panning of the image sensor about a pitch or yaw axis perpendicular to the central axis of the insertion shaft. One or more ultraviolet LEDs internal to the endoscope may be designed to sterilize a region of the interior of the endoscope. Hoses for insufflation fluid or gas may be designed on lie on or near a central axis of proximal handle portion. Two or more insertion shafts each having dimensions different than the others, may each be connectable to the proximal handle portion at the joint, to permit use of the proximal handle in surgery with different requirements for insertion shaft. A sterilization cabinet may be designed to sterilize components of the endoscope.

[0098] An endoscope may have a handle, and an insertion shaft. The insertion shaft may have at its distal end a solid state camera. Camera 410 may be enclosed within a plastic casing with an overmolded jacket that is designed to protect camera 410 from bodily fluids and to structurally hold components of the tip in an operating configuration. Camera 410 may be protected behind a transparent window. The window may be molded in two thicknesses. A thinner portion designed for mounting and to allow passage of illumination light, a thicker portion over camera 410. The handle may have retained within a circuit board with circuitry for control of and receipt of signals from camera 410. The handle and its components may be designed with no metal fasteners, and no adhesives, except those captured by overmolding. The handle may be formed of two shells concentric with each other. Rotation of the two shells relative to each other may be controlled via one or more O-rings frictionally engaged with the two respective shells. The handle may have an overmolded layer of a high-friction elastomer. The insertion shaft may be connected to the handle via a separable

joint, a water joint of the separable joint may be molded for an interference seal without O-rings. The insertion shaft may be connected to the handle via a separable joint. A water cavity of the separable joint may be designed to impart swirl to water flowing from the handle to the insertion shaft. The insertion shaft may be formed of stainless steel and connected to the handle via a separable joint. Plastic components of the endoscope may be joined to the insertion shaft via overmolding of plastic into slots aligned at an oblique angle in the wall of the insertion shaft, without adhesives. The insertion shaft may be connected to the handle via a separable joint. Obturator 104 may be designed to pierce tissue for introduction of the endoscope. Features for twist-locking obturator 104 into trocar 102 may be compatible with features for twist-locking the endoscope into trocar 102.

[0099] Embodiments of the invention may include one or more of the following features. The overmolded jacket may be designed to retain a transparent window in operating configuration with camera 410. The overmolded component may be formed of transparent plastic and designed to function as a lens for camera 410. Camera 410 may be mounted on a flexible circuit board: Flexible circuit board 416 may have mounted thereon an illumination LED. The LED and camera may be mounted on opposite sides of flexible circuit board 416. Control buttons of the endoscope may be molded with projections that function as return springs, the projections to be adhered into the endoscope handle via melting. The circuit board may be overmolded by plastic that encapsulates the circuit board from contact with water. The circuit board may be mounted into the handle via melting. Components of the handle may be joined to each other into a unitary structure via melting Components of the handle may be further joined by resilient clips designed to held the two components to each other before joining into unitary structure via melting. The joint may be formed as two frusta of cones in interference fit. The two frusta may interfere at their large diameters. The frusta may interfering via a ridge raised on a lip of the inner male cone.

[0100] An endoscope may have a handle and an insertion shaft. The insertion shaft has solid state illumination and imaging circuitry at or near a tip designed to provide illumination and imaging of the interior of a body cavity for a surgeon during surgery. The proximal portion of the handle has electronics for drive of the illumination circuitry and to receive imaging signal from the imaging circuitry, the proximal handle portion may be designed to permit sterilization between uses. A joint between the proximal handle portion and the insertion shaft is designed to separably connect the insertion shaft to the proximal handle portion. When it is separated, the joint permits removal of the insertion shaft for disposal and replacement. The joint is designed so that, when connected, the joint can transfer mechanical force from a surgeon's hand to the insertion shaft, and provides electrical connectivity between the proximal handle circuitry and the illumination and imaging circuitry.

[0101] An endoscope may have a handle and an insertion shaft, the insertion shaft having solid state illumination and imaging circuitry at or near a tip designed to provide illumination and imaging of the interior of a body cavity for a surgeon during surgery. The proximal portion of the handle may have electronics for drive of the illumination circuitry and to receive imaging signal from the imaging circuitry. The proximal handle portion may be designed to permit sterilization between uses. A joint between the proximal handle portion and the insertion shaft designed to separably connect the insertion shaft to the proximal handle portion. The joint may be separated to permit removal of the insertion shaft for disposal and replacement. The joint may be reconnected with a new insertion shaft, the connection designed to provide mechanical force transfer between a surgeon's hand to the insertion shaft, and electrical connectivity between the proximal handle circuitry and the illumination and imaging circuitry.

[0102] Embodiments of the invention may include one or more of the following features. The handle may have proximal and distal portions. The distal portion may lie between the insertion shaft and proximal handle portion. The insertion shaft may be rigidly affixed to the distal handle portion. The joint may be disposed to connect and disconnect the distal and proximal portions of the handle. The distal handle portion may be designed to indirectly transfer mechanical force between a surgeon's hand to the insertion shaft, and provide indirect electrical connectivity between the proximal handle circuitry and the illumination and imaging circuitry. The handle may have a rotation collar having surface features designed to assist the surgeon in rotating the insertion shaft in the roll dimension about the axis of the insertion shaft relative to the proximal handle portion. The electronics inside the proximal handle portion may be designed to sense roll of the insertion shaft, and provide an angular rotation signal designed to permit righting of a displayed image received from the imaging circuitry. A mounting for the image sensor may be designed to permit panning of the image sensor about a pitch or yaw axis perpendicular to the central axis of the insertion shaft. One or more ultraviolet LEDs internal to the endoscope may be designed to sterilize a region of the interior of the endoscope. Hoses for insufflation fluid or gas may be designed on lie on or near a central axis of proximal handle portion. Two or more insertion shafts each having dimensions different than the others, may each be connectable to the proximal handle portion at the joint, to permit use of the proximal handle in surgery with different requirements for insertion shaft. A sterilization cabinet may be designed to sterilize components of the endoscope.

[0103] A replaceable endoscope tip for an endoscope may have a rigid proximal portion and a distal portion. The distal portion may be bendable to direct a field of view of imaging circuitry in a desired direction. Illuminator and solid state imaging circuitry may be located at or near a distal tip of the articulable distal portion. The illuminator may be designed to illuminate, and the imaging

circuitry may be designed to capture imaging of, an interior of a body cavity for a surgeon during surgery. A coupling is designed to separably connect the replaceable endoscope tip at a joint to a handle portion, and to disconnect the joint. The coupling has mechanical connectors designed: (a) when separated, the mechanical connectors permitting removal of the replaceable endoscope tip from the handle for disposal and replacement; and (b) when connected, the joint designed to provide mechanical force transfer between a surgeon's hand to the insertion shaft. Electrical connectors are designed to connect the replaceable endoscope tip to electronics in the handle, the handle electronics designed for drive of the illuminator and to receive imaging signal from the imaging circuitry, the handle may be designed to permit sterilization between uses. Control force transfer elements are designed to permit a surgeon to direct a direction of the imaging circuitry by transfer of mechanical force directed by a surgeon to the bendable distal portion.

[00100] An optical prism may be designed to displace a field of view offset angle of an endoscope. A connector is designed to affix the optical prism to a tip of an endoscope that has a field of view at an initial offset angle displaced off-axis of the endoscope, and to retain the optical prism against displacement forces during insertion of the endoscope into a body cavity. The optical prism and connector are designed to reduce the offset angle of the field of view of the endoscope toward on-axis relative to the initial offset when the prism and connector are affixed to an optical tip of the endoscope. The endoscope may be inserted into a body cavity. The endoscope has a field of view at an initial offset angle displaced off-axis of the endoscope. The endoscope has affixed to its distal end an optical prism designed to reduce the offset angle of the field of view of the endoscope toward on-axis relative to the initial offset. The prism is affixed to the distal end of the endoscope by a connector designed to retain the optical prism against displacement forces during insertion of the endoscope into a body cavity. The endoscope is withdrawn from the body with the prism affixed. The prism is removed from the endoscope. The endoscope is reinserted back into the body cavity with its field of view at the initial offset angle. The optical prism may be designed to reduce the offset angle of the endoscope's field of view to no more than 10°, or to no more than 5°, or to no more than 3°. The optical prism may be optically convex to magnify an image. The optical prism may be optically concave to enlarge the endoscope's field of view. The connector may be designed to affix to the endoscope by mechanical forces. An optical filter may be coupled with the prism. The endoscope may have a wetting surface designed to entrain an anti-adhesive lubricant in a layer over a lens or window of the endoscope. The wetting surface may be a porous solid. The porous solid may be formed by sintering or other heating of particles. The optical prism and connector may be affixed to the endoscope for shipment, and designed to retain an anti-adhesive lubricant in contact with a lens or window of the endoscope during shipment. The vial, well, or cavity may have a cap with a seal to

seal around a shaft of the endoscope. The anti-adhesive lubricant may comprise silicone oil, or mixtures thereof. The anti-adhesive lubricant may comprise a mixture of silicone oils of different viscosities. The vial or cavity may include an optical prism designed to displace a field of view of an endoscope.

[00101]packaging for an endoscope may have mechanical features designed to retain components of an endoscope, and to protect the endoscope for shipping and/or delivery. The packaging has a vial, well, or cavity designed to retain anti-adhesive lubricant in contact with a lens or window of the endoscope.

[0104] The distal bendable portion may include a series of articulated rigid segments. A sheath or cover may cover the articulated rigid segments designed to reduce intrusion or pinching. The distal bendable portion may be formed of a solid component, bendable in its lateral and elevation dimensions, and relatively incompressible in compression in its longitudinal dimension. The distal bendable portion may be extendable from and retractable into a solid sheath. The distal bendable portion may be bendable in one dimension. The distal bendable portion may be bendable in two orthogonal dimensions. The imaging circuitry may be mounted within at or near a distal tip of the bendable distal portion via a pannable mounting. The pannable mounting may be designed as two sides of a parallelogram, and the imaging circuitry may be mounted on a structural segment hinged to the two parallelogram sides. Passages and apertures may be designed to pass irrigation fluid to improve view from a lens or window over the imaging circuitry. Passages and apertures may be designed to pass inflation fluid to enlarge a cavity for surgery. Mechanical connectors of the coupling may include a twist-lock designed to affix the endoscope replaceable endoscope tip to the handle portion. A plurality of the endoscope replaceable endoscope tips may be packaged for integrated shipment and sale with a reusable handle, the handle having electronics designed for drive of the illuminator and to receive imaging signal from the imaging circuitry. The illuminator may be an illumination LED mounted at or near the distal tip. The illuminator may be an emission end of a fiber optic fiber driven by an illumination source in the handle.

[0105] Various processes described herein may be implemented by appropriately programmed general purpose computers, special purpose computers, and computing devices. Typically a processor (*e.g.*, one or more microprocessors, one or more microcontrollers, one or more digital signal processors) will receive instructions (*e.g.*, from a memory or like device), and execute those instructions, thereby performing one or more processes defined by those instructions. Instructions may be embodied in one or more computer programs, one or more scripts, or in other forms. The processing may be performed on one or more microprocessors, central processing units (CPUs), computing devices, microcontrollers, digital signal processors, or like devices or any

combination thereof. Programs that implement the processing, and the data operated on, may be stored and transmitted using a variety of media. In some cases, hard-wired circuitry or custom hardware may be used in place of, or in combination with, some or all of the software instructions that can implement the processes. Algorithms other than those described may be used.

[0106] Programs and data may be stored in various media appropriate to the purpose, or a combination of heterogeneous media that may be read and/or written by a computer, a processor or a like device. The media may include non-volatile media, volatile media, optical or magnetic media, dynamic random access memory (DRAM), static ram, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, a RAM, a PROM, an EPROM, a FLASH-EEPROM, any other memory chip or cartridge or other memory technologies.

[0107] Databases may be implemented using database management systems or ad hoc memory organization schemes. Alternative database structures to those described may be readily employed. Databases may be stored locally or remotely from a device which accesses data in such a database.

[0108] In some cases, the processing may be performed in a network environment including a computer that is in communication (e.g., via a communications network) with one or more devices. The computer may communicate with the devices directly or indirectly, via any wired or wireless medium (e.g. the Internet, LAN, WAN or Ethernet, Token Ring, a telephone line, a cable line, a radio channel, an optical communications line, commercial on-line service providers, bulletin board systems, a satellite communications link, a combination of any of the above). Transmission media include coaxial cables, copper wire and fiber optics, including the wires that comprise a system bus coupled to the processor. Transmission may occur over transmission media, or over electromagnetic waves, such as via infrared, WiFi, Bluetooth, and the like, at various frequencies using various protocols. Each of the devices may themselves comprise computers or other computing devices, such as those based on the Intel® Pentium® or Centrino™ processor, that are adapted to communicate with the computer. Any number and type of devices may be in communication with the computer.

[0109] A server computer or centralized authority may or may not be necessary or desirable. In various cases, the network may or may not include a central authority device. Various processing functions may be performed on a central authority server, one of several distributed servers, or other distributed devices.

[0110] The following applications are incorporated by reference. U.S. App. Ser. No. 17/824,857, filed May 25, 2022, titled Endoscope; U.S. Prov. App. Ser. No. 63/249,479, filed Sept. 28, 2021, titled Endoscope; U.S. Prov. App. Ser. No. 63/237,906, fled Aug. 27, 2021, titled

Endoscope; U.S. App. Ser. No. 17/361,711, filed Jun. 29, 2021, titled Endoscope with Bendable Camera Shaft; U.S. Prov. App. Ser. No. 63/214,296, filed Jun. 24, 2021, titled Endoscope with Bendable Camera Shaft; U.S. Provisional App. Ser No. 63/193,387 titled Anti-adhesive Window or Lens for Endoscope Tip; U.S. Provisional App. Ser. No. 63/067,781, filed Aug. 19, 2020, titled Endoscope with Articulated Camera Shaft; U.S. Provisional Application Ser. No. 63/047,588, filed Jul. 2, 2020, titled Endoscope with Articulated Camera Shaft; U.S. Provisional App. Ser. No. 63/046,665, filed Jun. 30, 2020, titled Endoscope with Articulated Camera Shaft; U.S. App. Ser. No. 16/434,766, filed Jun. 7, 2019, titled Endoscope with Disposable Camera Shaft and Reusable Handle; U.S. Provisional App. Ser. No. 62/850,326, filed May 20, 2019, titled Endoscope with Disposable Camera Shaft; U.S. App. Ser. No. 16/069,220, filed Oct. 24, 2018, titled Anti-Fouling Endoscopes and Uses Thereof; U.S. Provisional App. Ser. No. 62/722,150, filed August 23, 2018, titled Endoscope with Disposable Camera Shaft; U.S. Provisional App. Ser. No. 62/682,585 filed June 8, 2018, titled Endoscope with Disposable Camera Shaft.

[0111] For clarity of explanation, the above description has focused on a representative sample of all possible embodiments, a sample that teaches the principles of the invention and conveys the best mode contemplated for carrying it out. The invention is not limited to the described embodiments. Well known features may not have been described in detail to avoid unnecessarily obscuring the principles relevant to the claimed invention. Throughout this application and its associated file history, when the term "invention" is used, it refers to the entire collection of ideas and principles described; in contrast, the formal definition of the exclusive protected property right is set forth in the claims, which exclusively control. The description has not attempted to exhaustively enumerate all possible variations. Other undescribed variations or modifications may be possible. Where multiple alternative embodiments are described, in many cases it will be possible to combine elements of different embodiments, or to combine elements of the embodiments described here with other modifications or variations that are not expressly described. A list of items does not imply that any or all of the items are mutually exclusive, nor that any or all of the items are comprehensive of any category, unless expressly specified otherwise. In many cases, one feature or group of features may be used separately from the entire apparatus or methods described. Many of those undescribed alternatives, variations, modifications, and equivalents are within the literal scope of the following claims, and others are equivalent. The claims may be practiced without some or all of the specific details described in the specification. In many cases, method steps described in this specification can be performed in different orders than that presented in this specification, or in parallel rather than sequentially.

CLAIMS

The invention claimed is:

1. An endoscope, comprising:

a handle and an insertion shaft, the insertion shaft having at its distal end a solid state camera, the handle having retained within a circuit board with circuitry for control of and receipt of signals from the camera;

the handle and its components being formed of biocompatible materials, and designed with no metal fasteners, no adhesives, and no detachable parts small enough to travel though fluid passages of the insertion shaft, except those encapsulated by overmolding or melt-fusing to prevent dislodgement.

2. The endoscope of claim 1:

the handle being formed of inner and outer shells concentric with each other, rotation of the shells relative to each controlled via one or more resilient components frictionally engaged between the two respective shells.

3. The endoscope of any one of claims 1 or 2, wherein the inner and outer shells of the handle are formed of plastic components, the components having resilient clips designed to held the components to each other before joining into unitary structure via melting.

4. The endoscope of claim 1, further comprising:

a cannula and obturator;

the obturator designed to pierce tissue for introduction of the endoscope;

the cannula being a tube designed to accept passage of the endoscope insertion shaft and to offer structural protection to the insertion shaft;

the cannula having a connector and locking feature designed to engage with mating connectors and locking features of the obturator and the endoscope, both successively.

5. The endoscope of any one of claims 1, 2, or 4, wherein one or more control buttons of the endoscope are molded with projections that function as return springs, the projections to be adhered into the endoscope handle via melting.

6. The endoscope of any one of claims 1, 2, or 4, wherein the circuit board is overmolded by plastic that encapsulates the circuit board from contact with water

7. The endoscope of any one of claims 1, 2, or 4, wherein components of the handle are joined to each other into a unitary structure via melting.

8. An endoscope, comprising:

a handle and an insertion shaft, the insertion shaft having at its distal end a solid state camera, the handle having retained within a circuit board with circuitry for control of and receipt of signals from the camera;

the handle being formed of inner and outer shells concentric with each other, rotation of the shells relative to each other controlled via one or more resilient components frictionally engaged between the respective shells.

9. The endoscope of claim 8, wherein:

the resilient components include O-rings.

10. The endoscope of claim 8:

the handle and its components being formed of biocompatible materials, and having no metal fasteners, no adhesives, and no detachable parts small enough to travel though fluid passages of the insertion shaft, except those encapsulated by overmolding or melt-fusing to prevent dislodgement.

11. The endoscope of claim 8, further comprising:

a cannula and obturator;

the obturator designed to pierce tissue for introduction of the endoscope;

the cannula being a tube designed to accept passage of the endoscope insertion shaft and to offer structural protection to the insertion shaft;

the cannula having a connector and locking feature designed to engage with mating connectors and locking features of the obturator and the endoscope, both successively.

12. The endoscope of any one of claims 8, 10, or 11, wherein:

the outer shell of the handle having an overmolded layer of a high-friction elastomer.

13. An endoscope set, comprising:

an endoscope, cannula, and obturator;

the endoscope having a handle and an insertion shaft, the insertion shaft having at its distal end a solid state camera, the handle having retained within a circuit board with circuitry for control of and receipt of signals from the camera;

an obturator designed to pierce tissue for introduction of the endoscope;

the cannula being a tube designed to accept passage of the endoscope insertion shaft and to offer structural protection to the insertion shaft;

the cannula having a connector and locking feature designed to engage with mating connectors and locking features of the obturator and the endoscope, both successively.

14. The endoscope of claim 13:

the handle and its components being formed of biocompatible materials, and designed with no metal fasteners, no adhesives, and no detachable parts small enough to travel though fluid passages of the insertion shaft, except those encapsulated by overmolding or melt-fusing to prevent dislodgement.

15. The endoscope of claim 13:

the handle being formed of inner and outer shells concentric with each other, rotation of the shells relative to each other controlled via one or more resilient components frictionally engaged between the respective shells.

16. The endoscope of any one of claims 13, 14, or 15:

the locking features of the obturator and endoscope being engageable by twisting of the endoscope relative to the cannula.

17. The endoscope of any one of claims 13, 14, or 15:

the connectors of the endoscope and cannula being watertight, molded for an interference seal without O-rings.

18. The endoscope of claim 17:

the connectors being formed as two frusta of cones in interference fit.

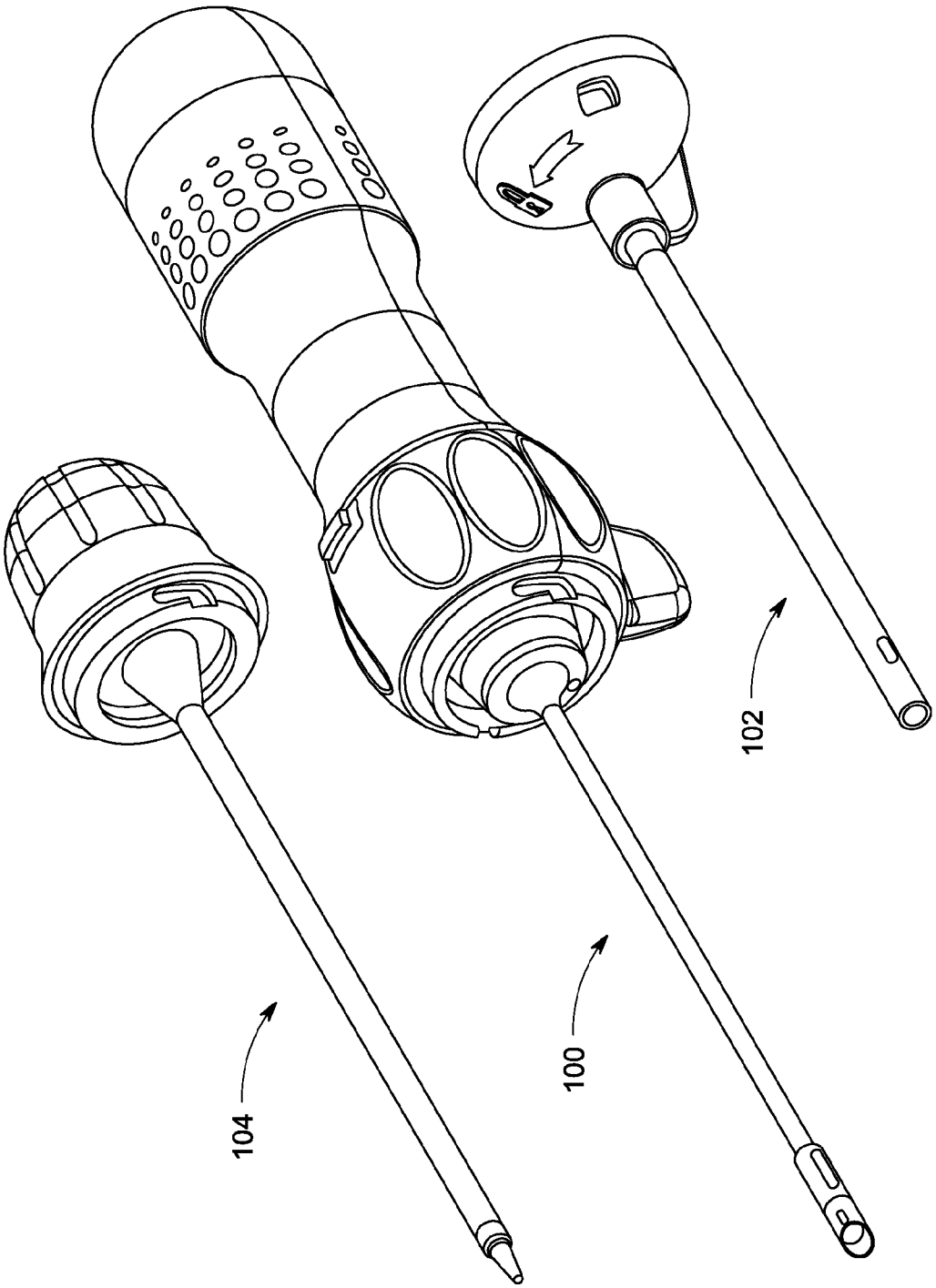


FIG. 1A

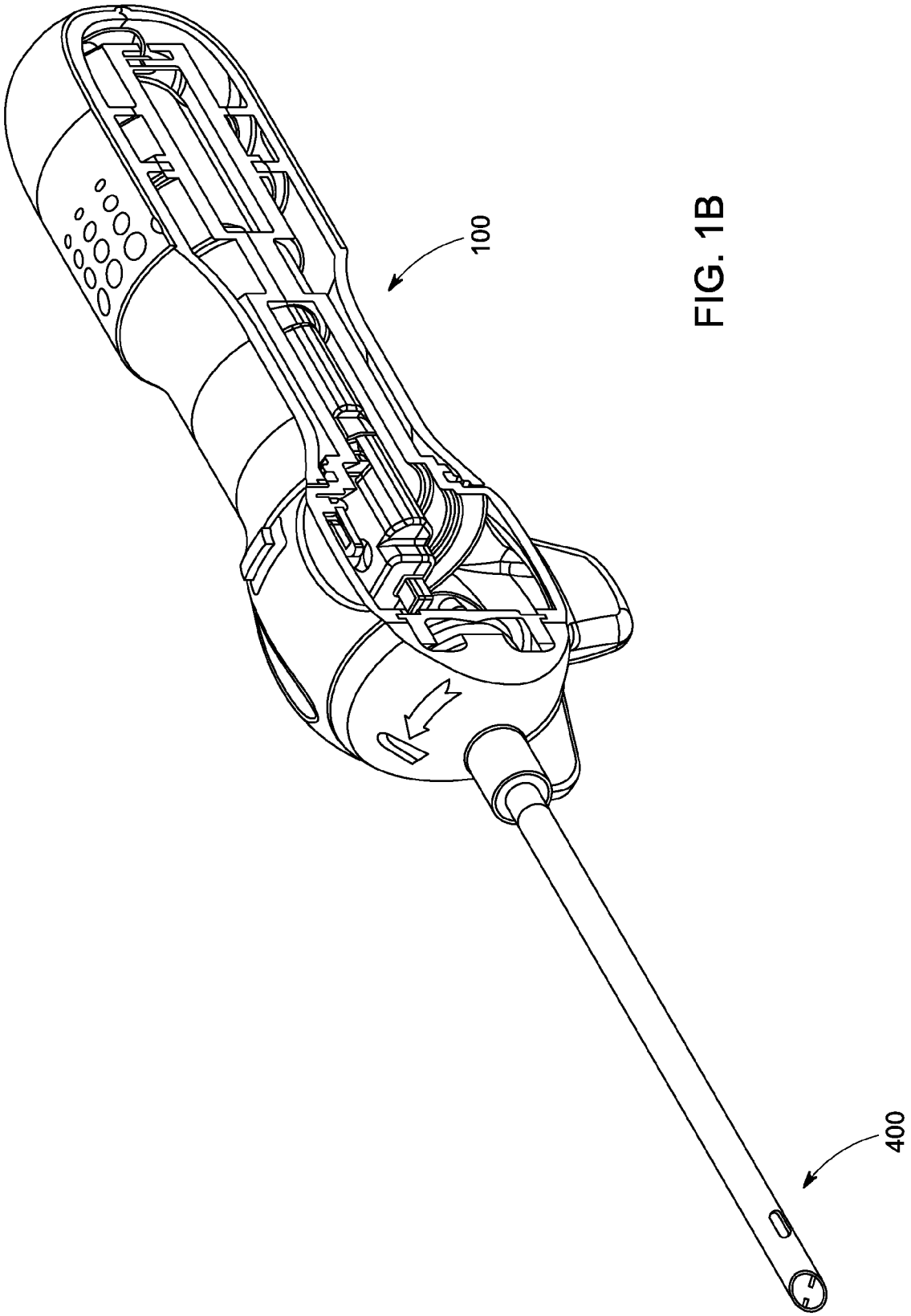


FIG. 1B

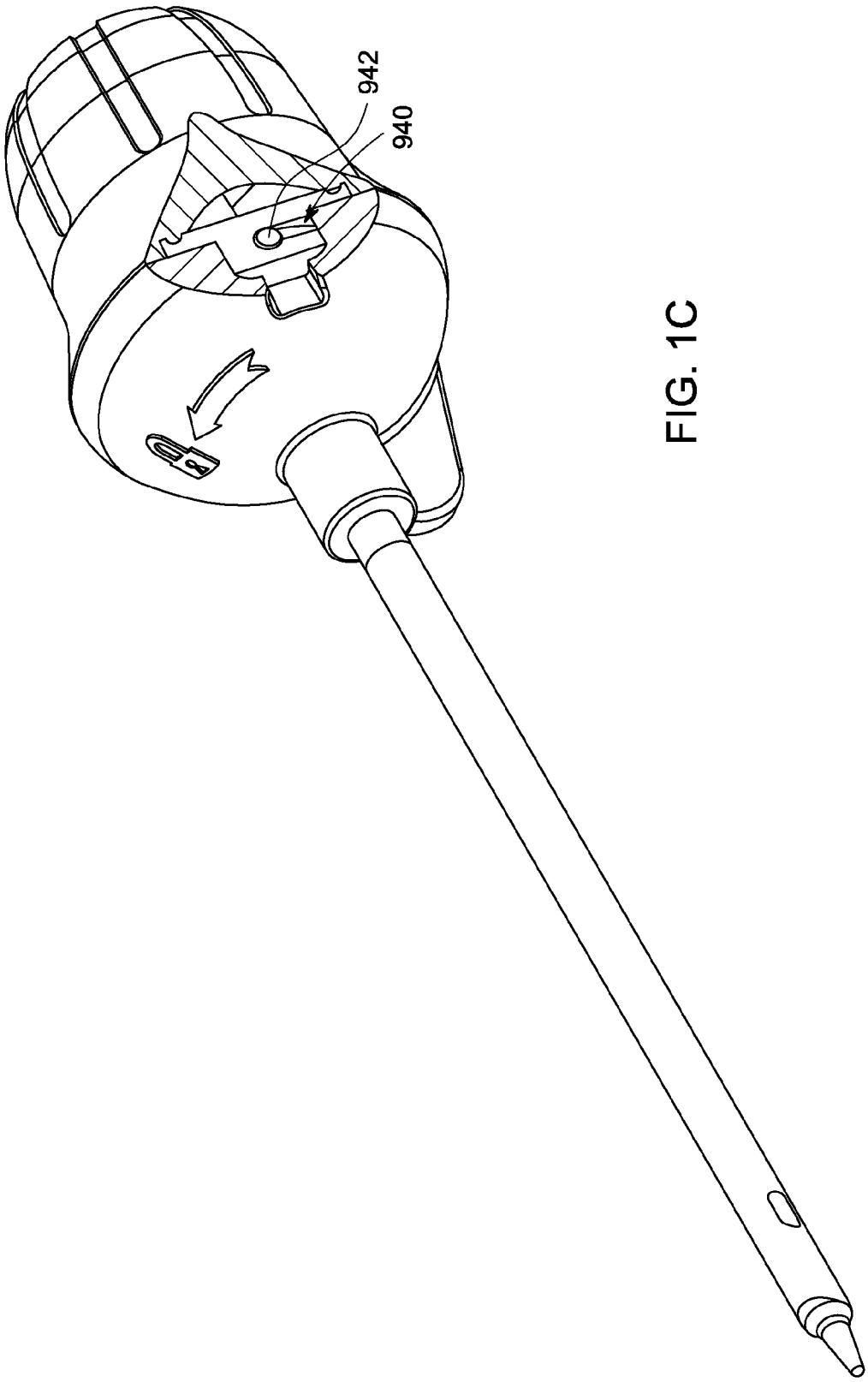


FIG. 1C

FIG. 1D

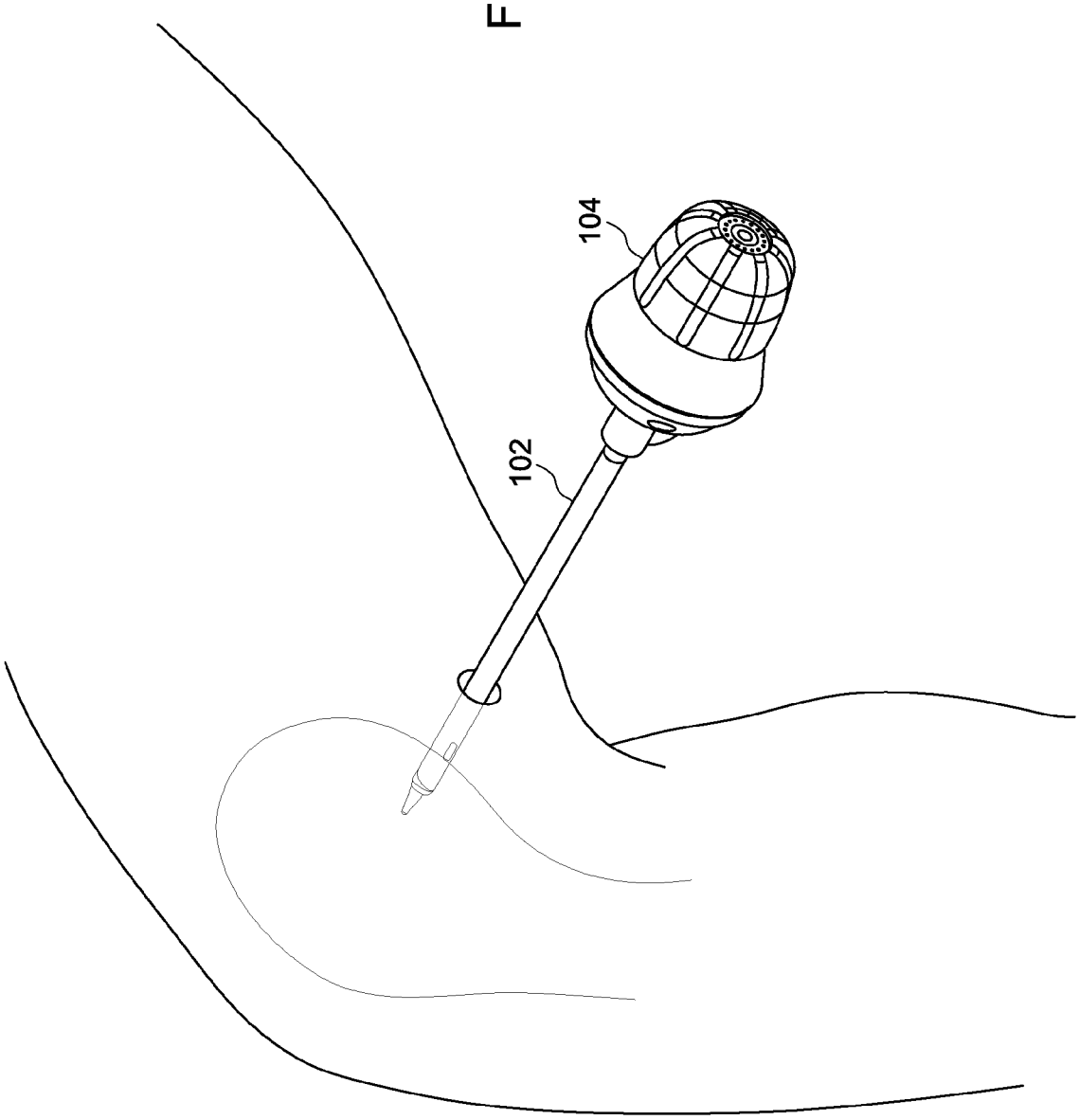


FIG. 1E

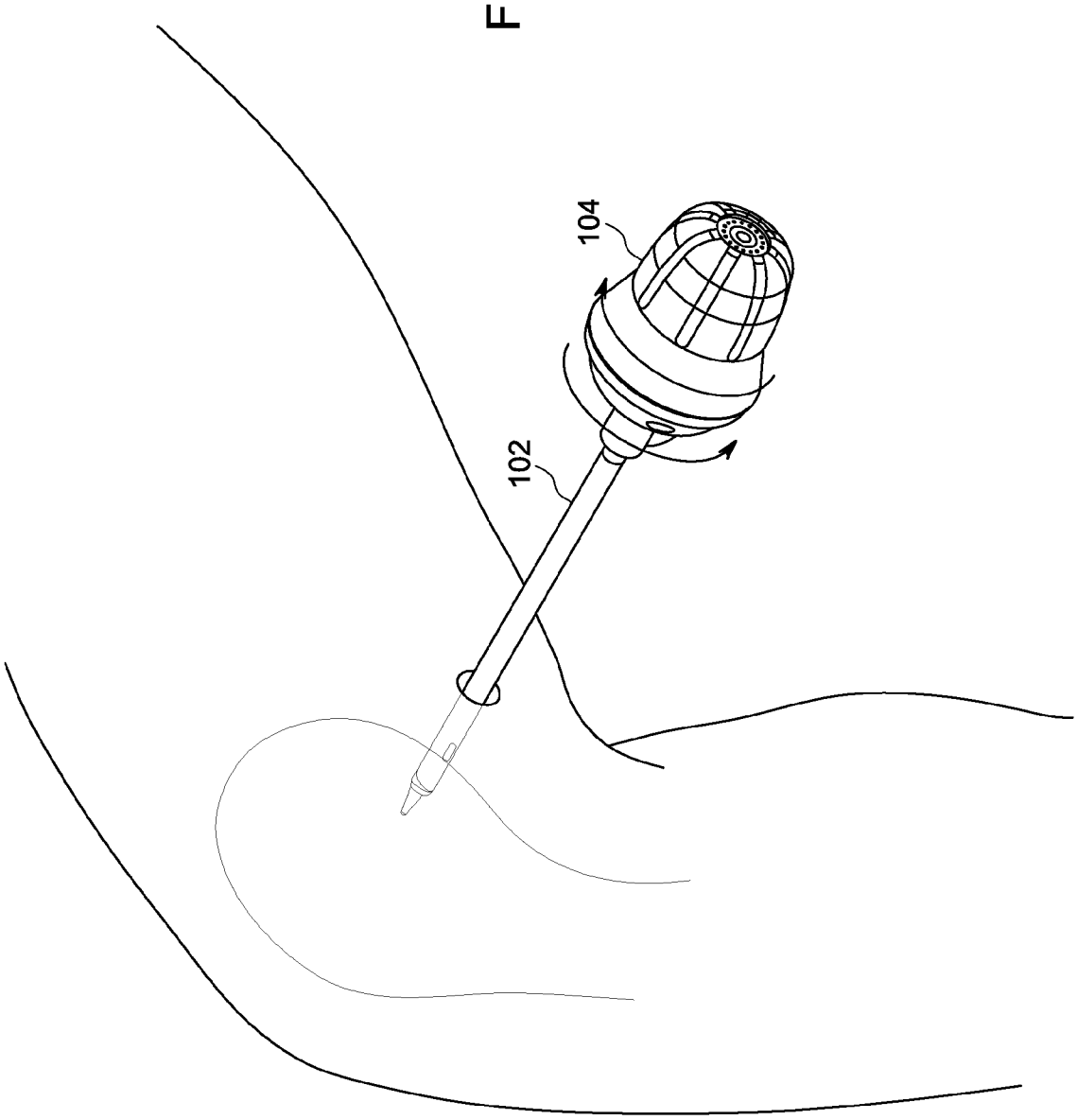
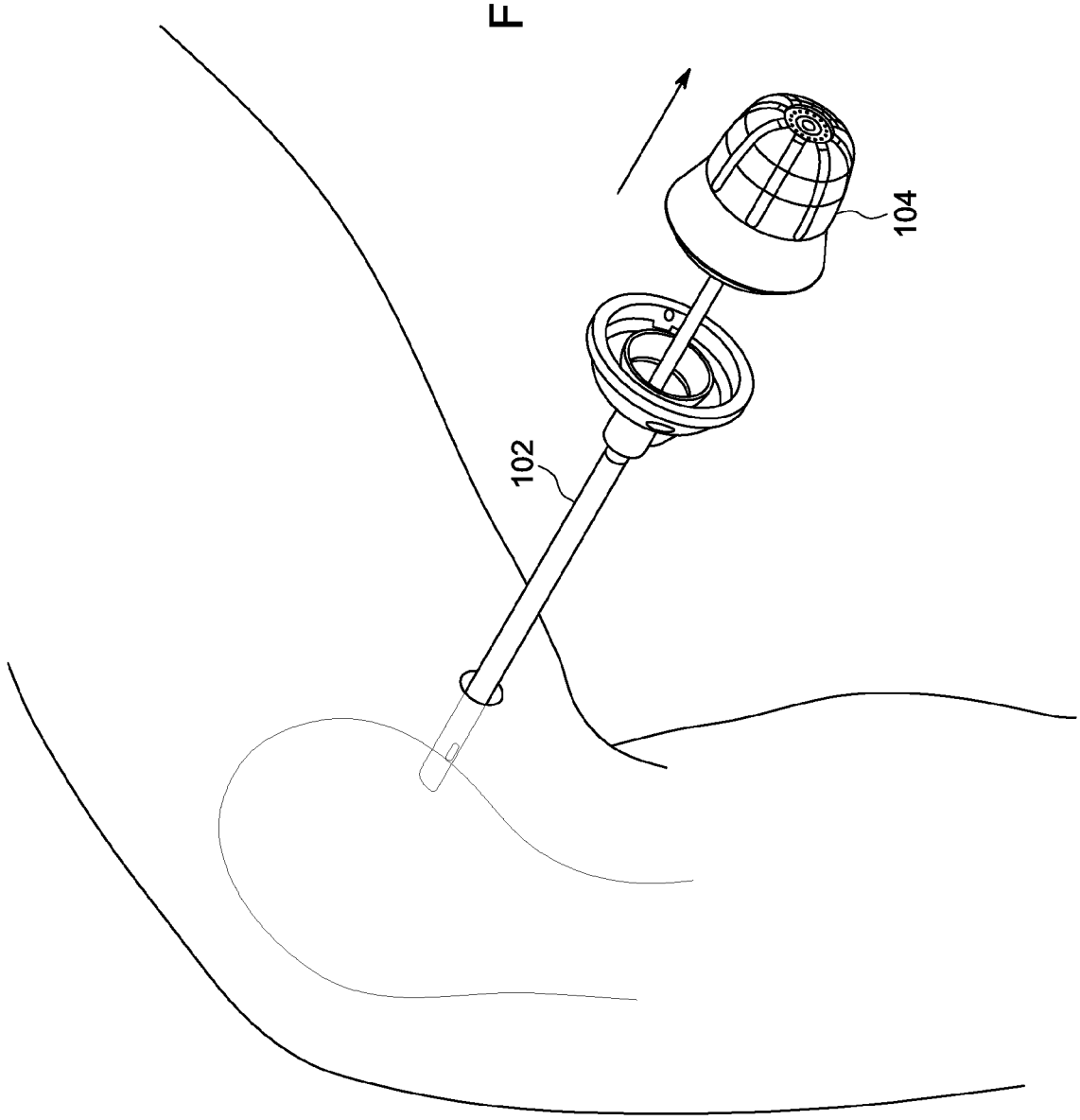


FIG. 1F



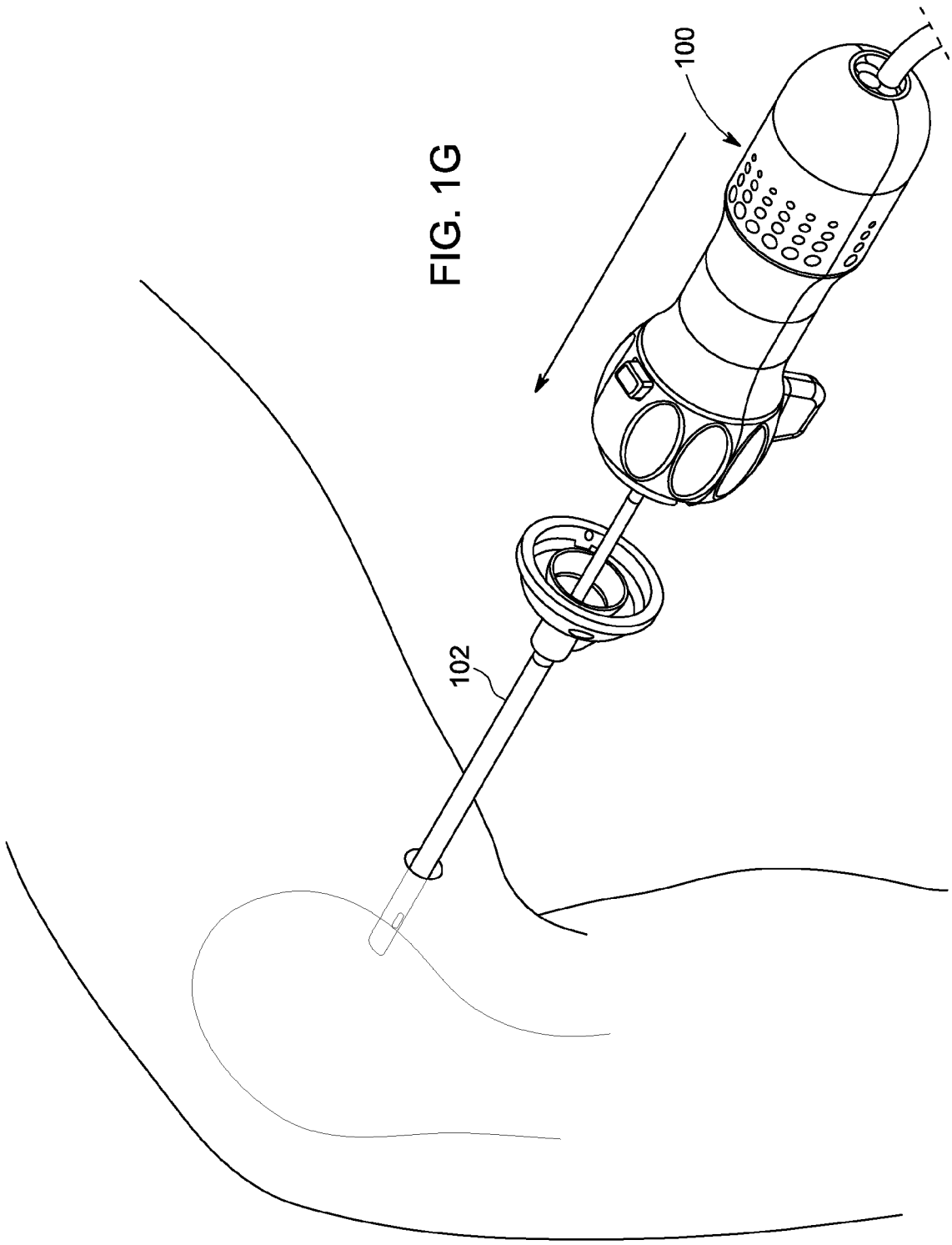
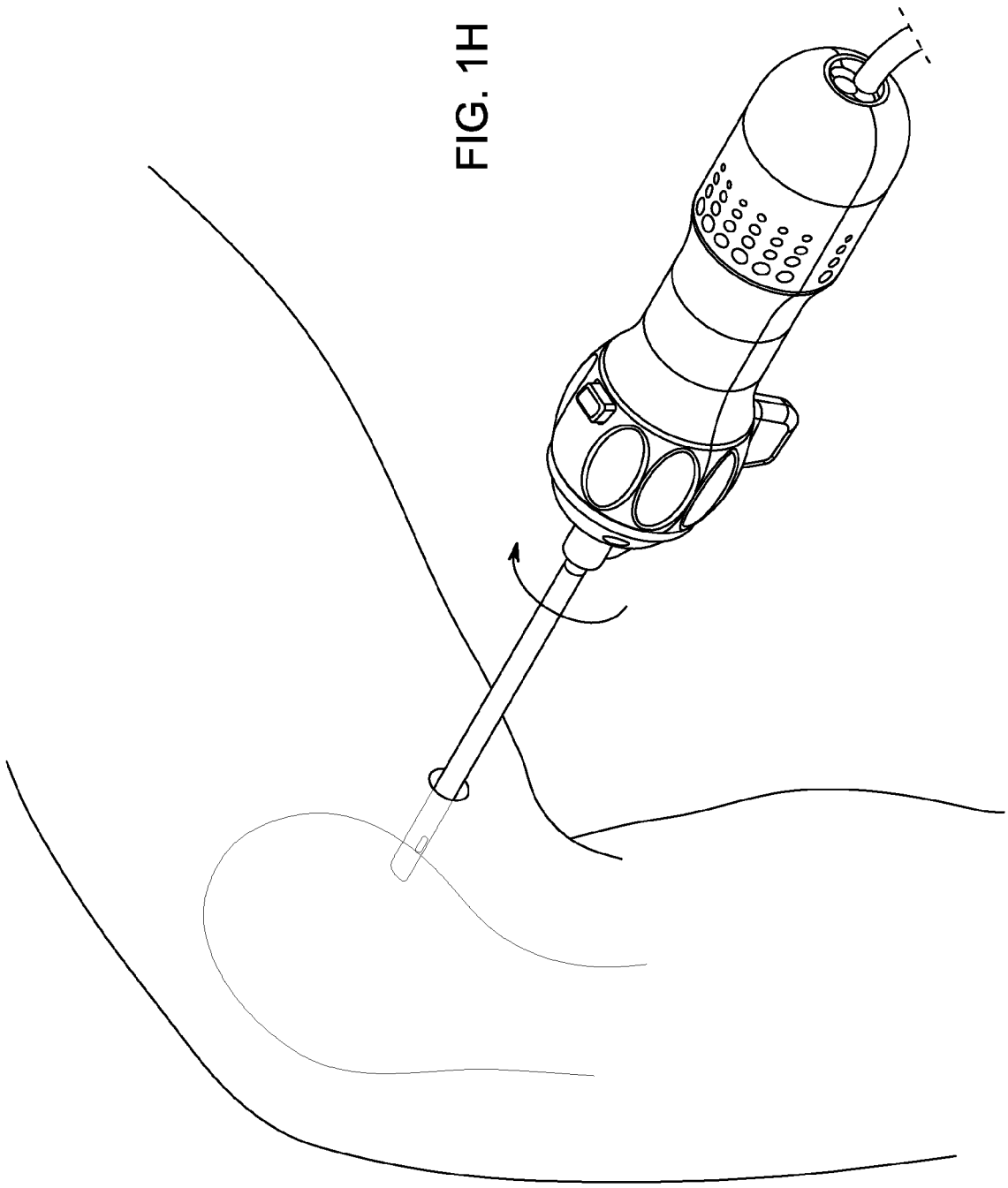


FIG. 1G

FIG. 1H



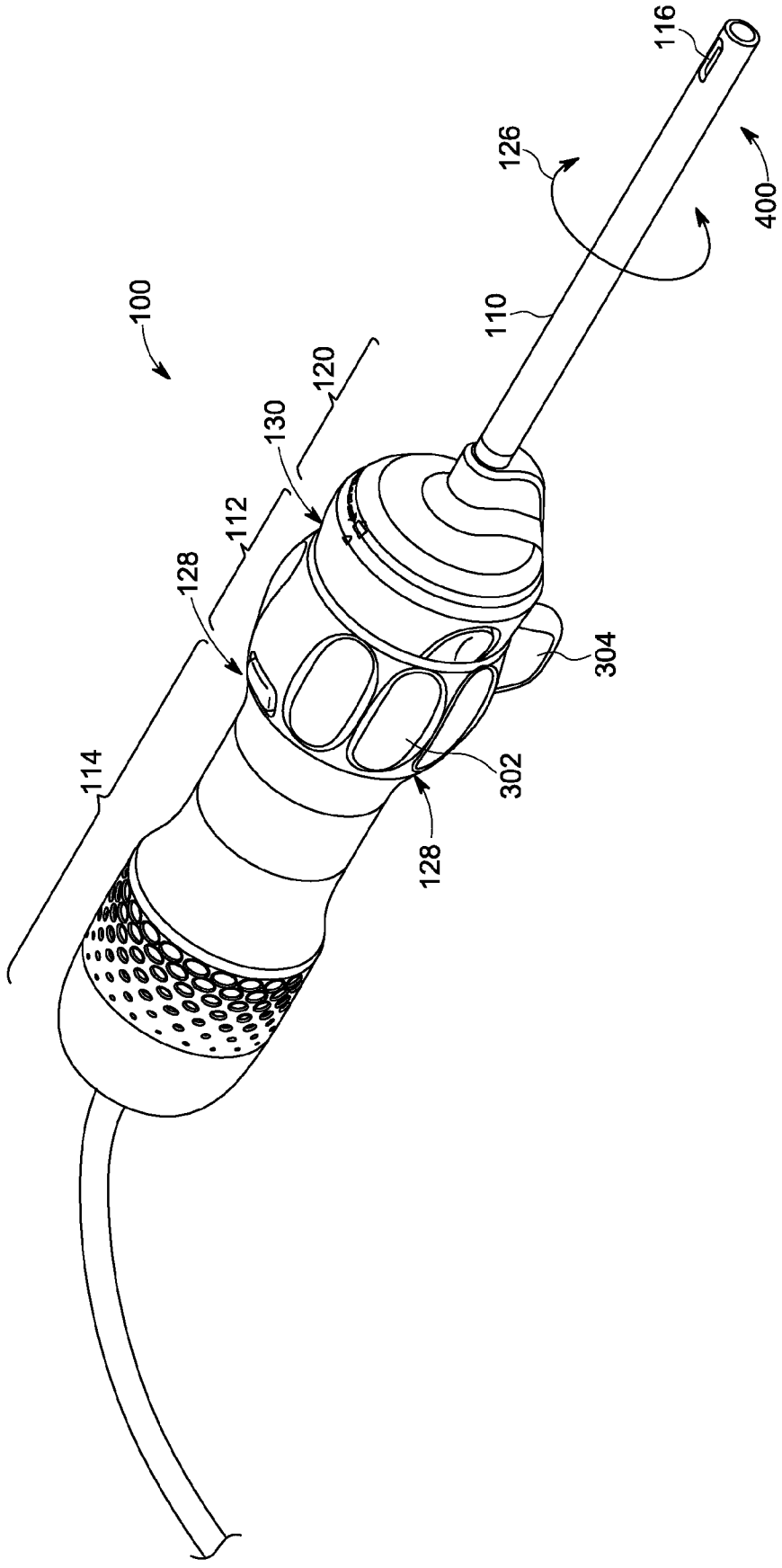


FIG. 2A

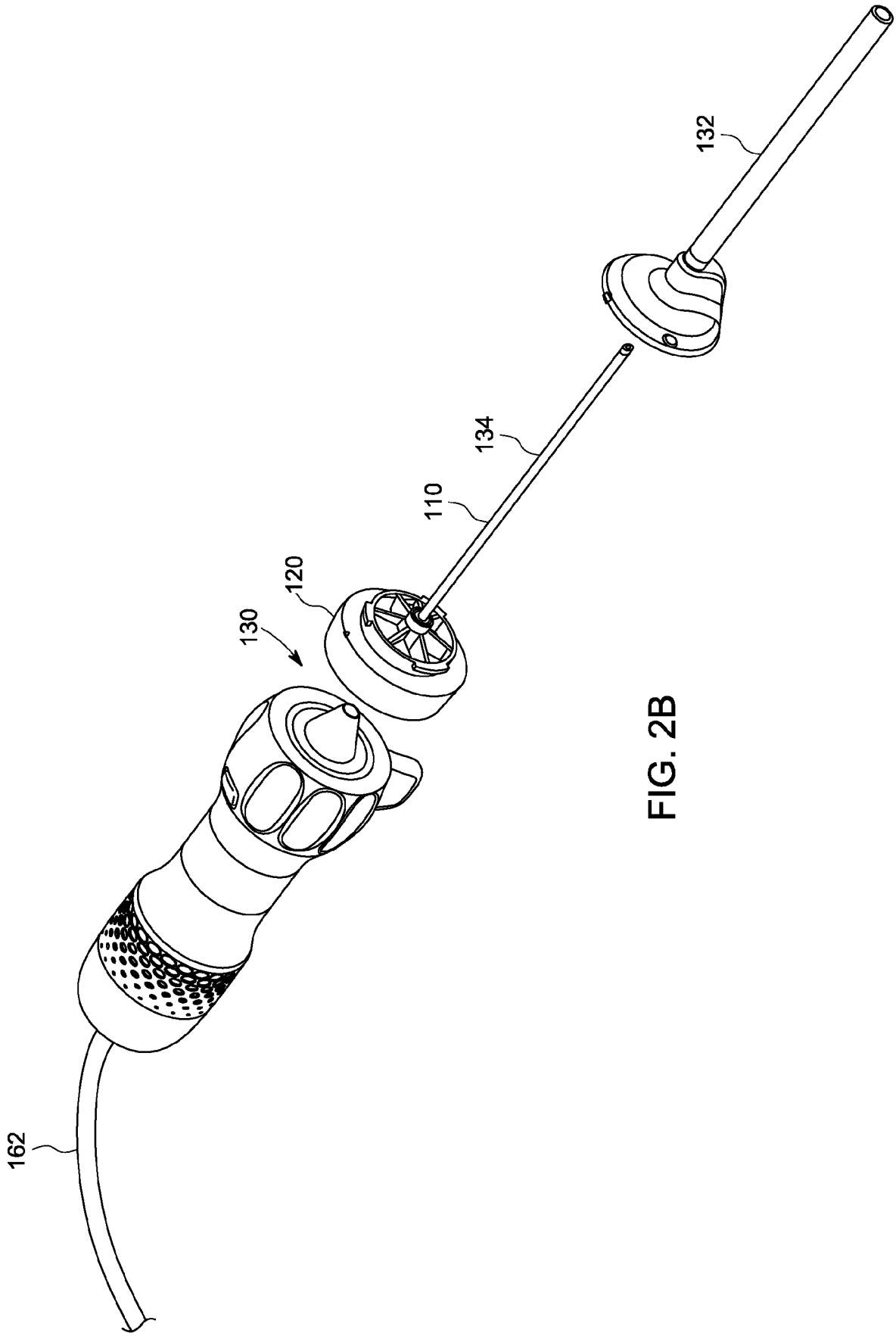


FIG. 2B

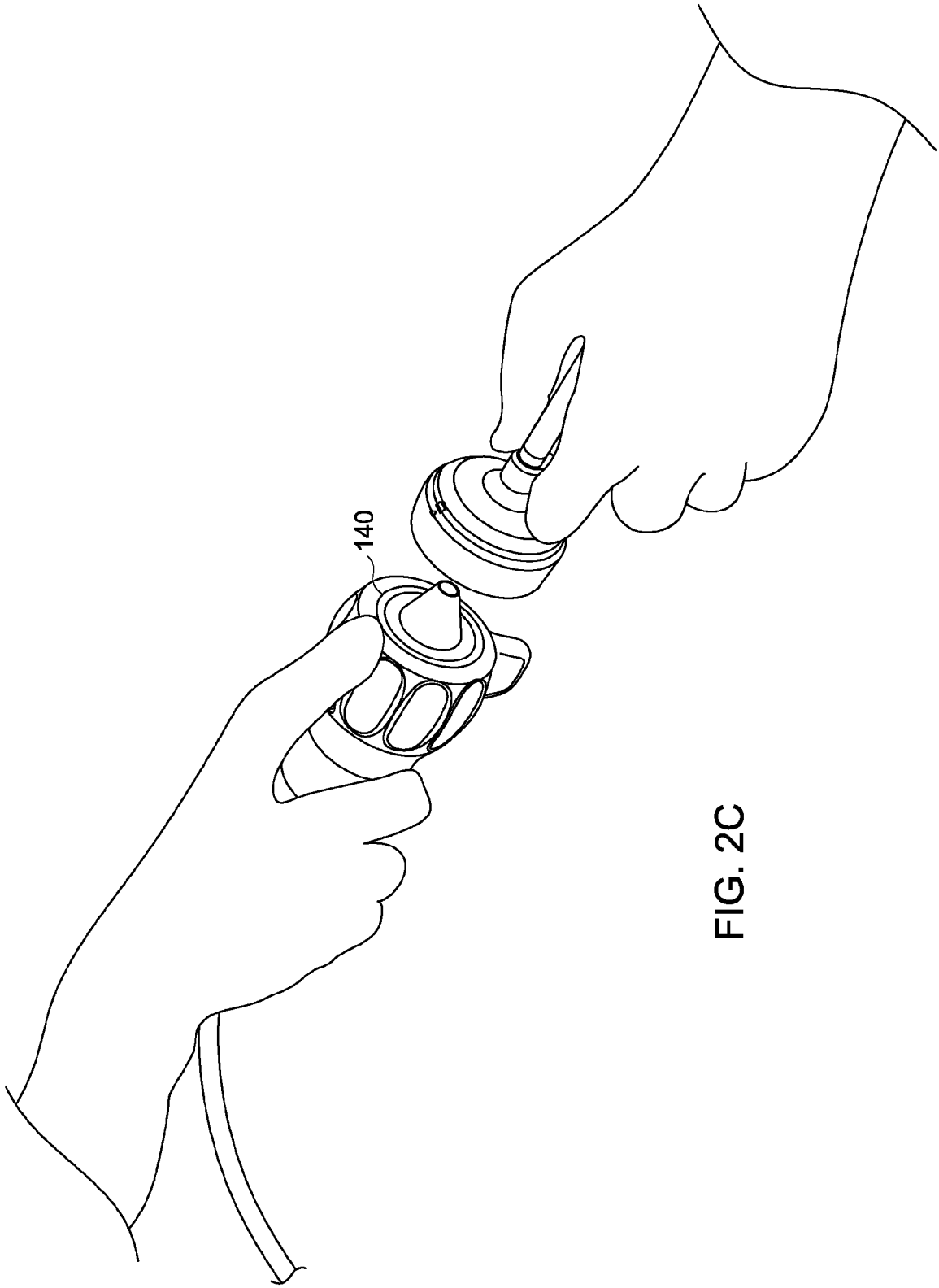


FIG. 2C

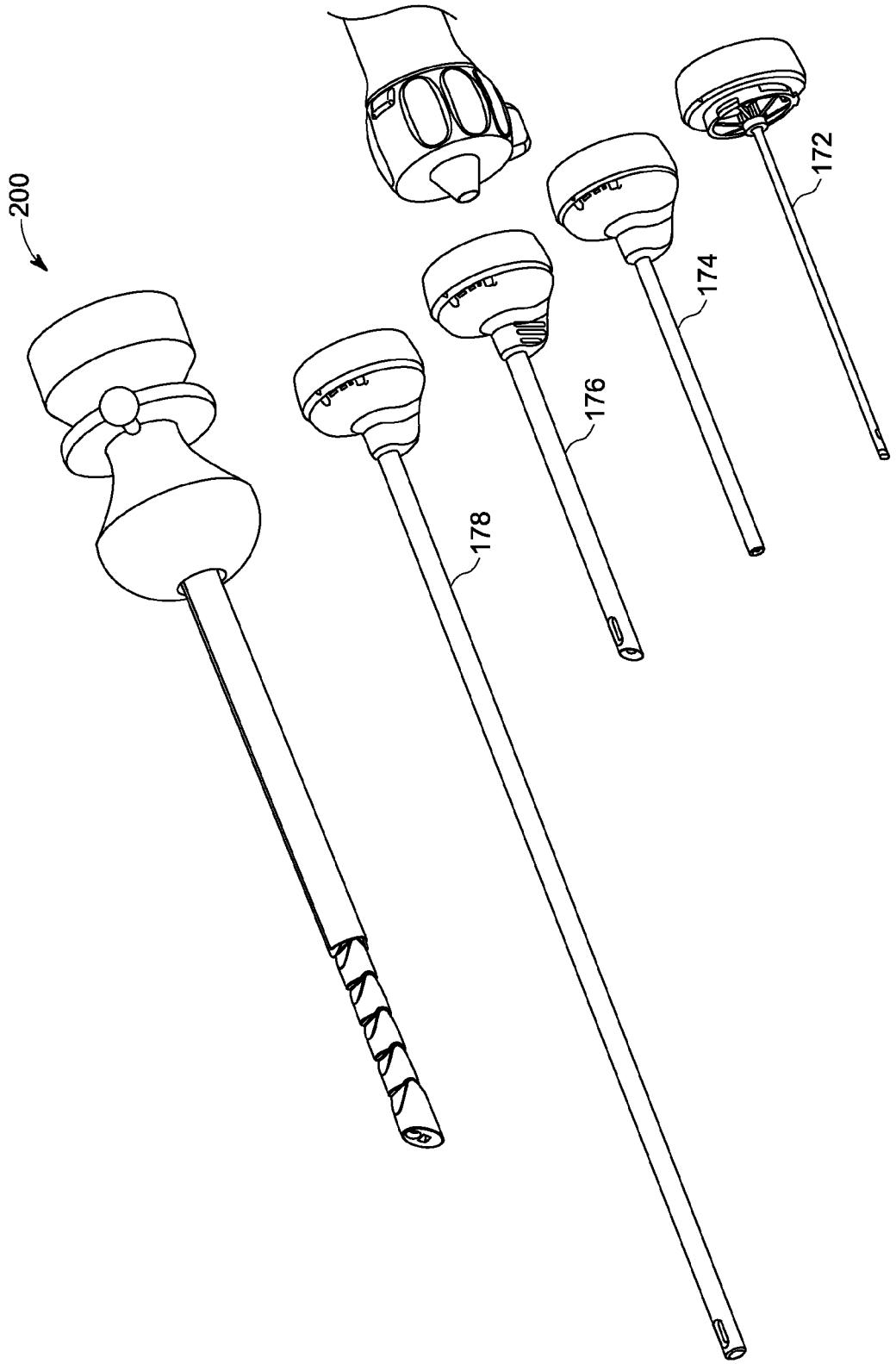


FIG. 2D

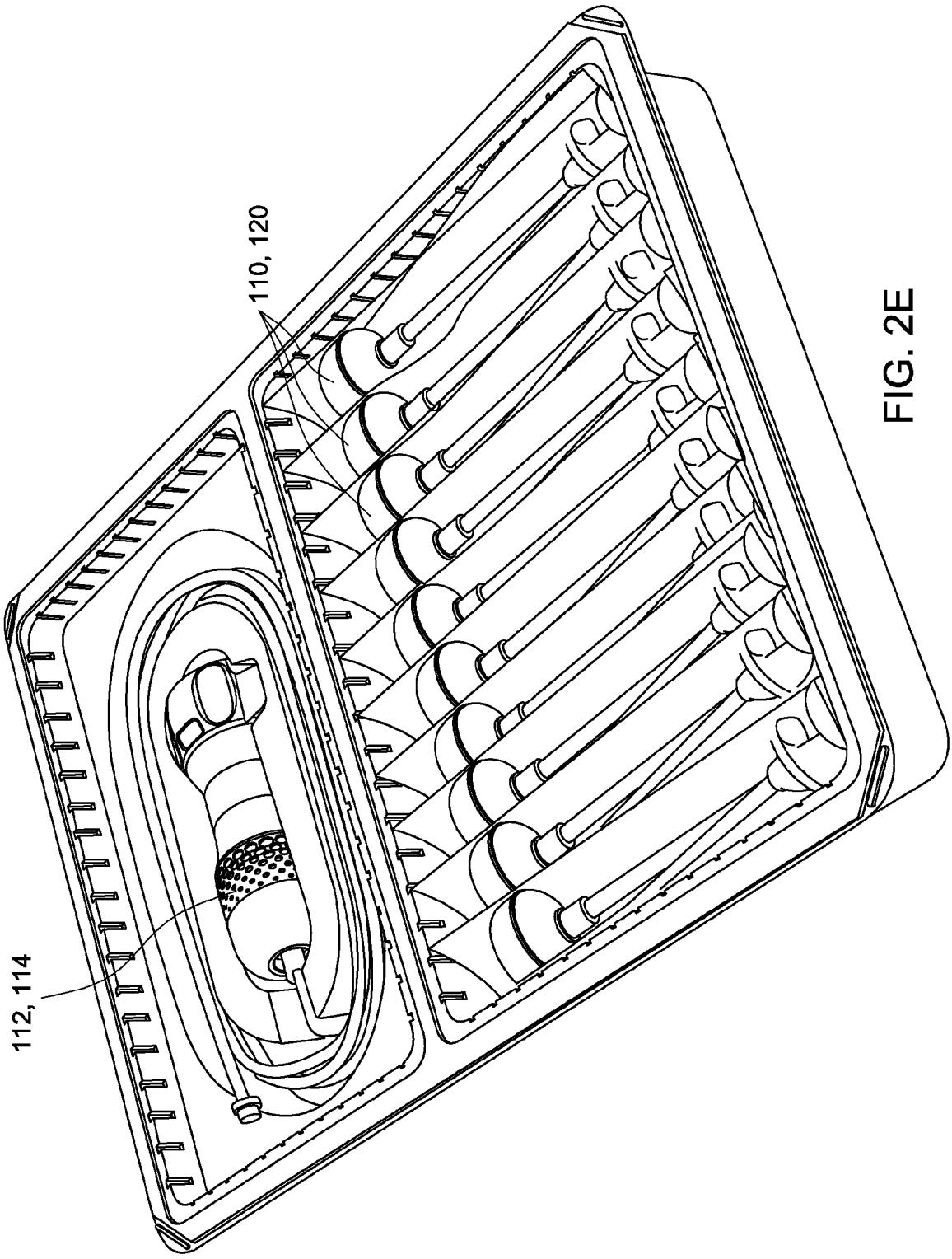


FIG. 2E

FIG. 2F

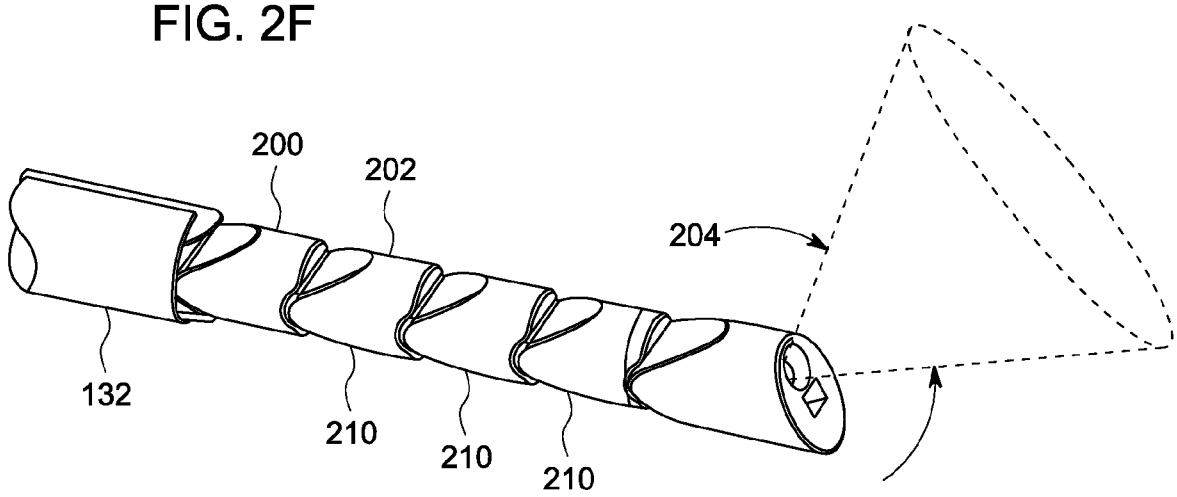
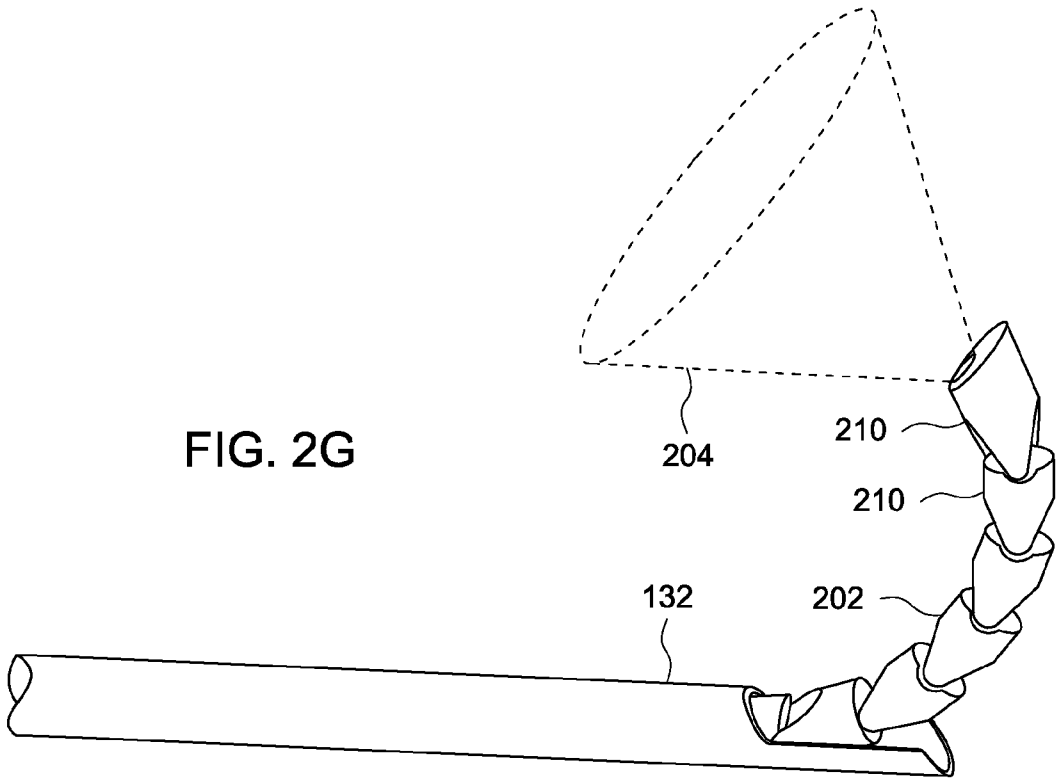


FIG. 2G



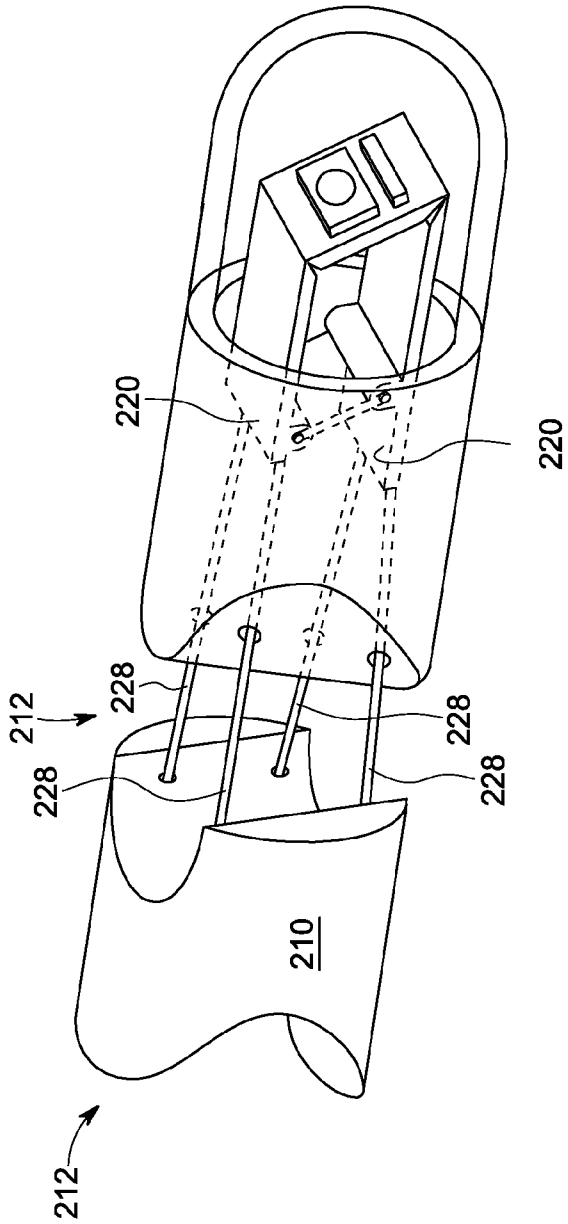


FIG. 2H

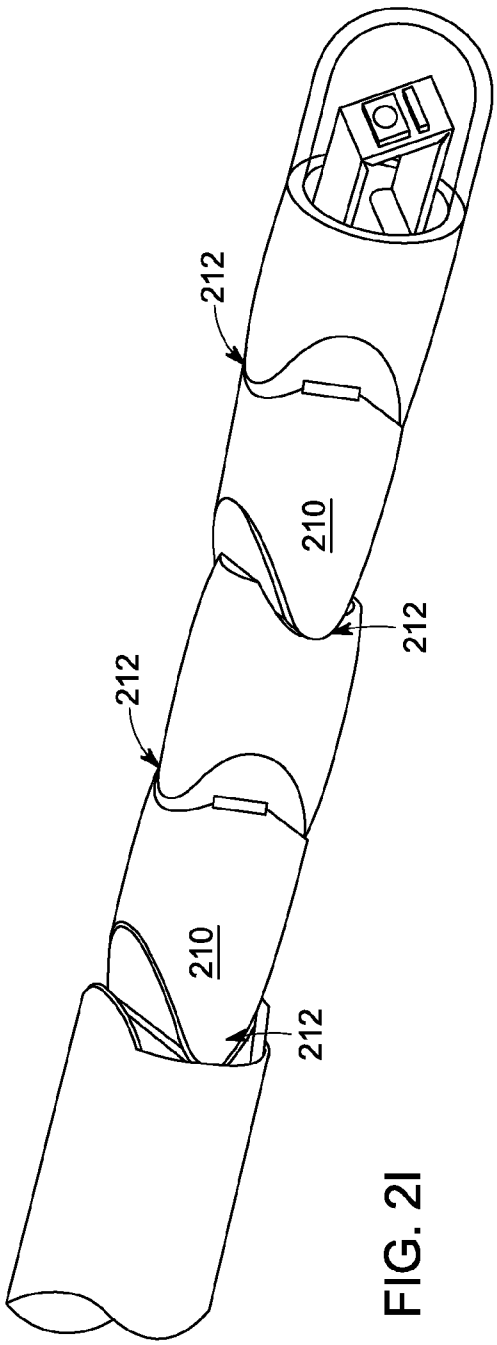


FIG. 2I

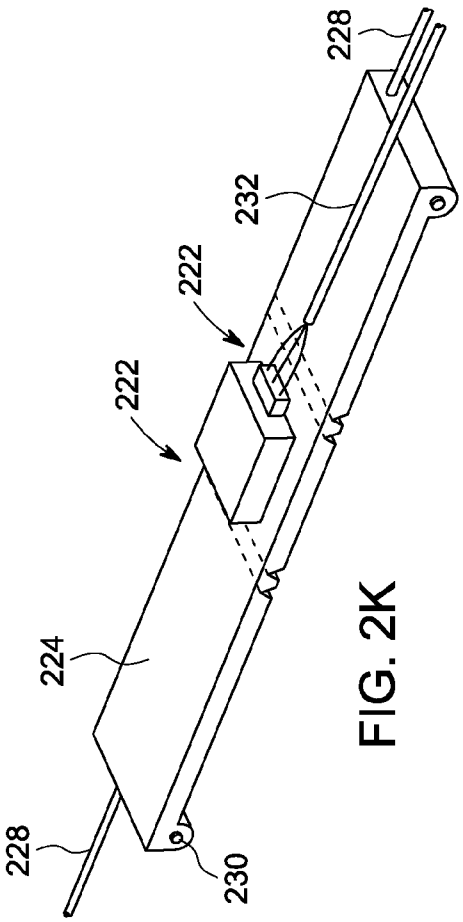


FIG. 2K

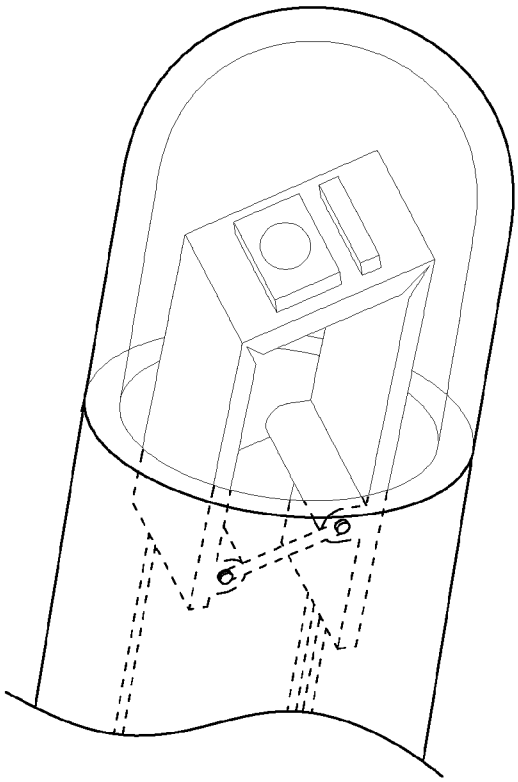


FIG. 2M

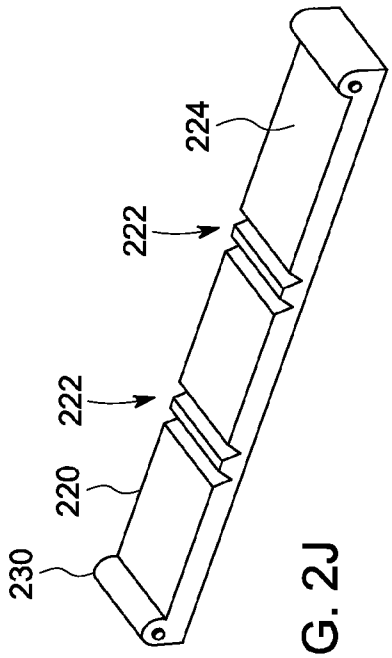


FIG. 2J

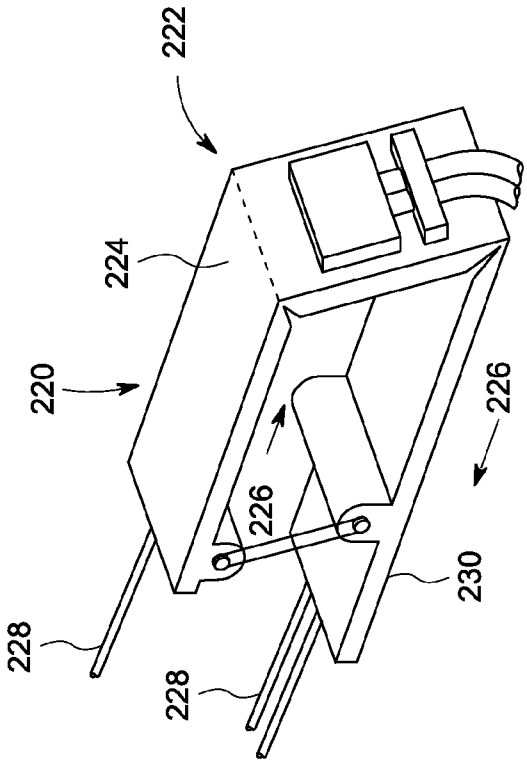


FIG. 2L

FIG. 2N

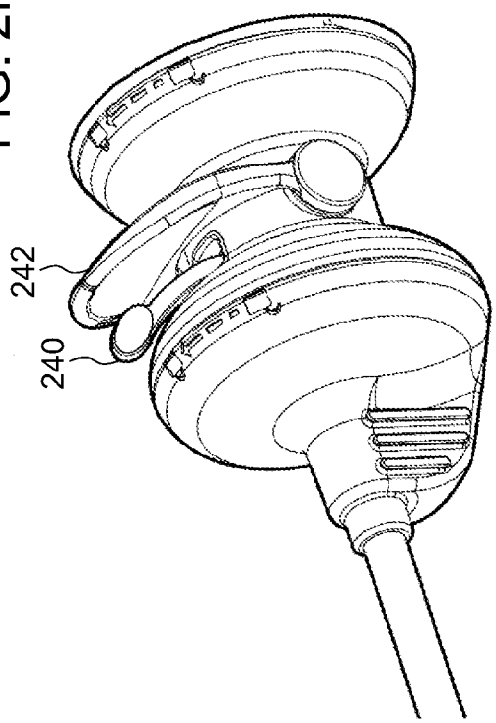


FIG. 2O

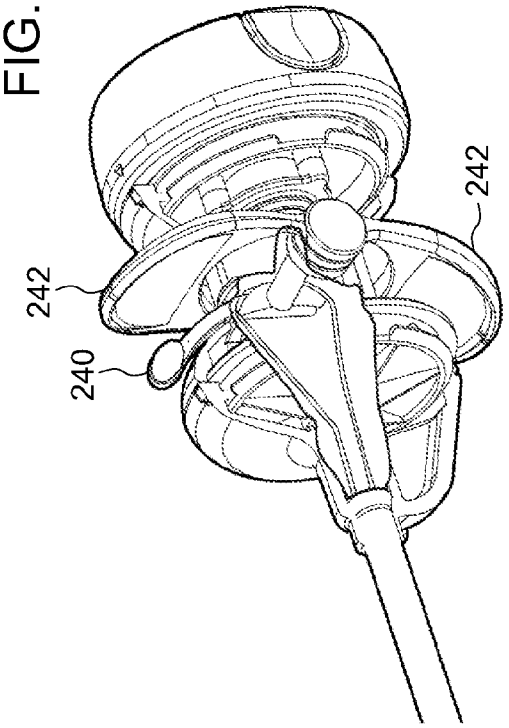


FIG. 2P

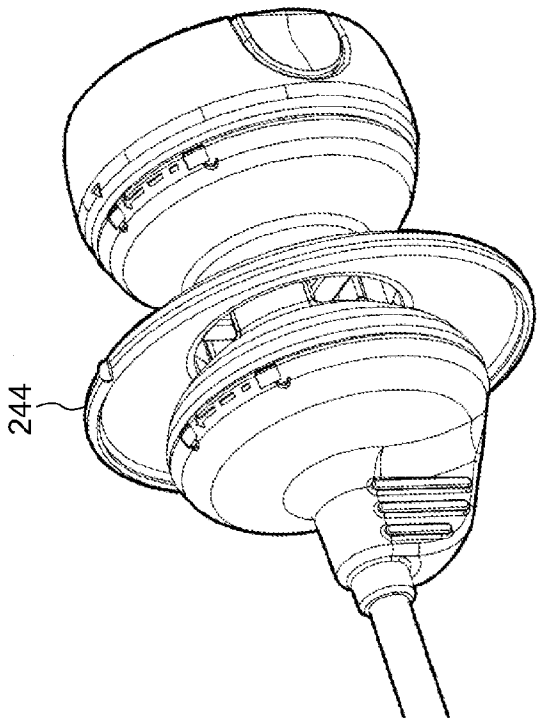
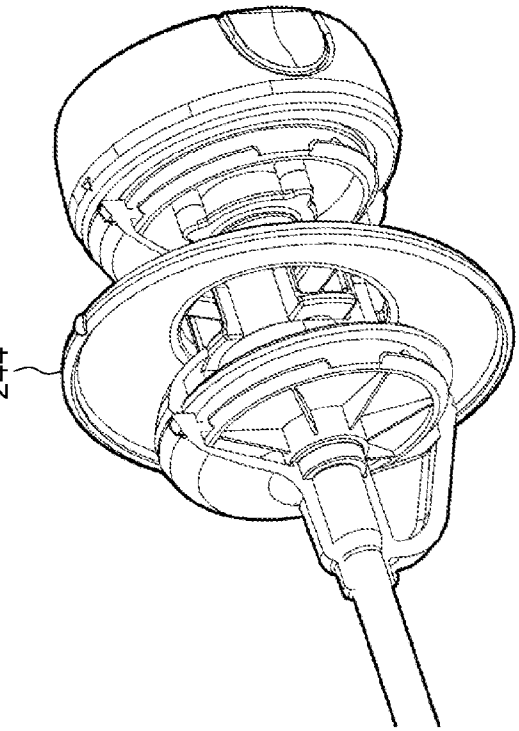


FIG. 2Q



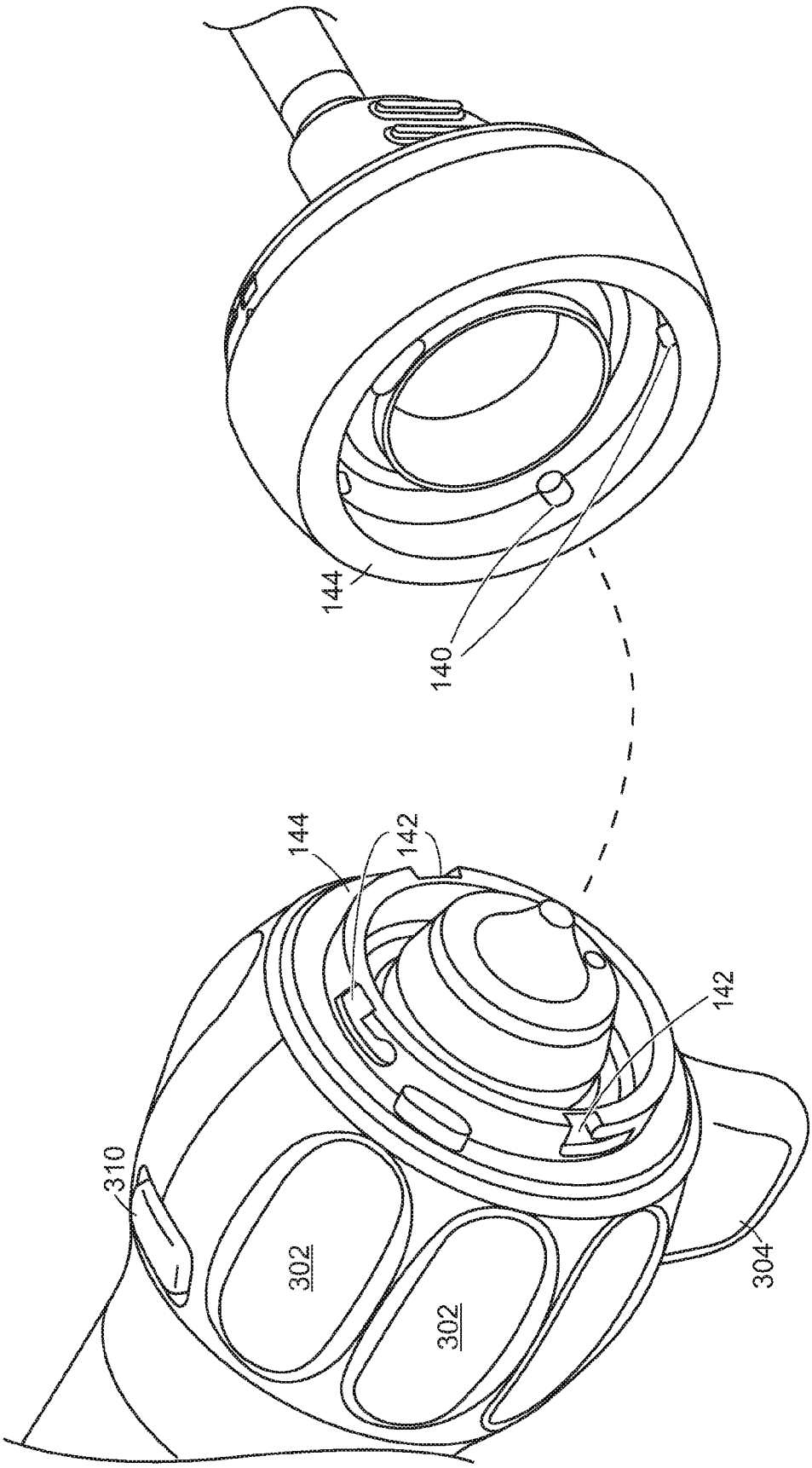


FIG. 3A

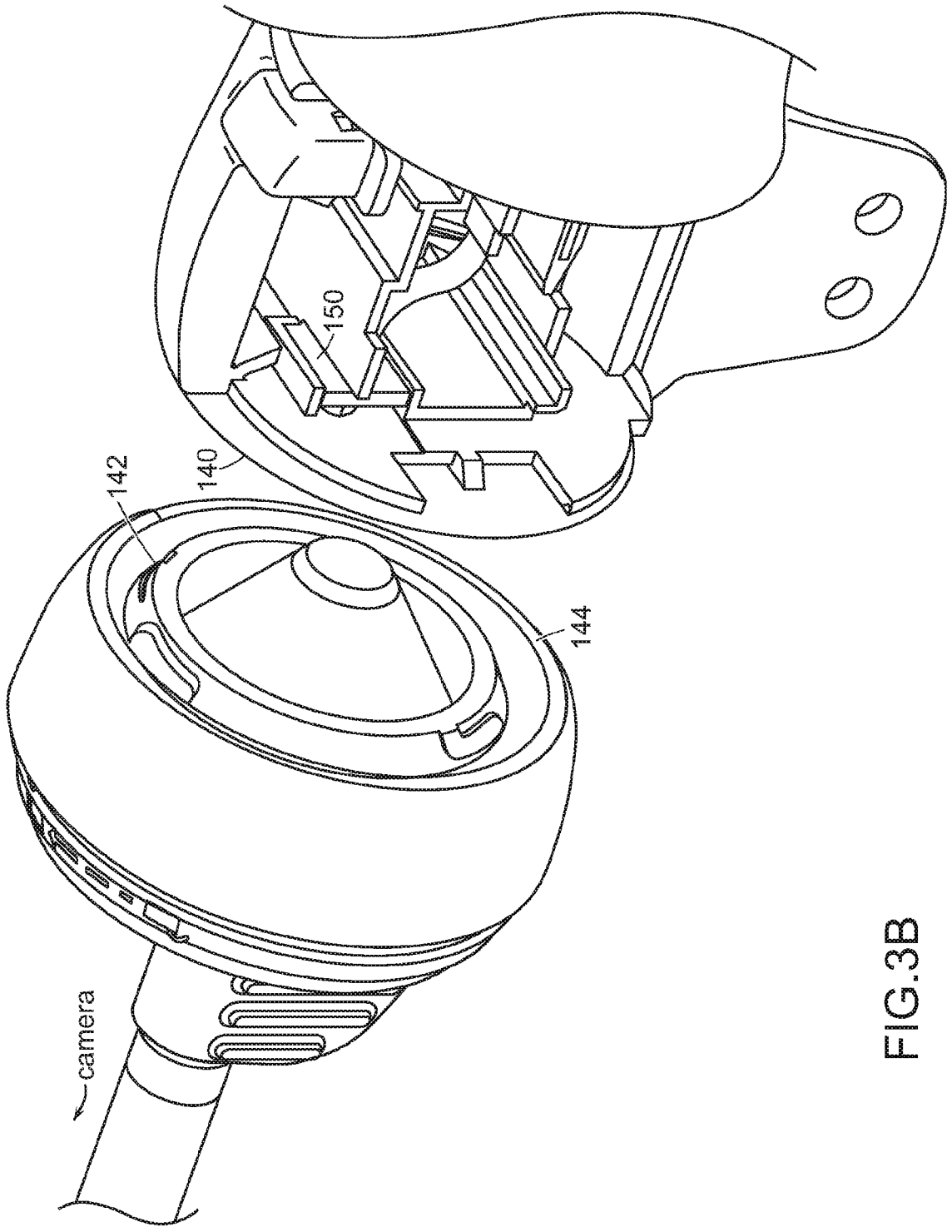


FIG.3B

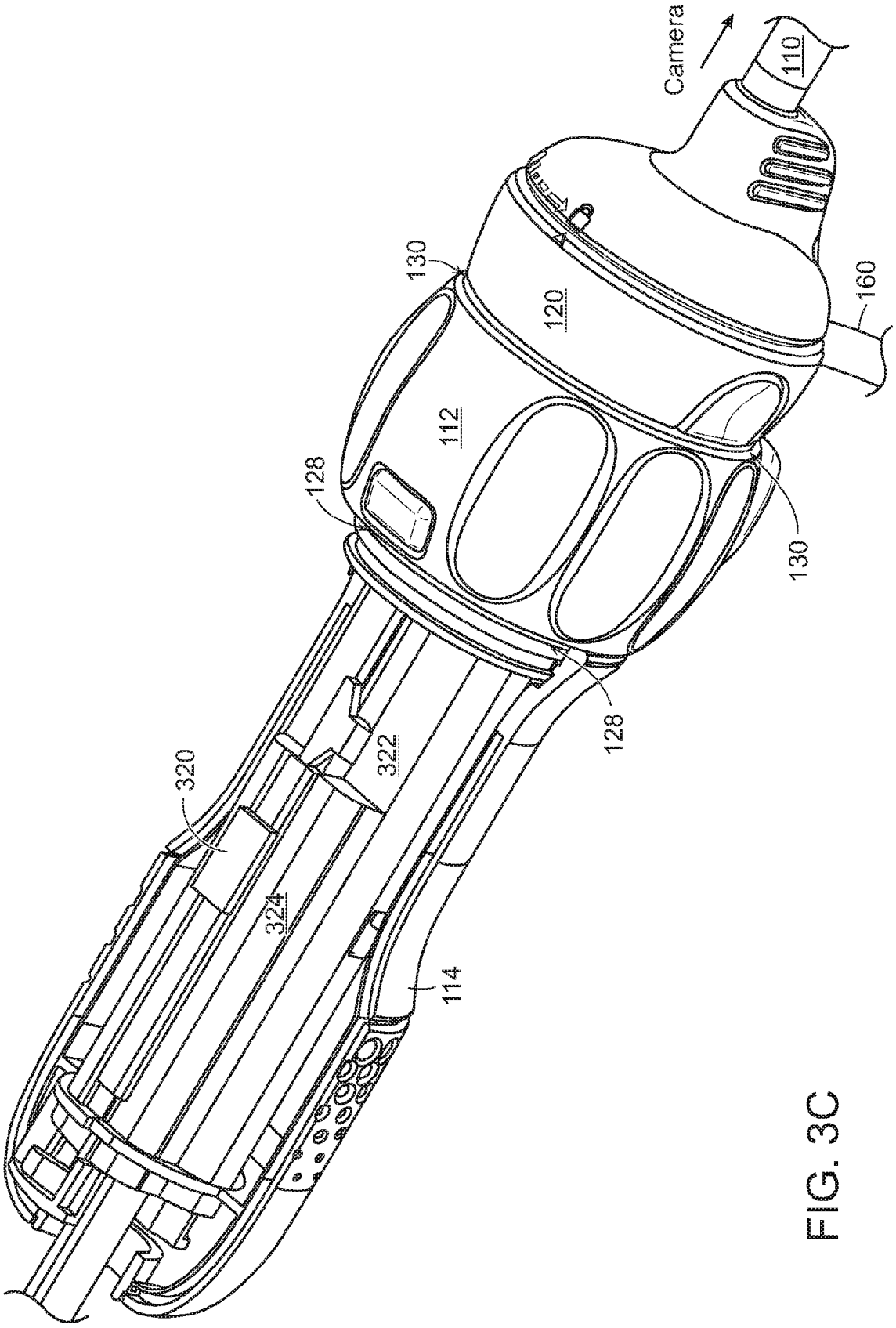


FIG. 3C

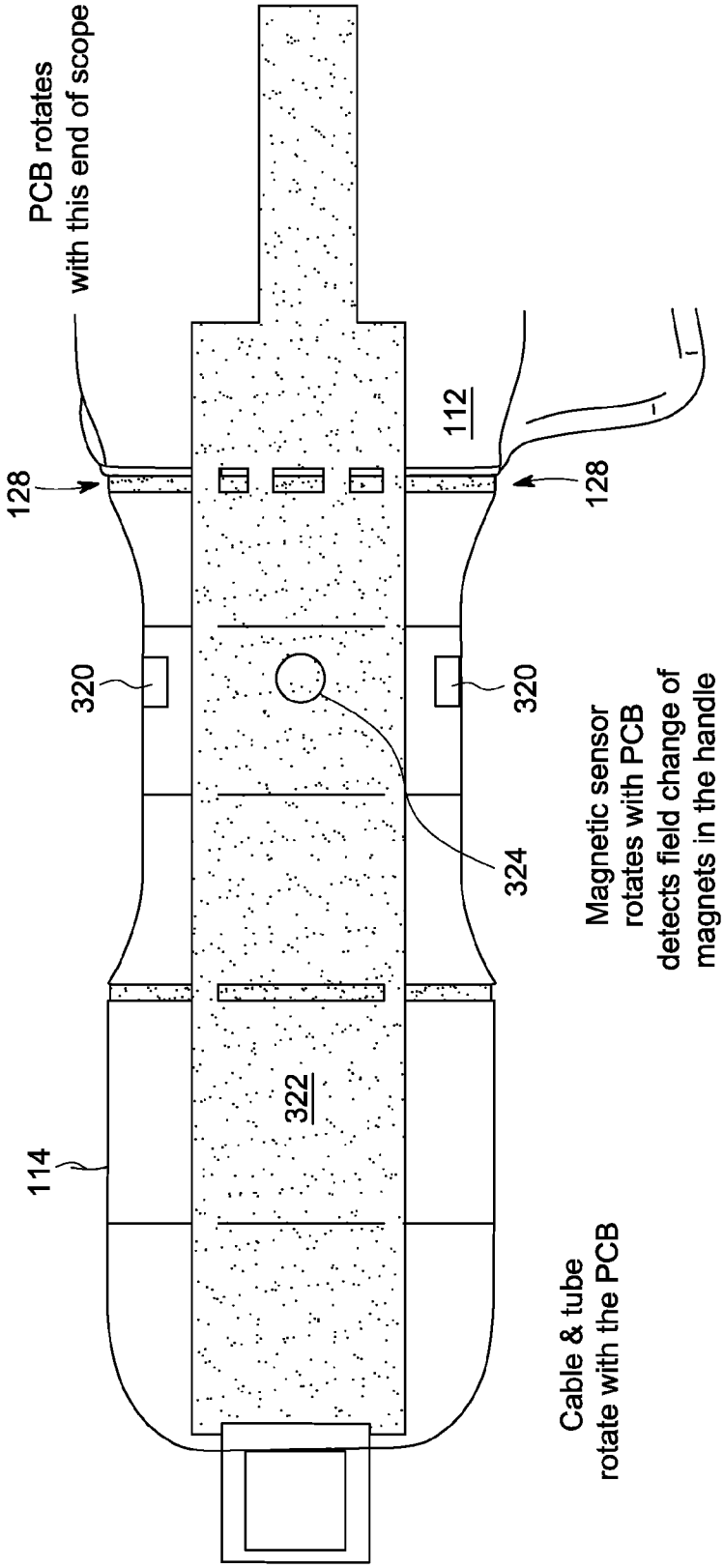

PCB rotates
with this end of scope
128
112
128
320
320
324
Magnetic sensor
rotates with PCB
detects field change of
magnets in the handle
322
114
Cable & tube
rotate with the PCB

FIG. 3D

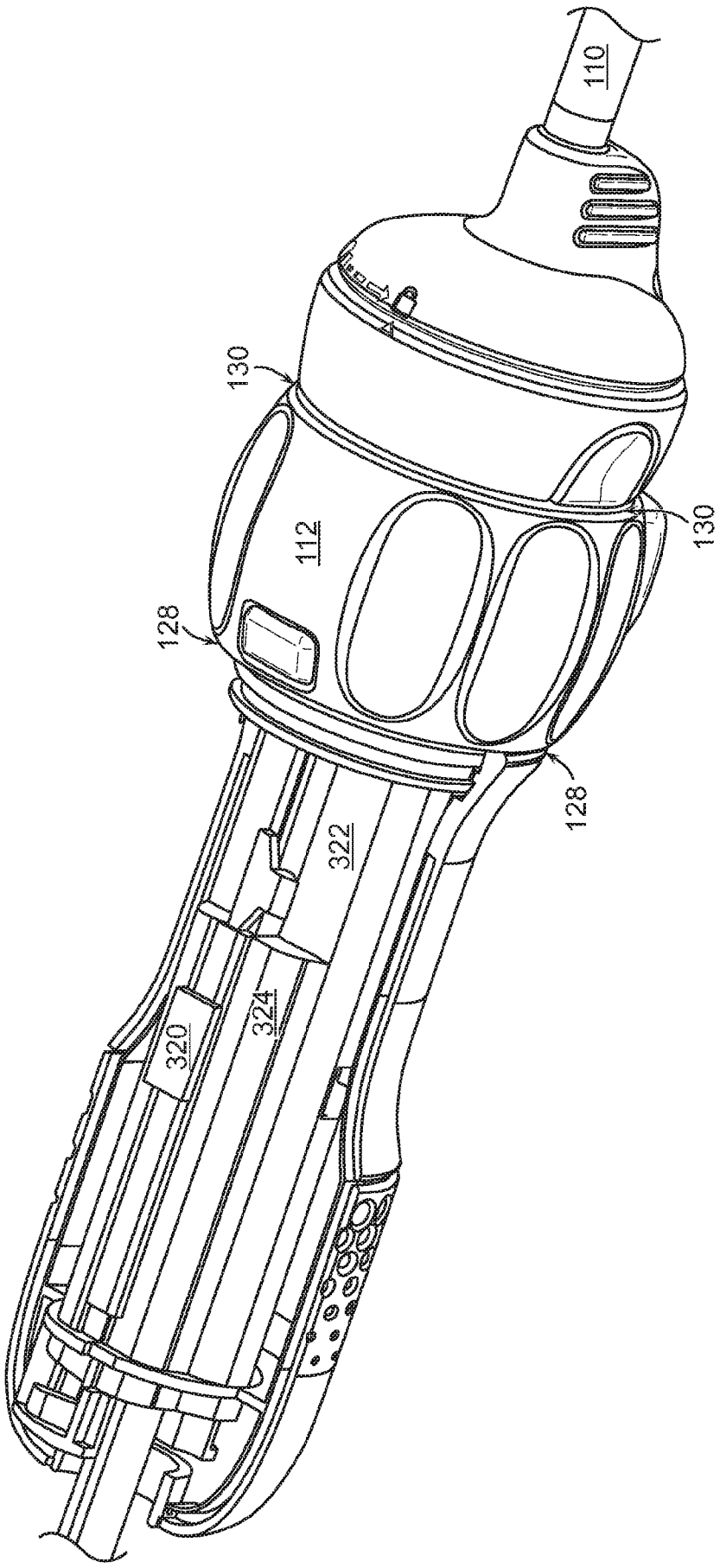


FIG. 3E

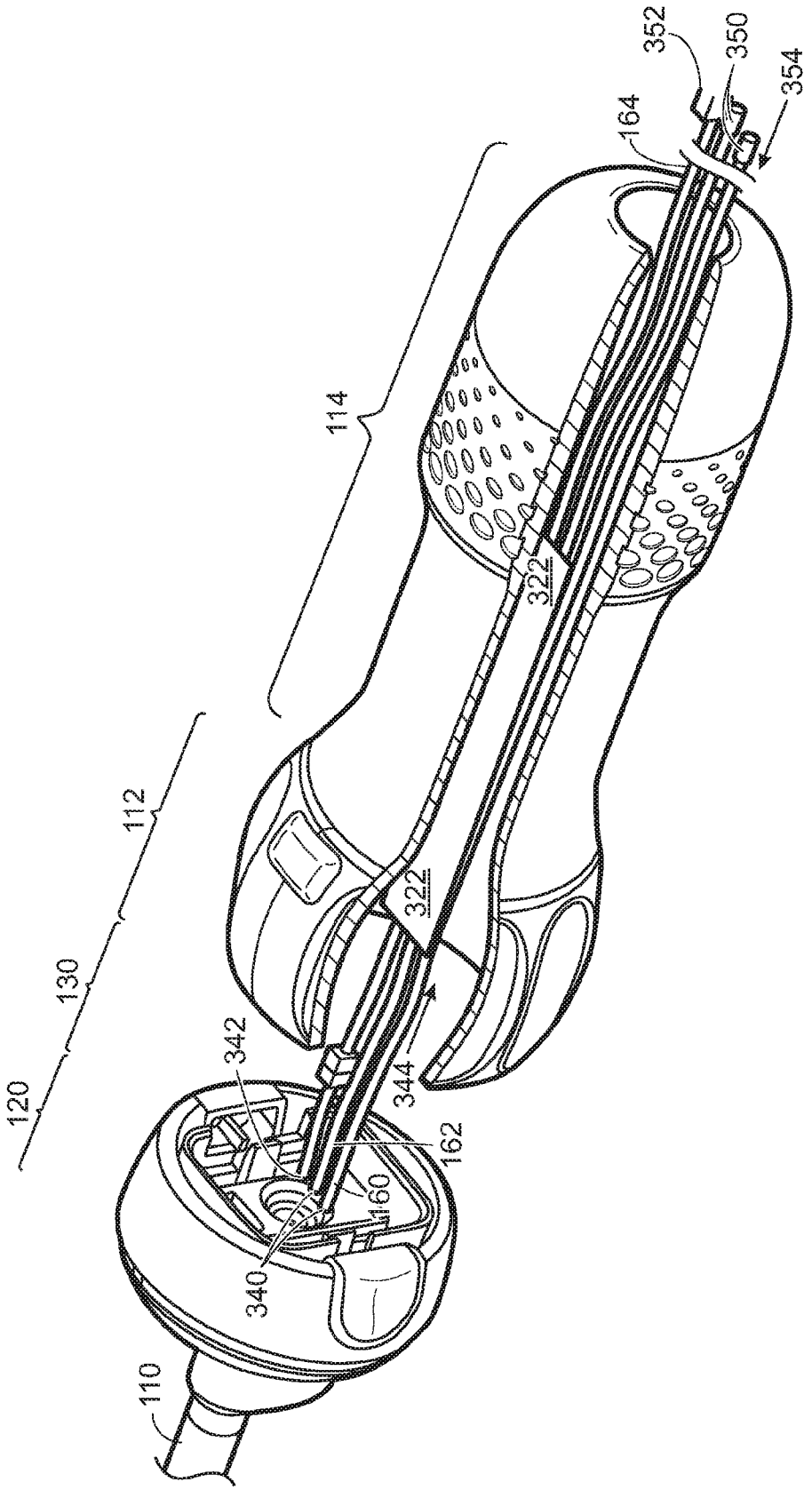


FIG. 3F

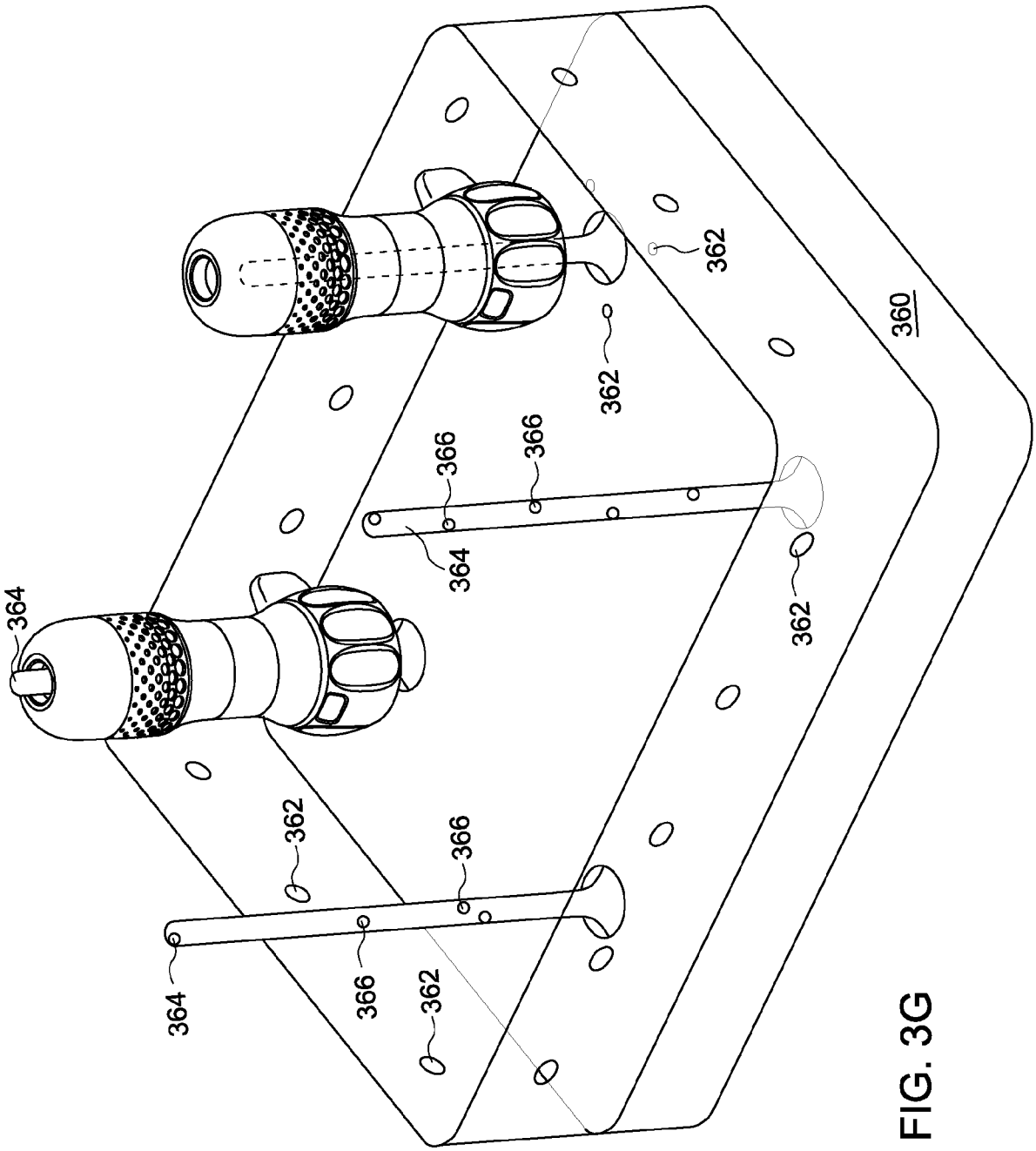


FIG. 3G

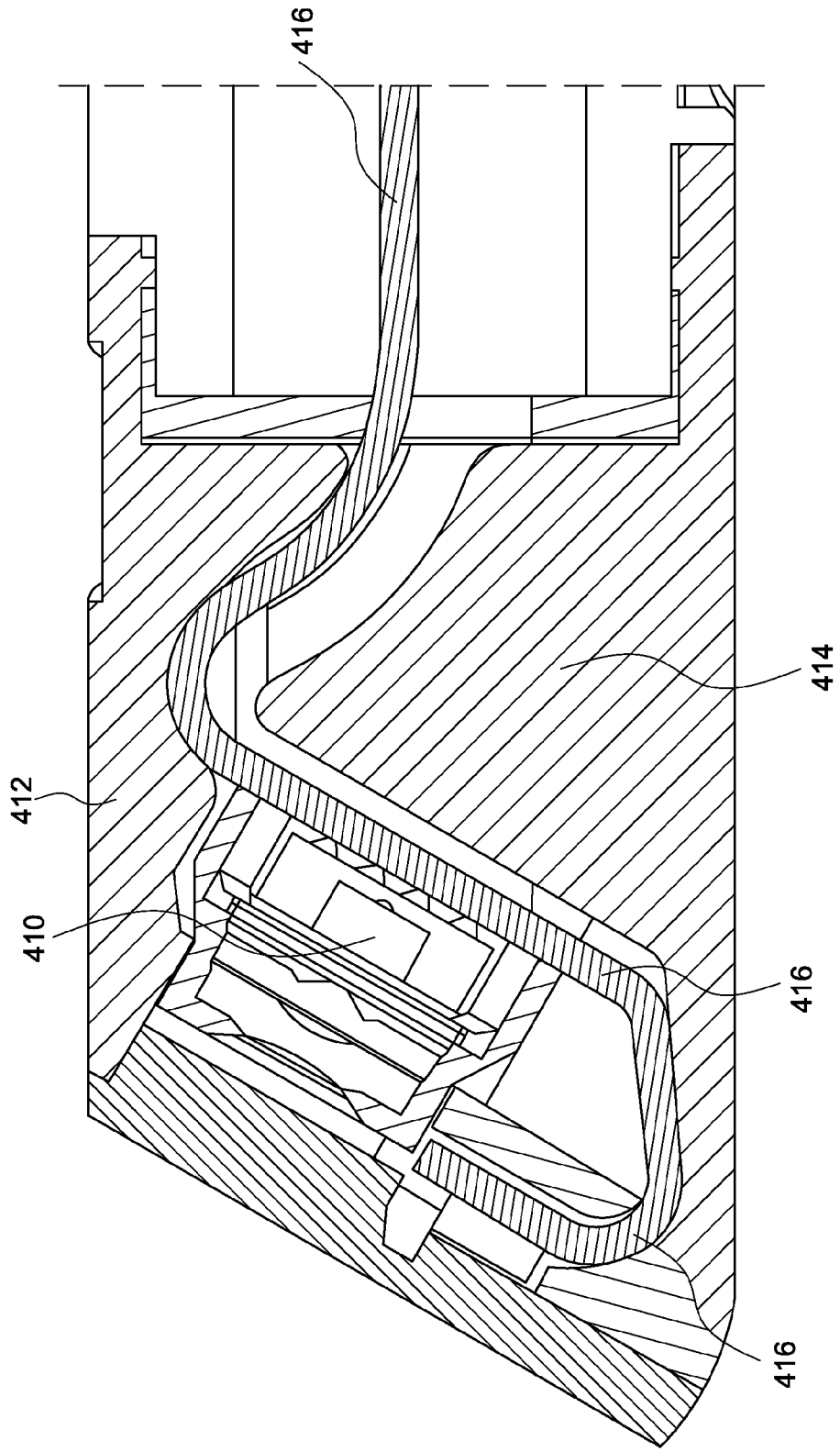


FIG. 4A

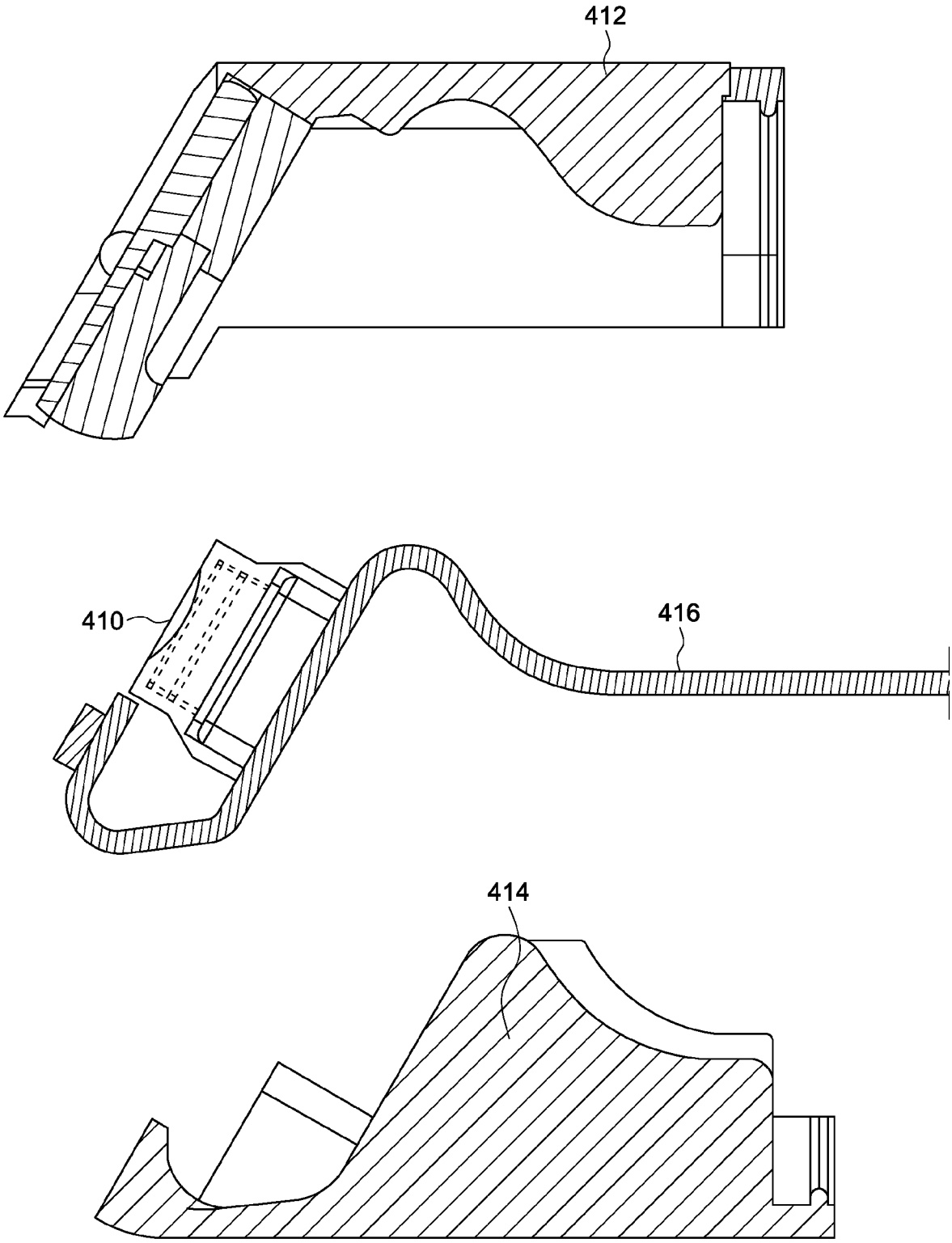
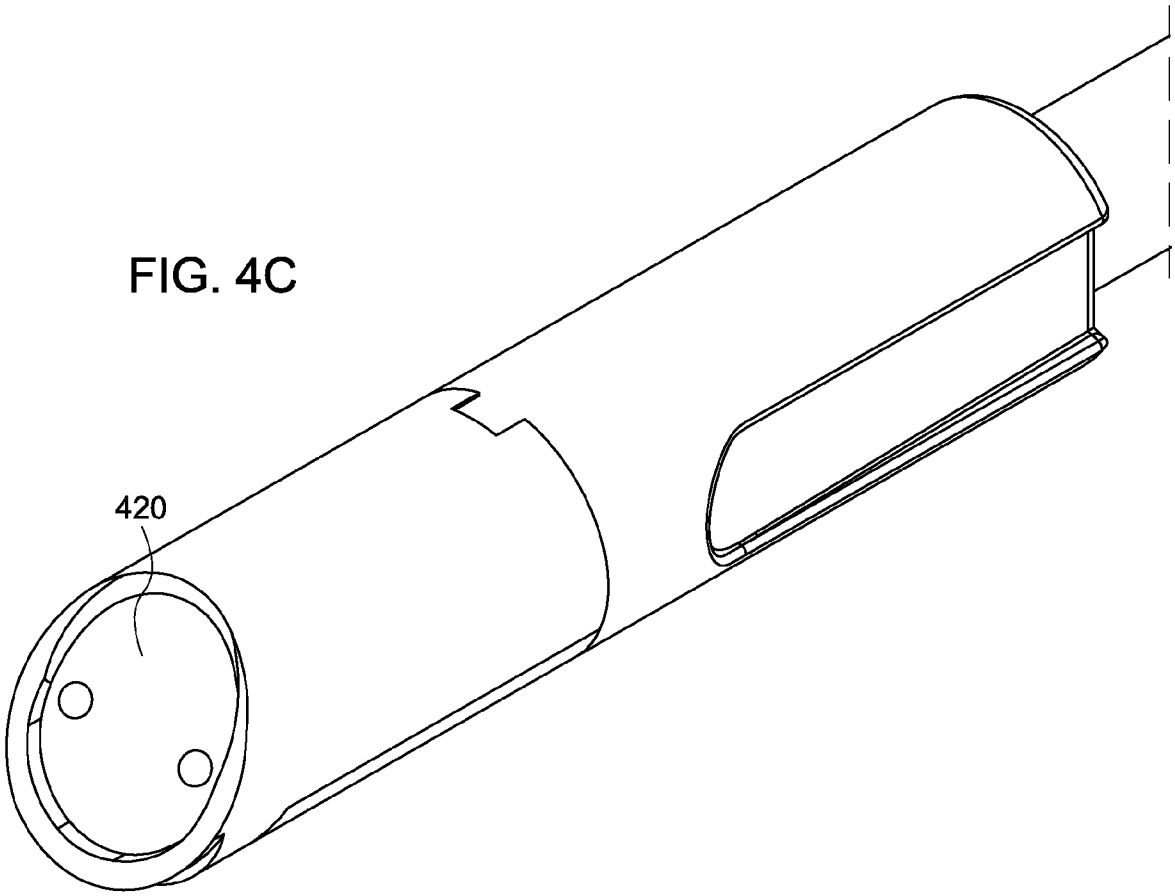


FIG. 4B

FIG. 4C



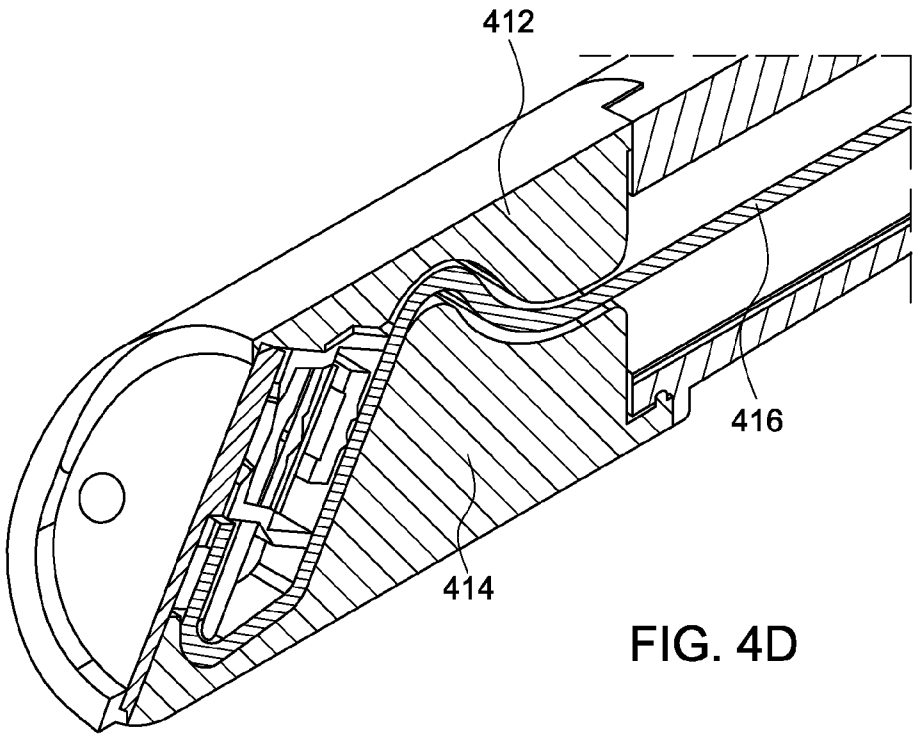


FIG. 4D

FIG. 4E

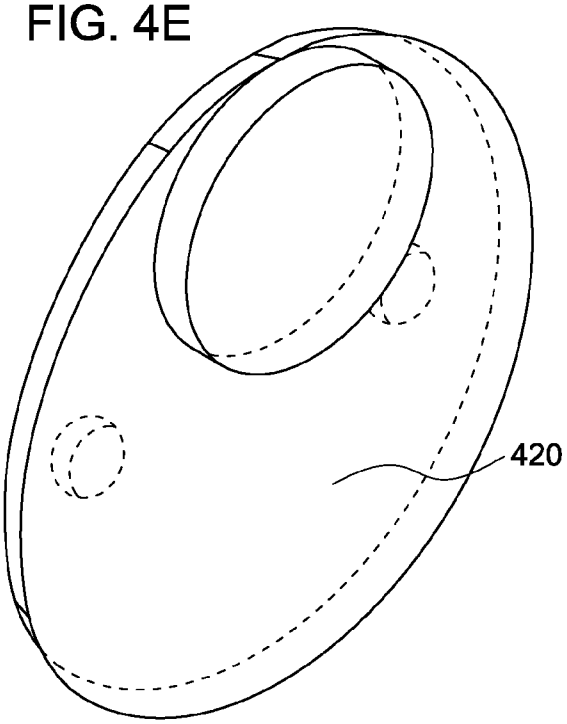


FIG. 4F

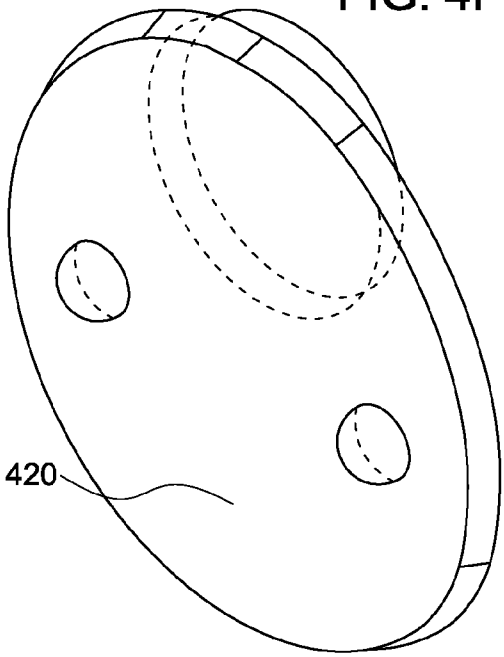
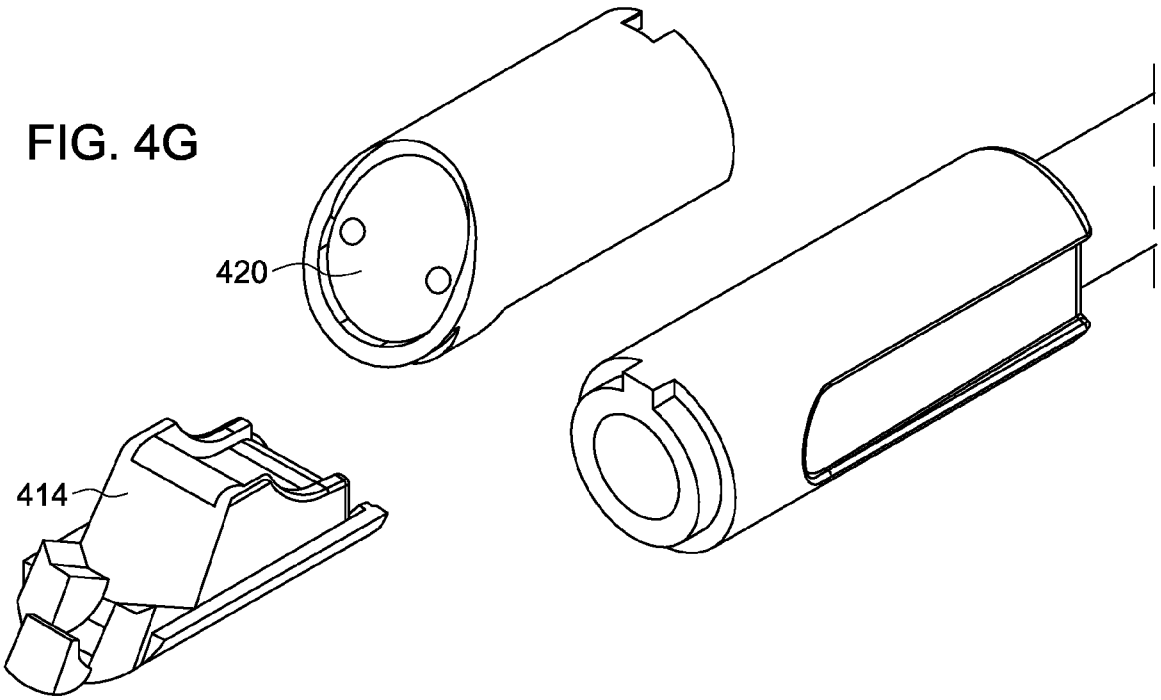


FIG. 4G



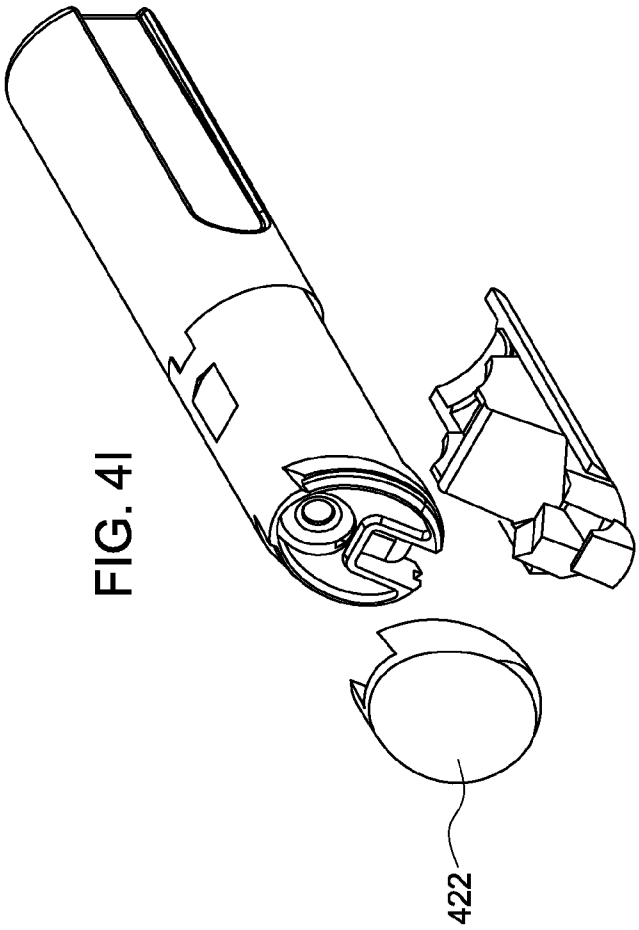


FIG. 4I

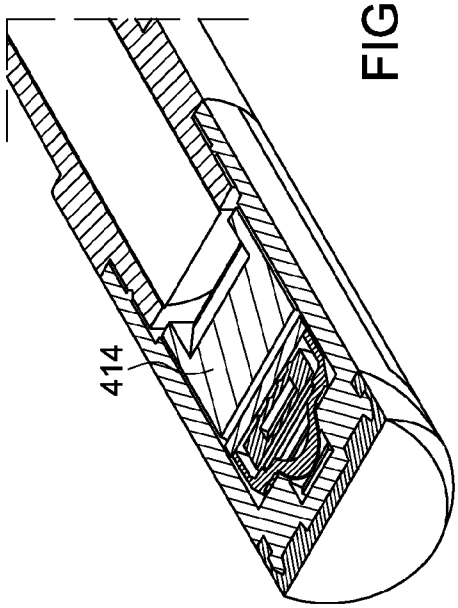


FIG. 4K

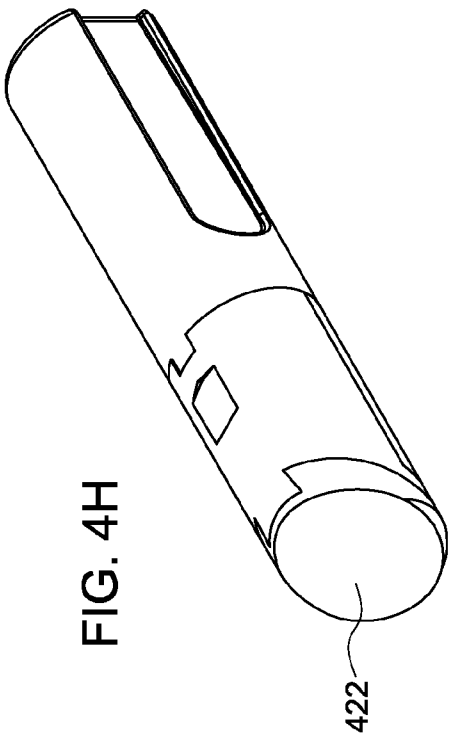


FIG. 4H

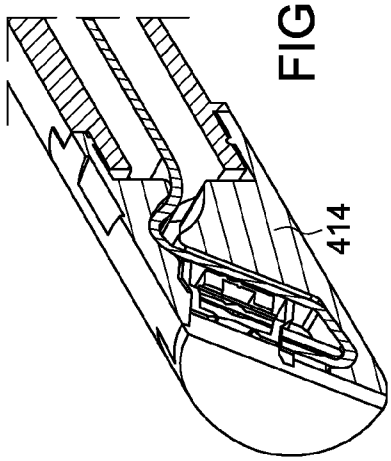


FIG. 4J

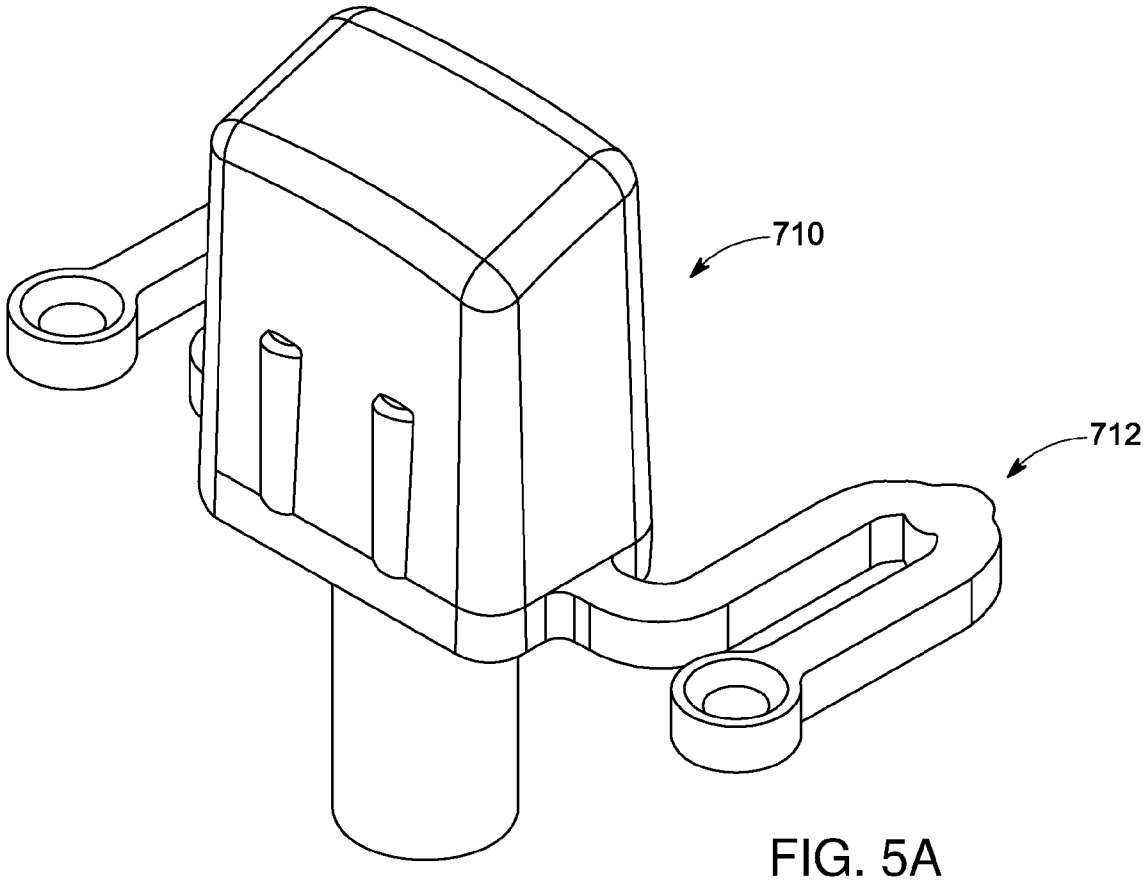


FIG. 5A

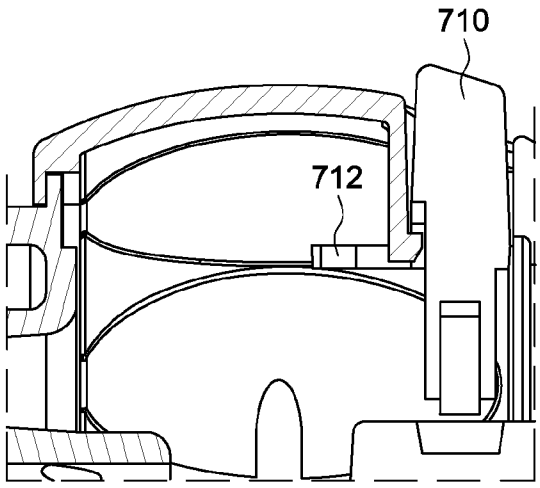


FIG. 5B

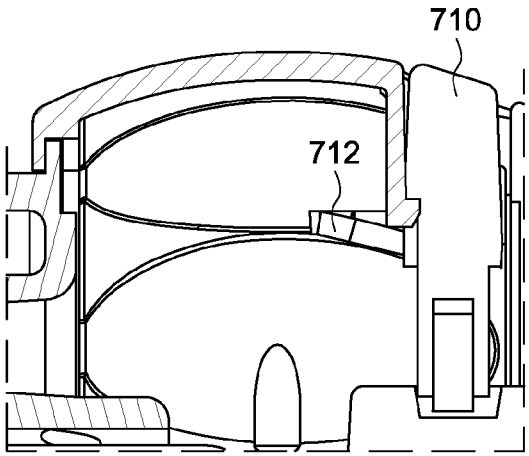


FIG. 5D

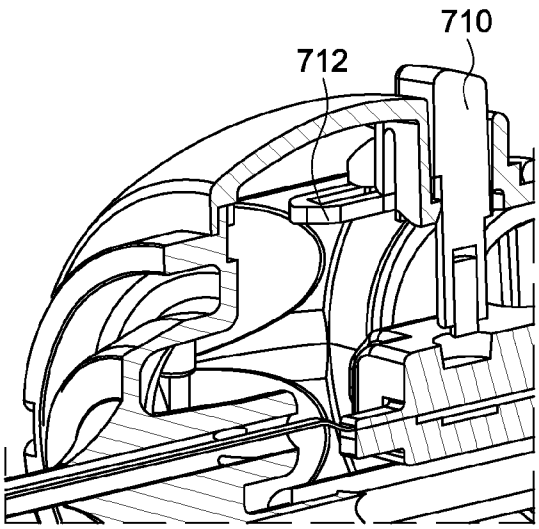


FIG. 5C

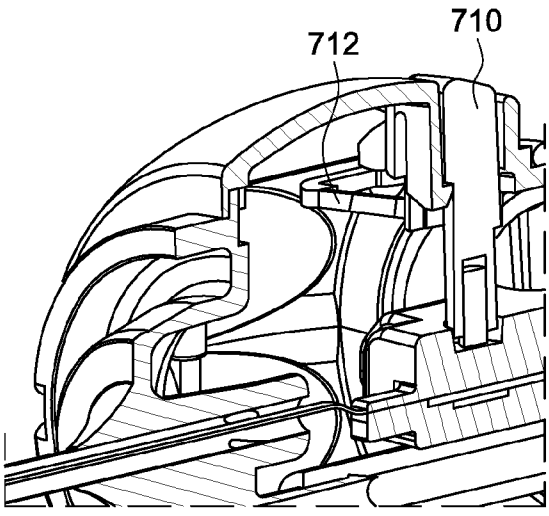


FIG. 5E

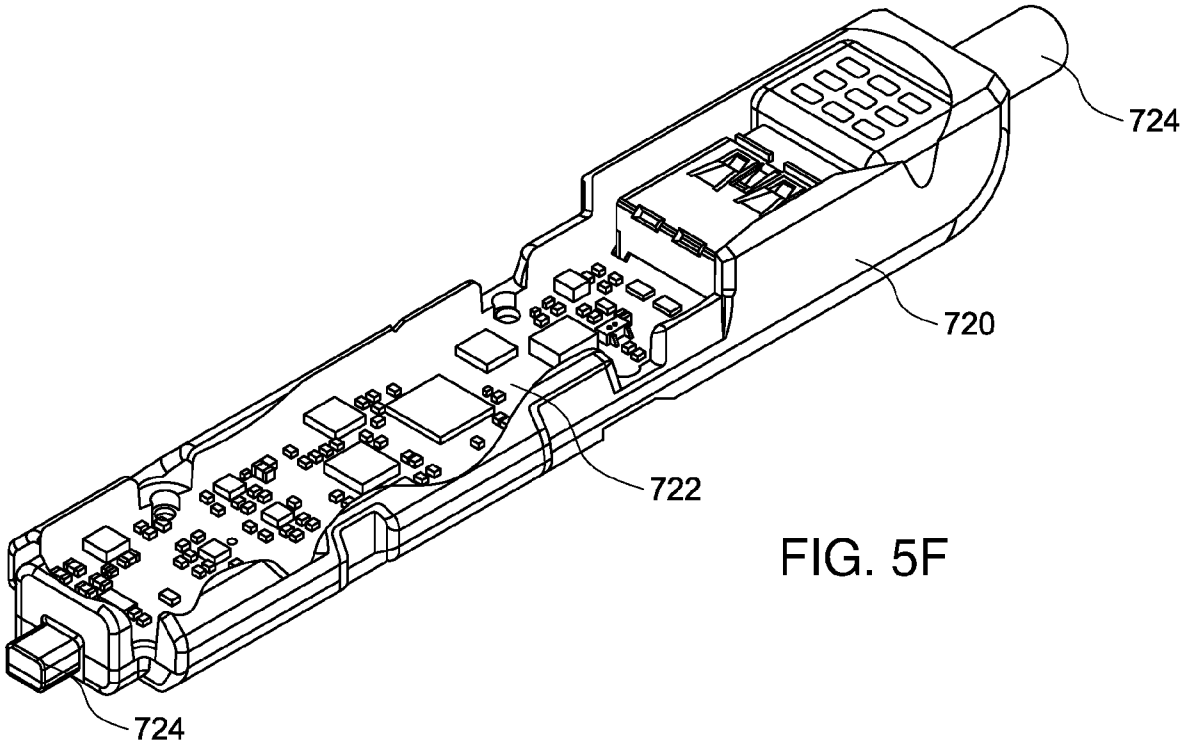


FIG. 5F

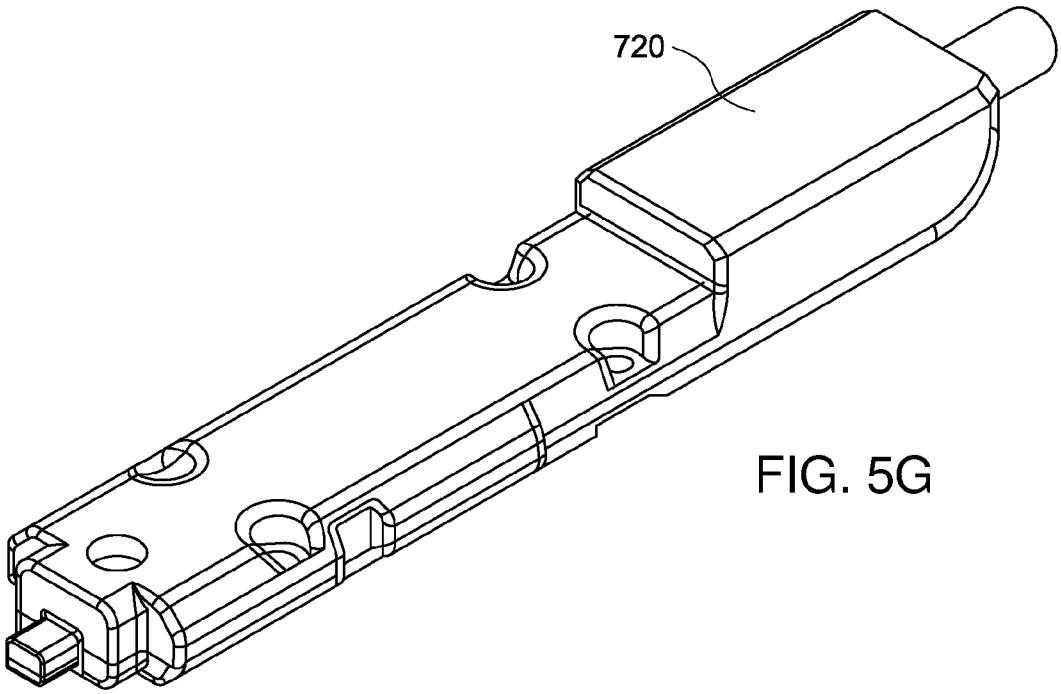


FIG. 5G

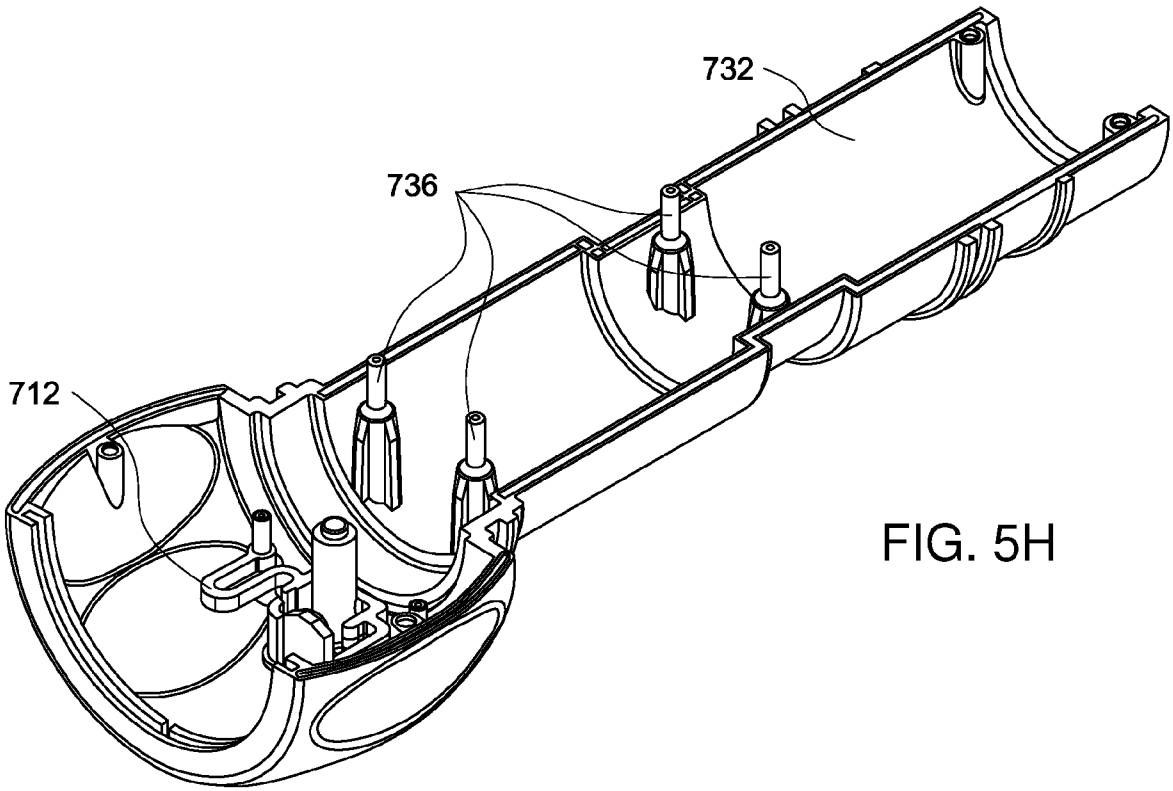


FIG. 5H

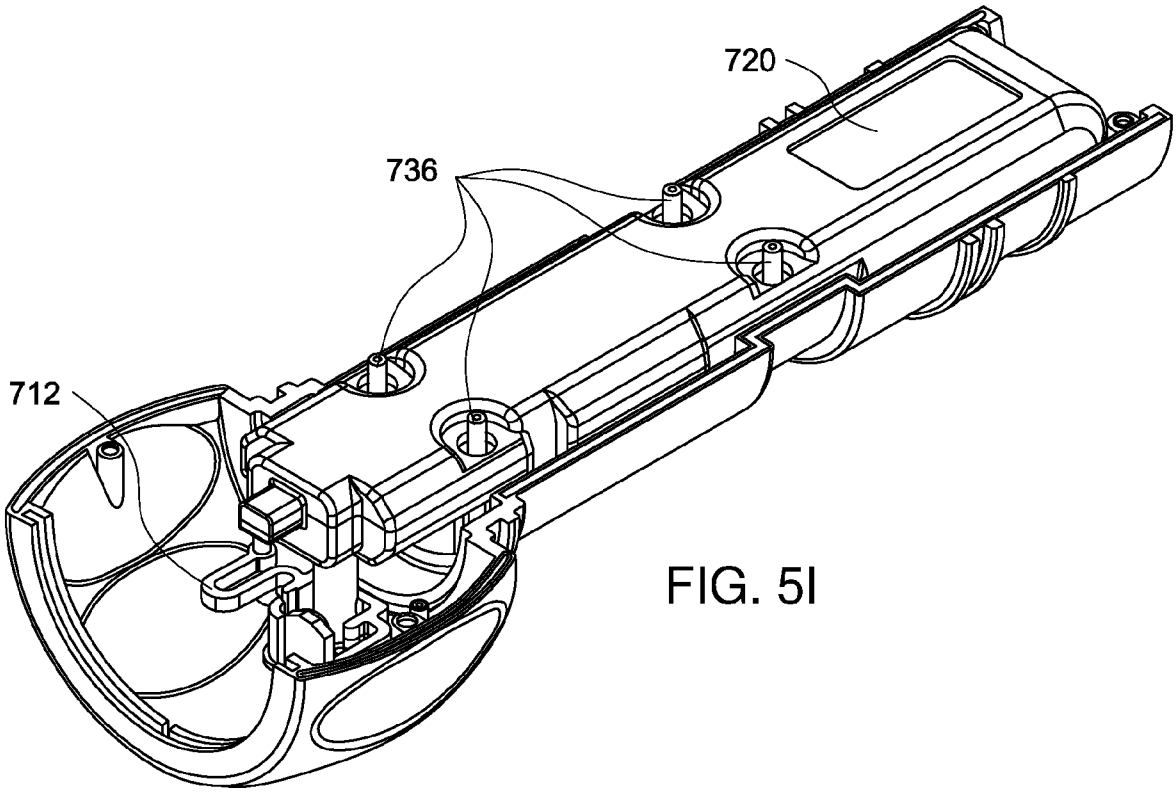


FIG. 5I

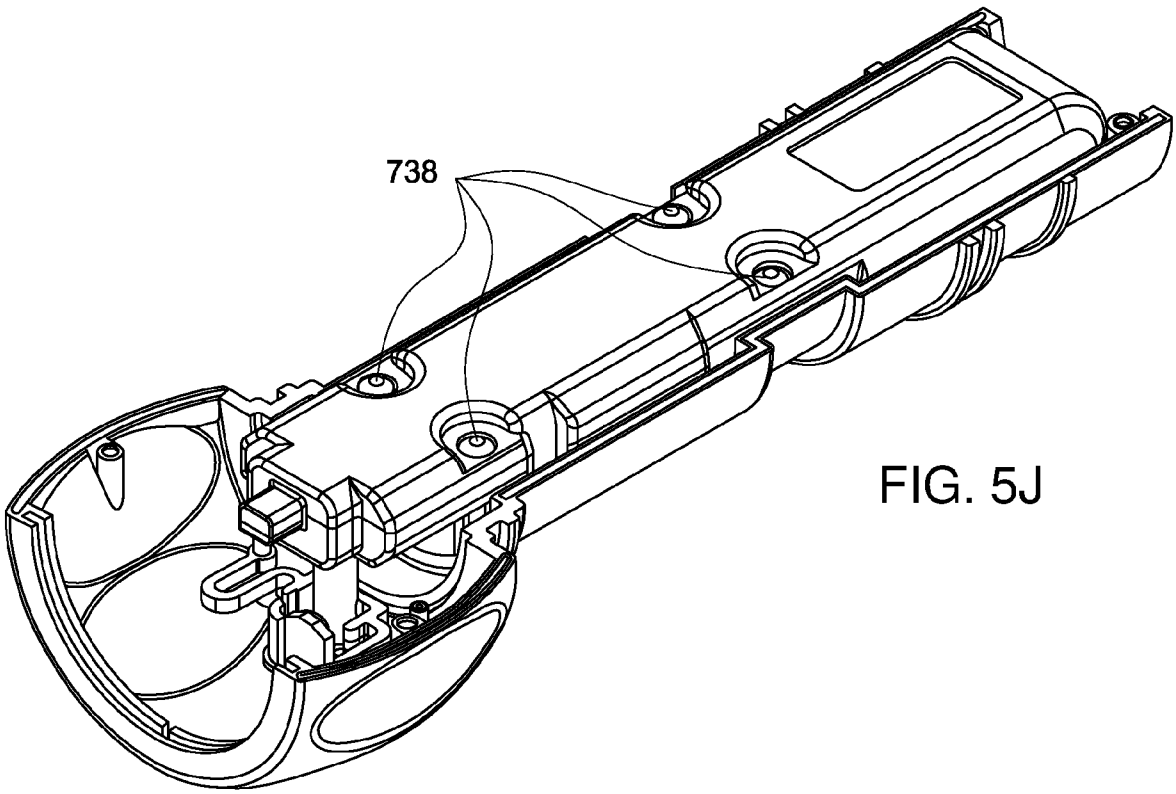


FIG. 5J

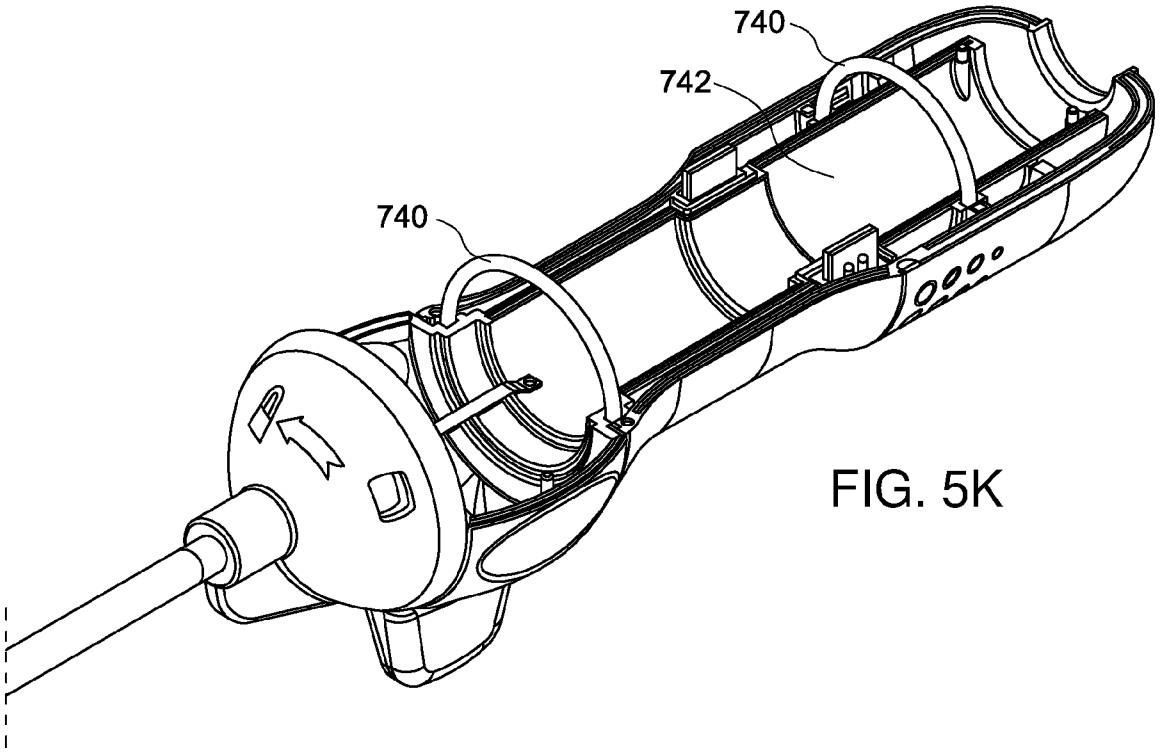


FIG. 5K

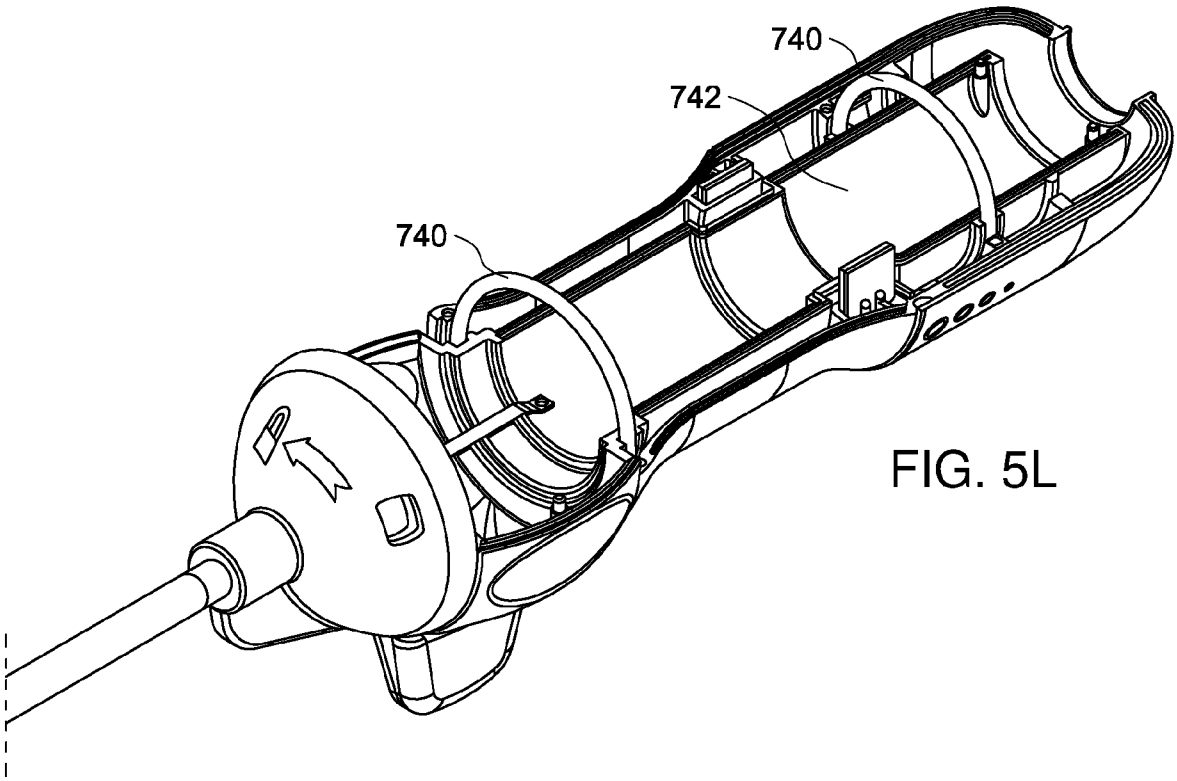


FIG. 5L

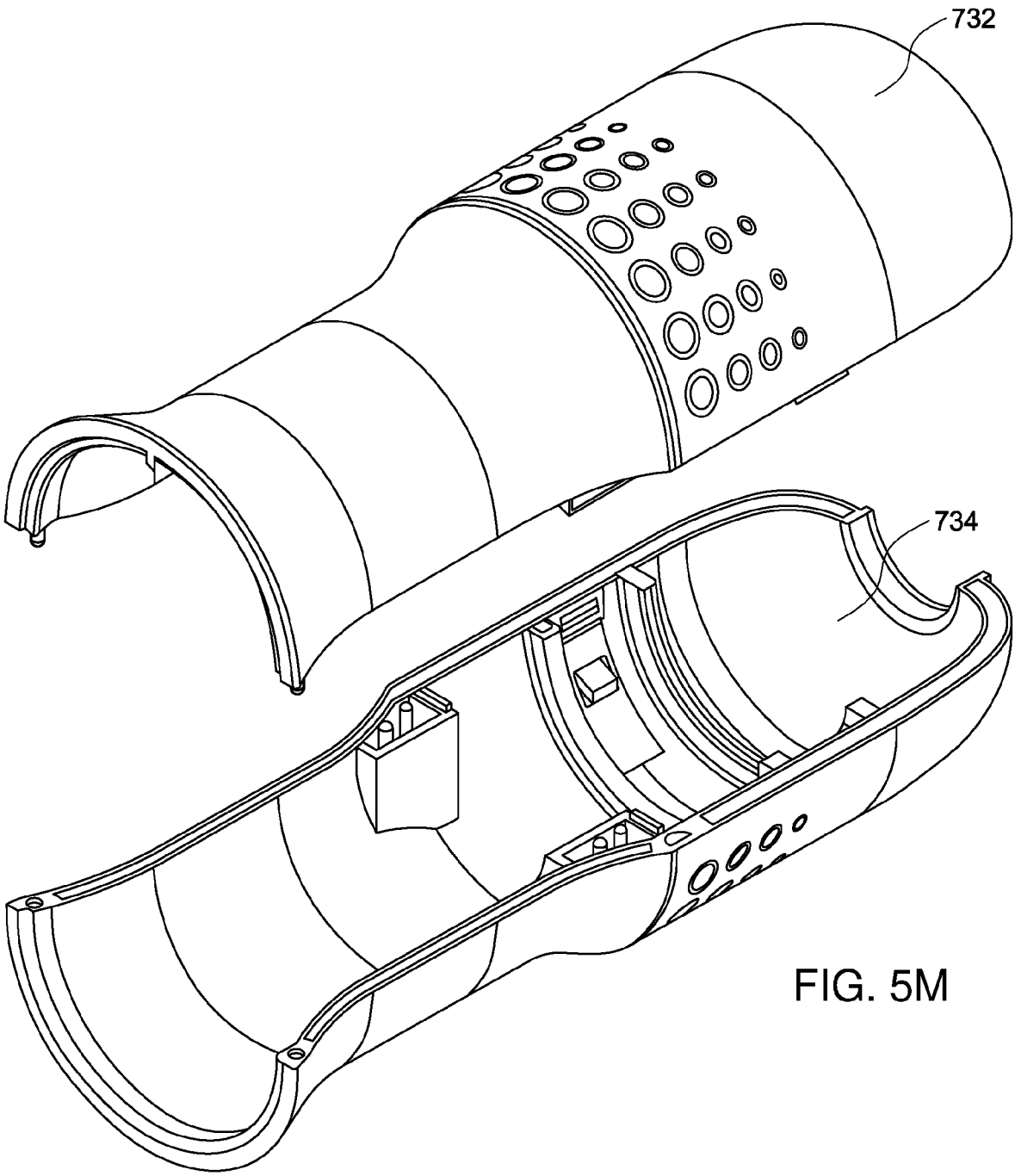


FIG. 5M

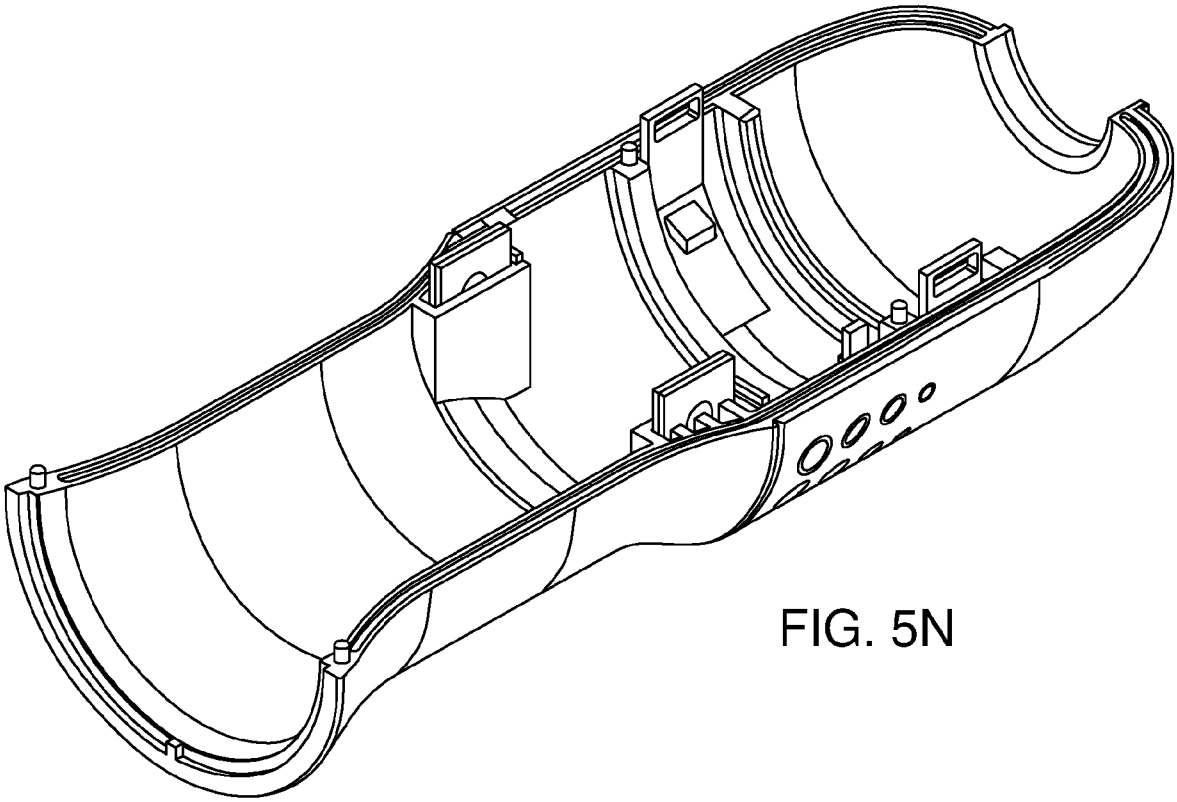


FIG. 5N

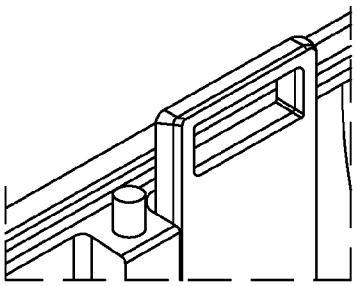


FIG. 5O

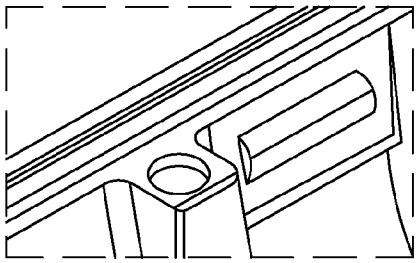


FIG. 5P

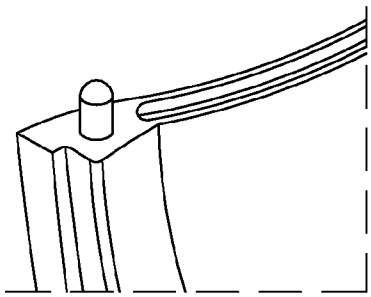


FIG. 5Q

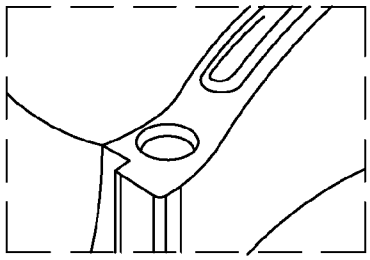


FIG. 5R

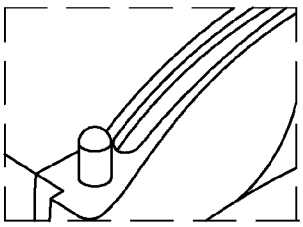


FIG. 5S

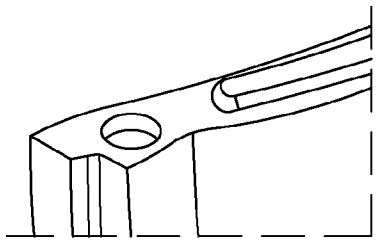


FIG. 5T

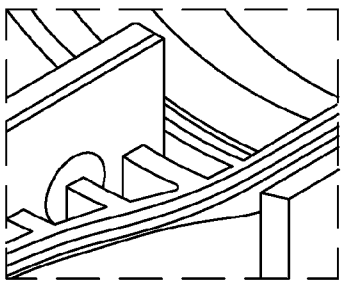


FIG. 5U

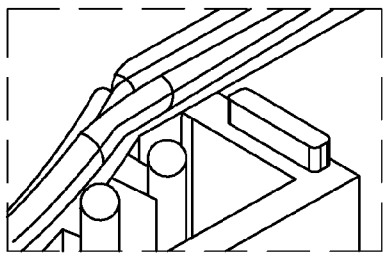


FIG. 5V

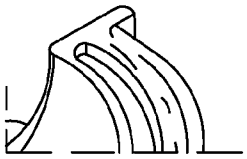


FIG. 5W

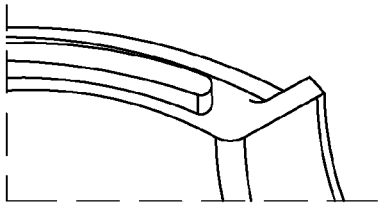


FIG. 5X

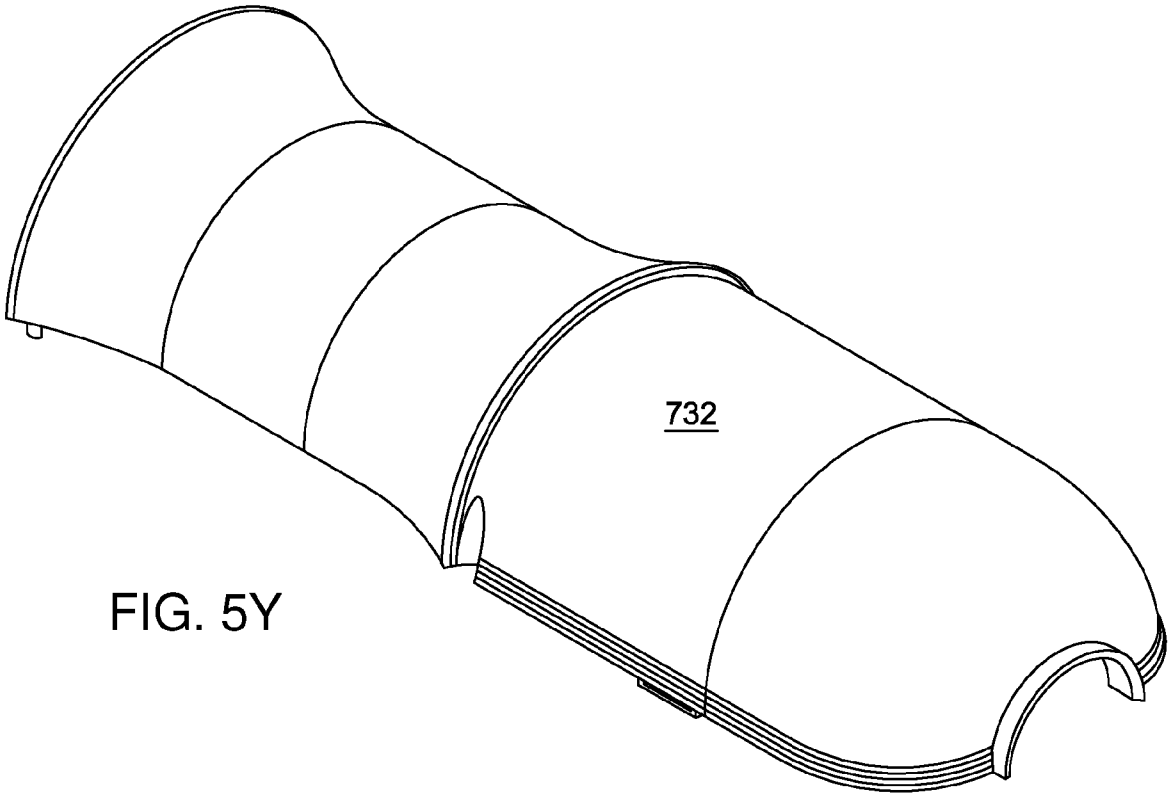


FIG. 5Y

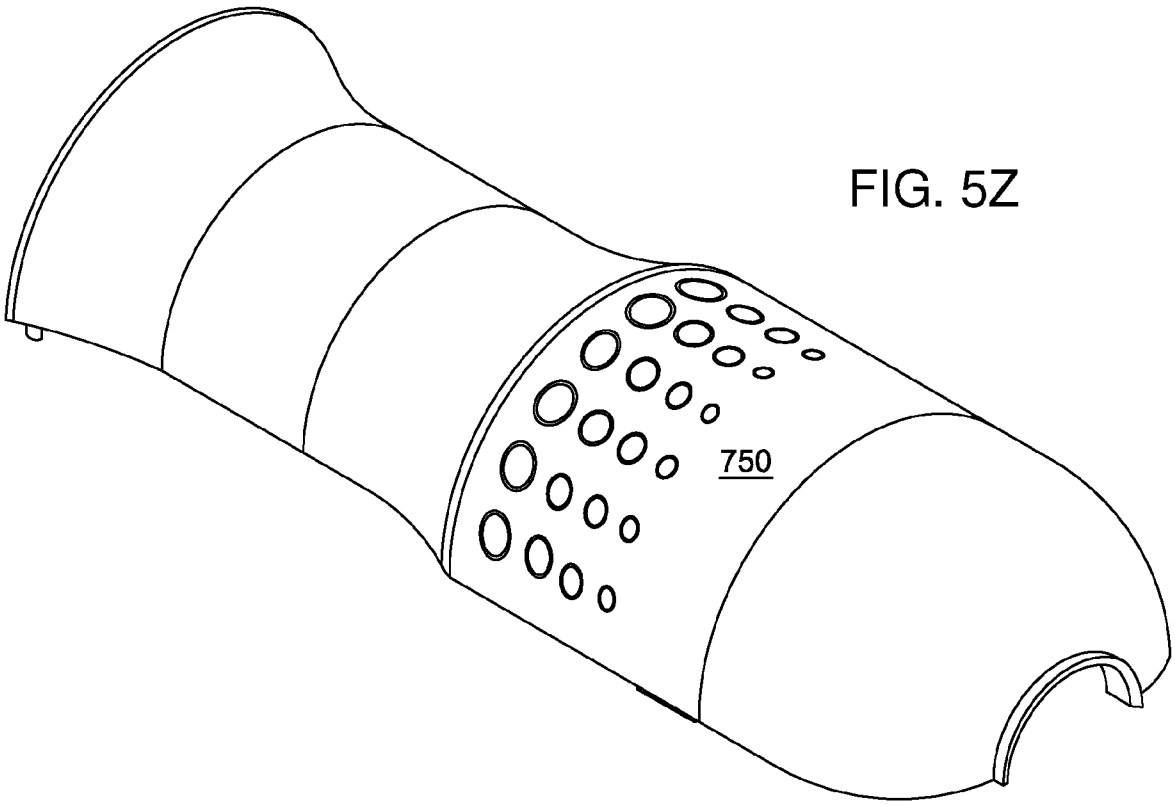


FIG. 5Z

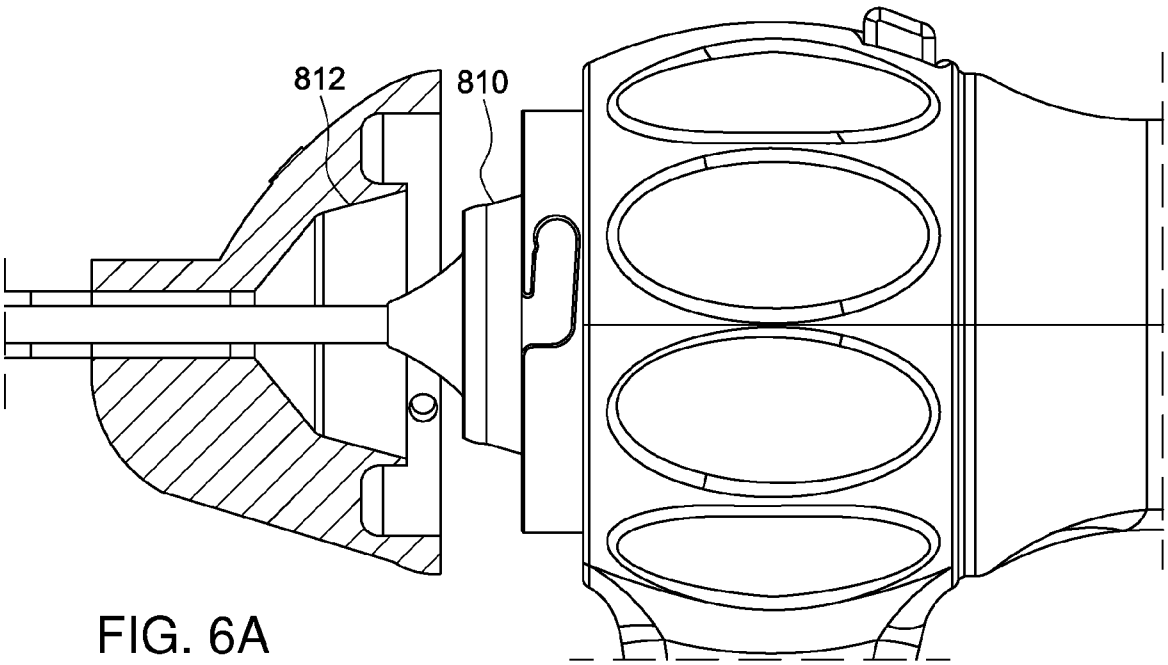


FIG. 6A

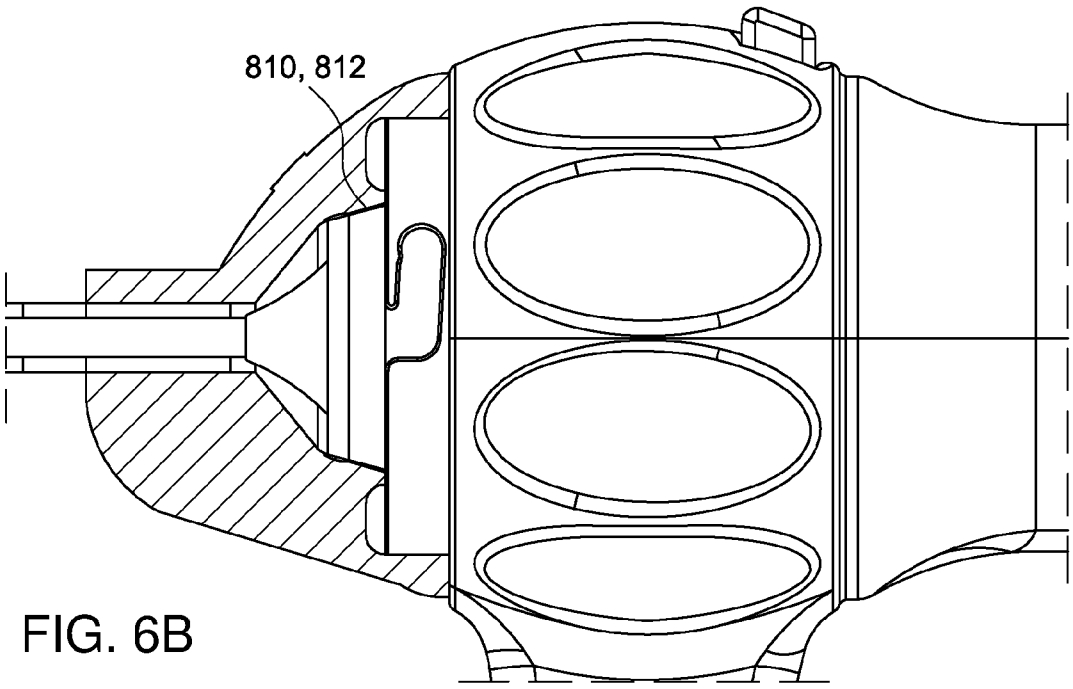


FIG. 6B

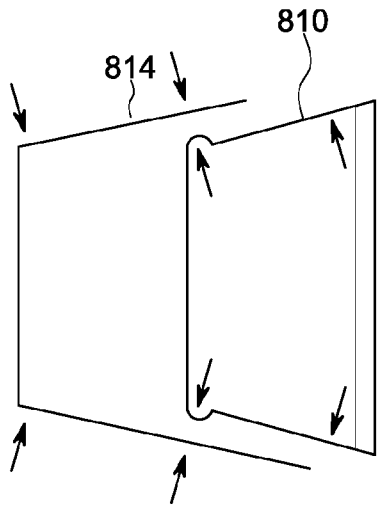


FIG. 6C

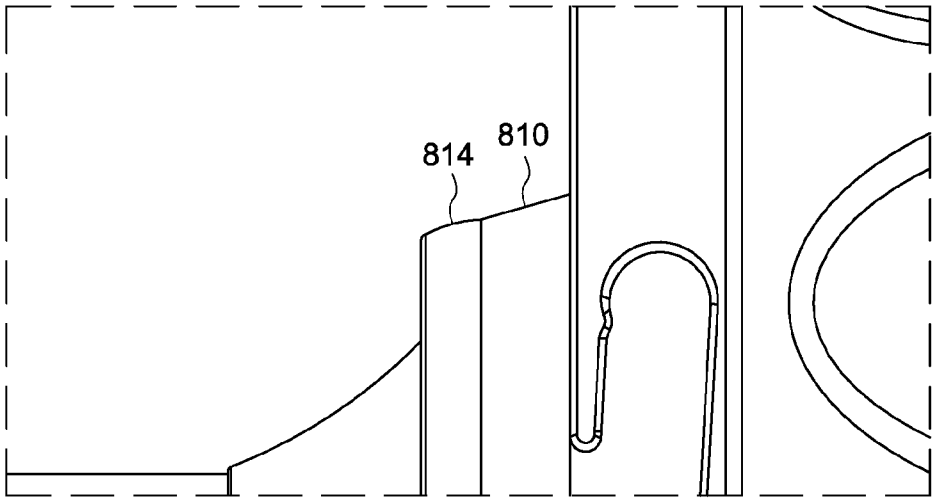


FIG. 6D

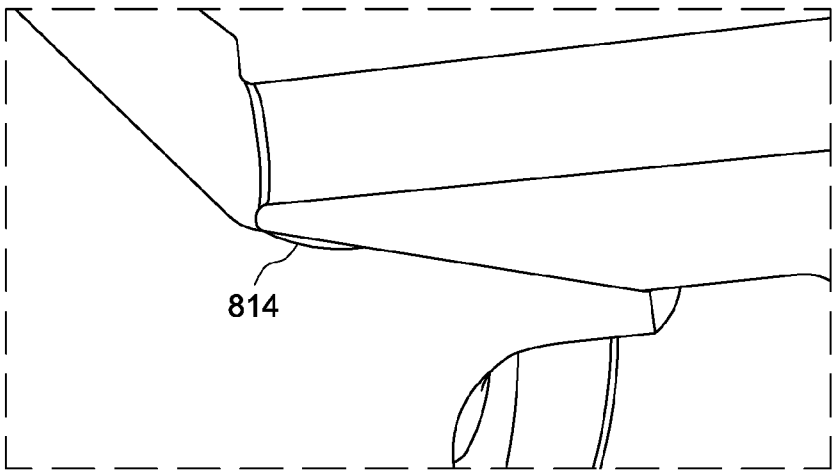


FIG. 6E

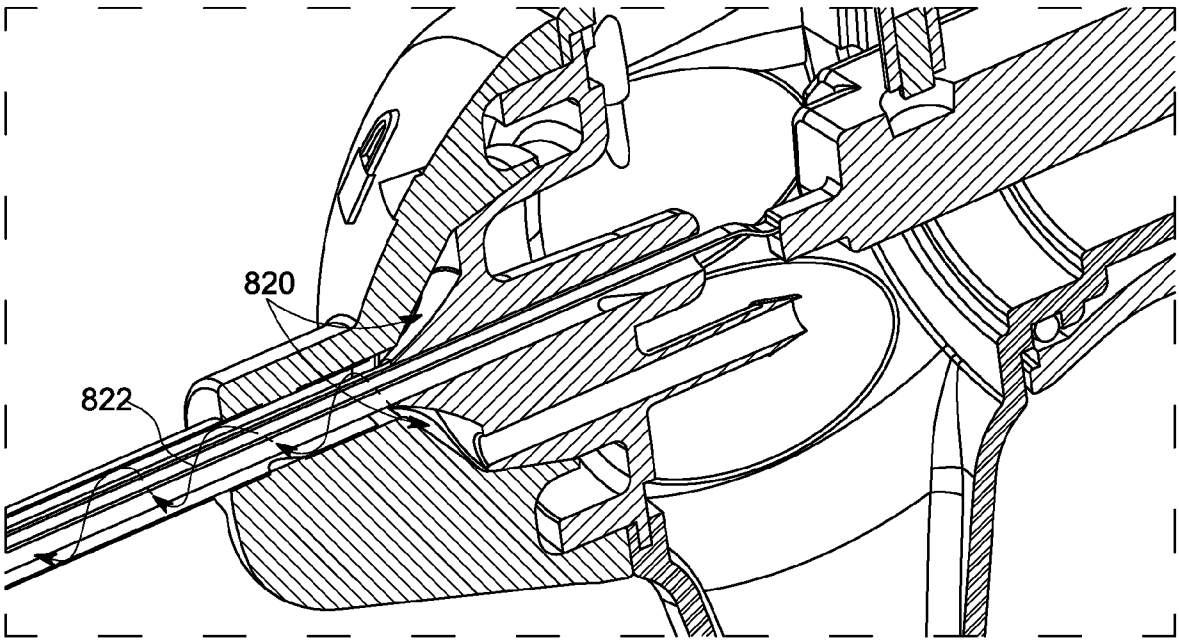


FIG. 6F

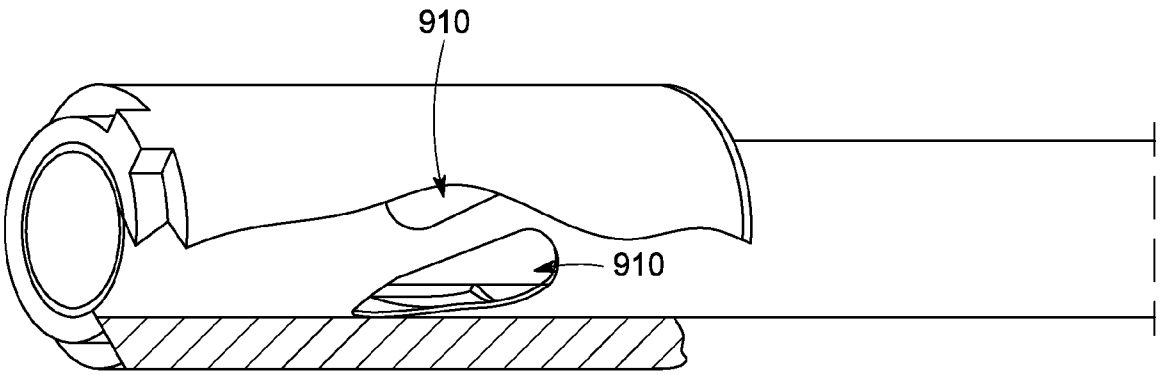


FIG. 7A

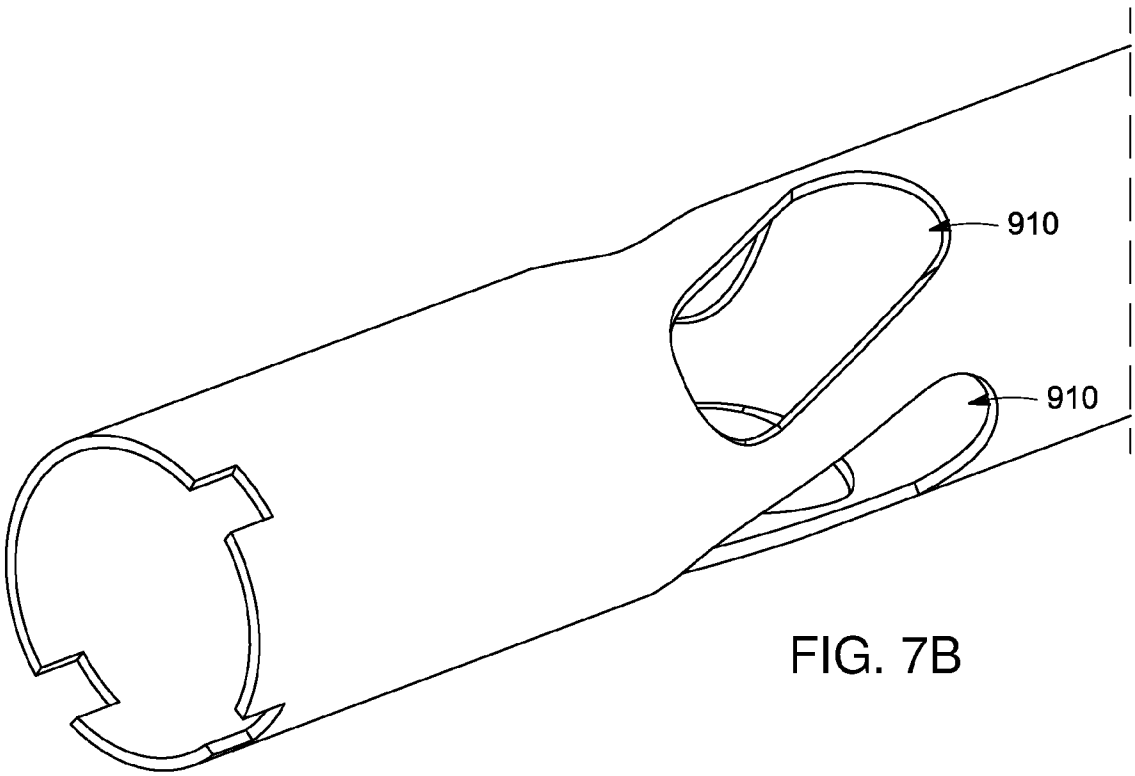


FIG. 7B

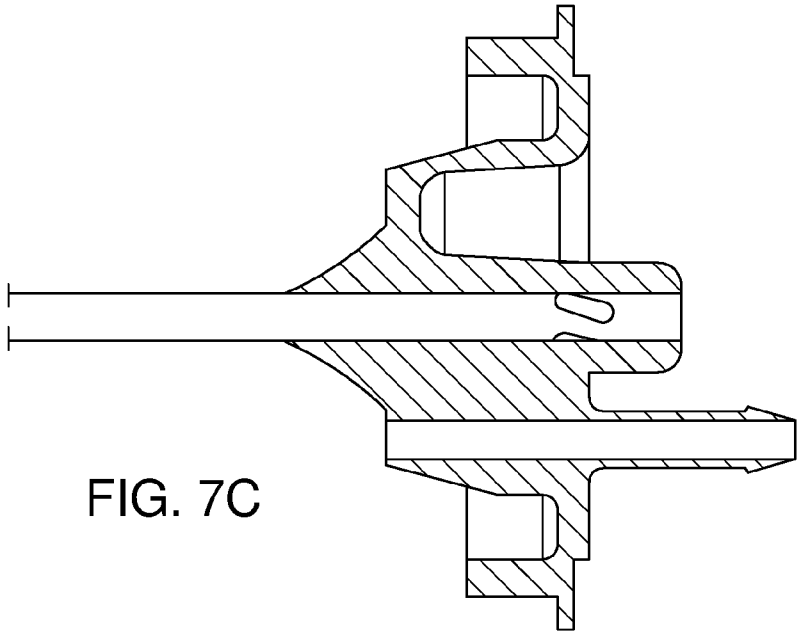


FIG. 7C

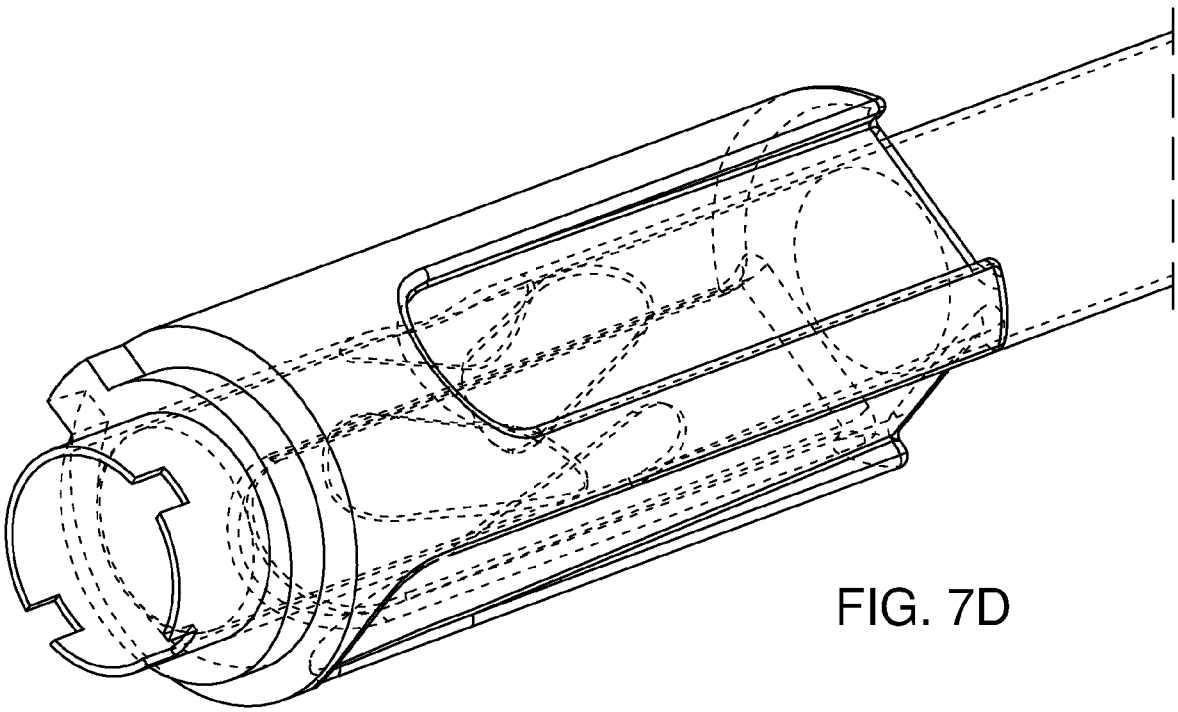


FIG. 7D

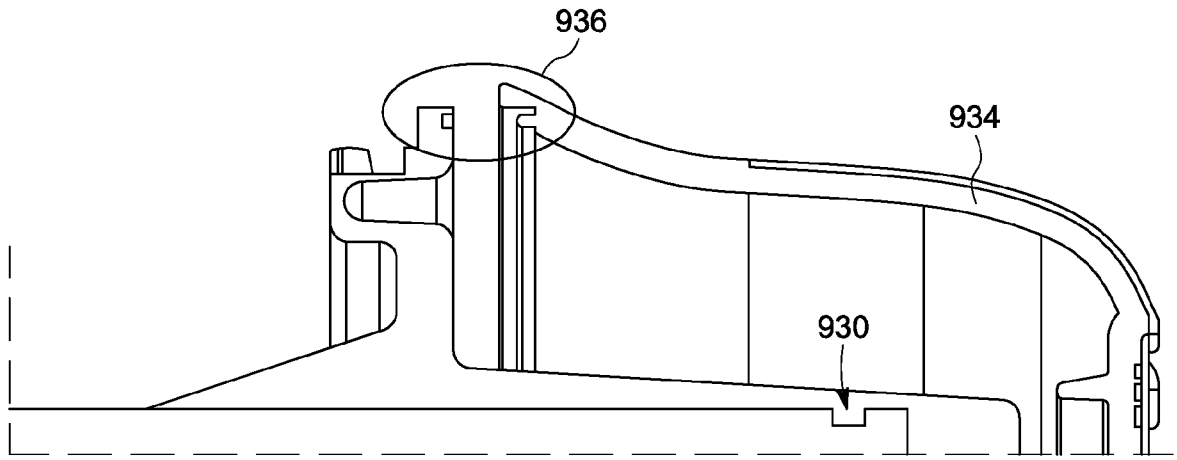


FIG. 7E

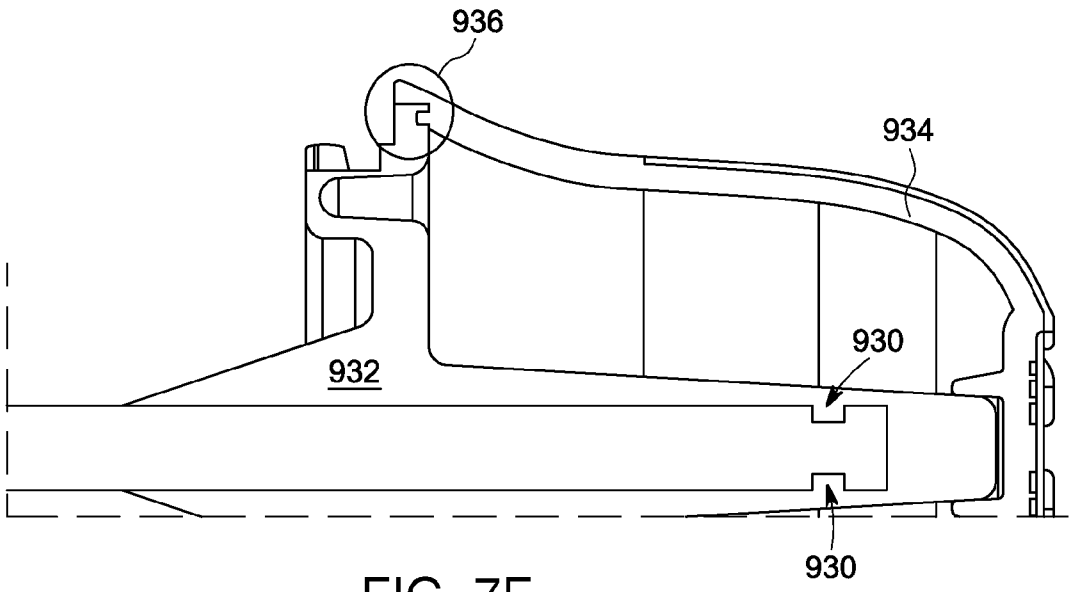


FIG. 7F

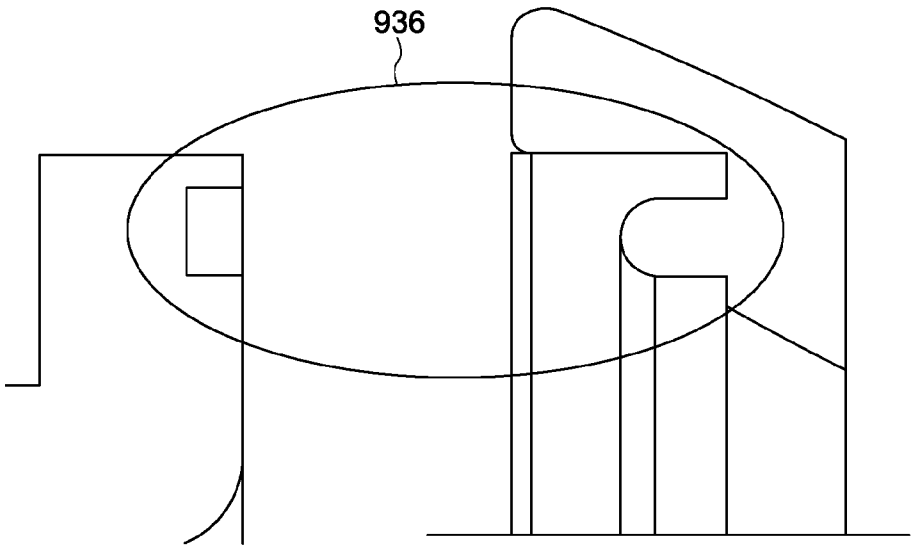


FIG. 7G

FIG. 7H

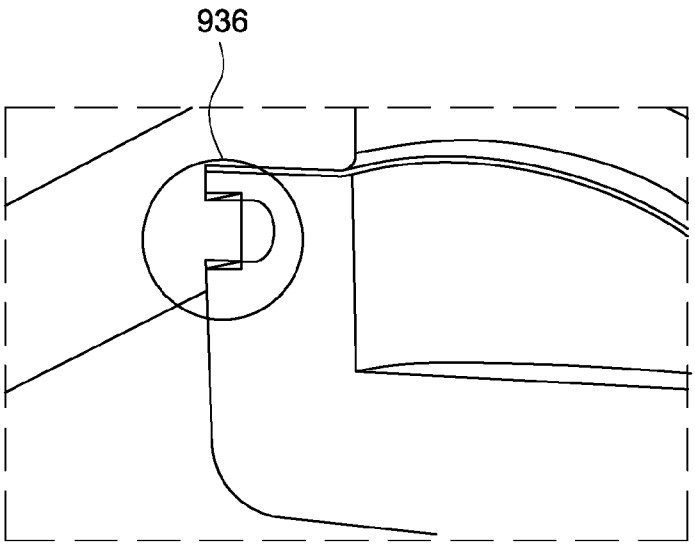


FIG. 7I

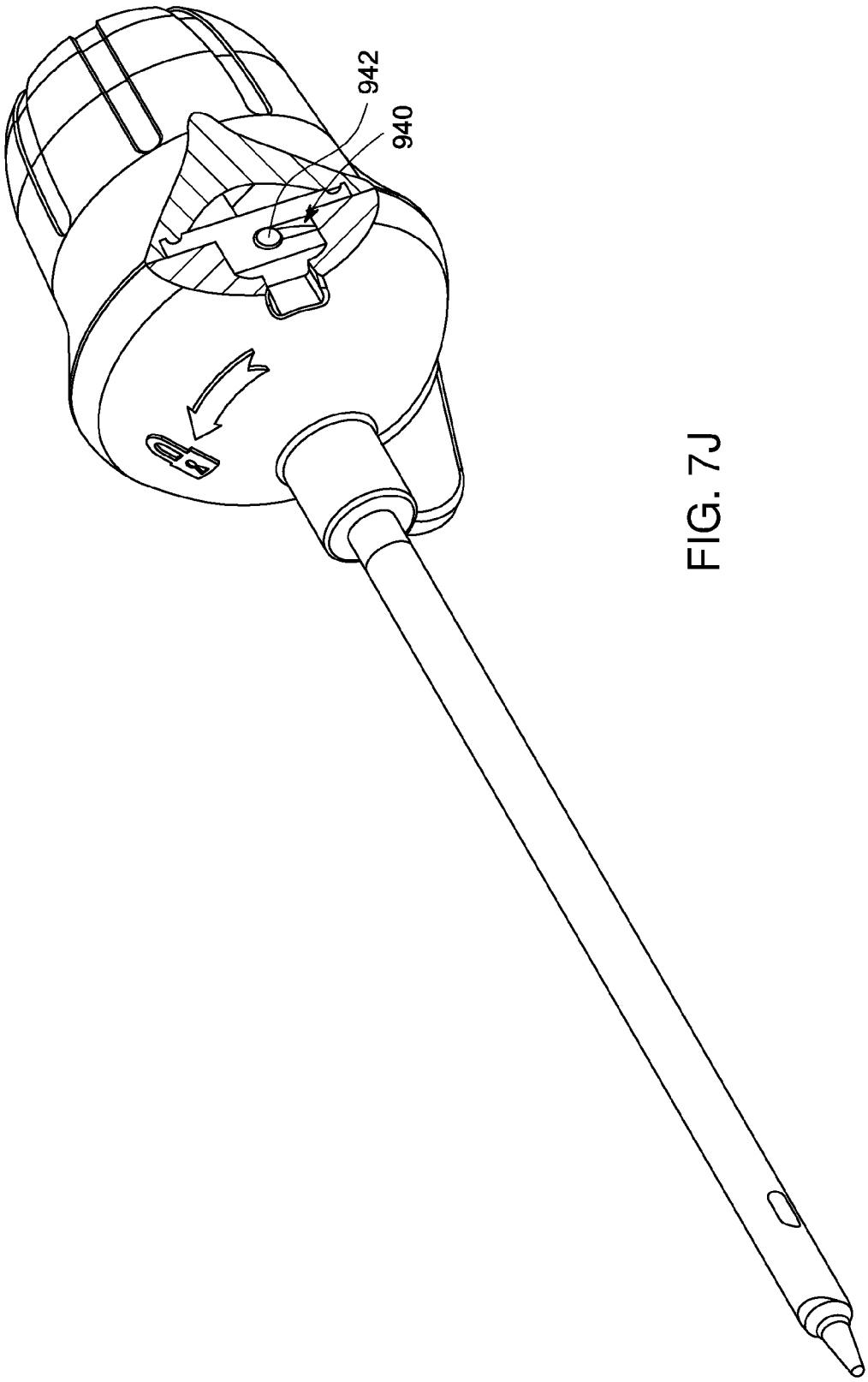


FIG. 7J

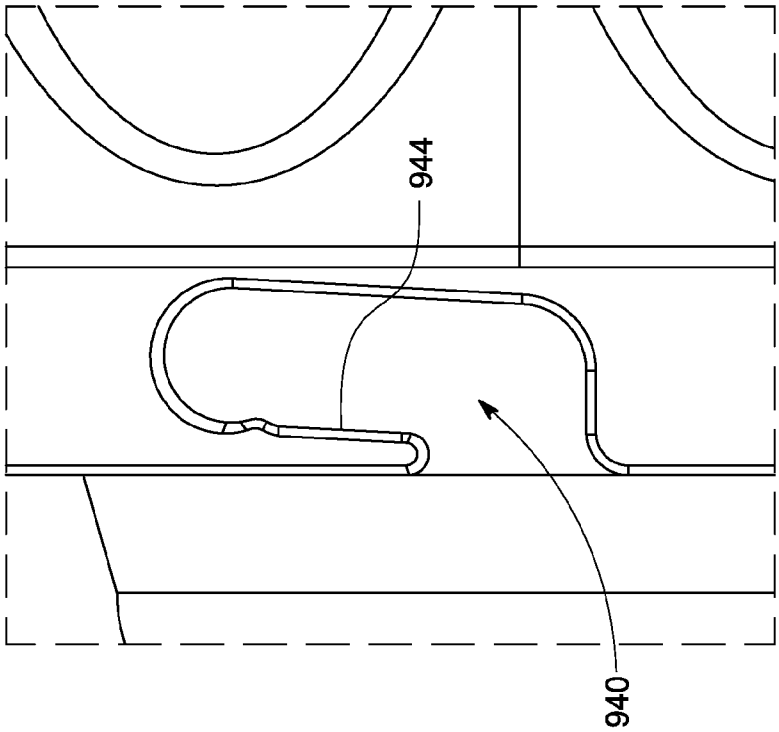


FIG. 7L

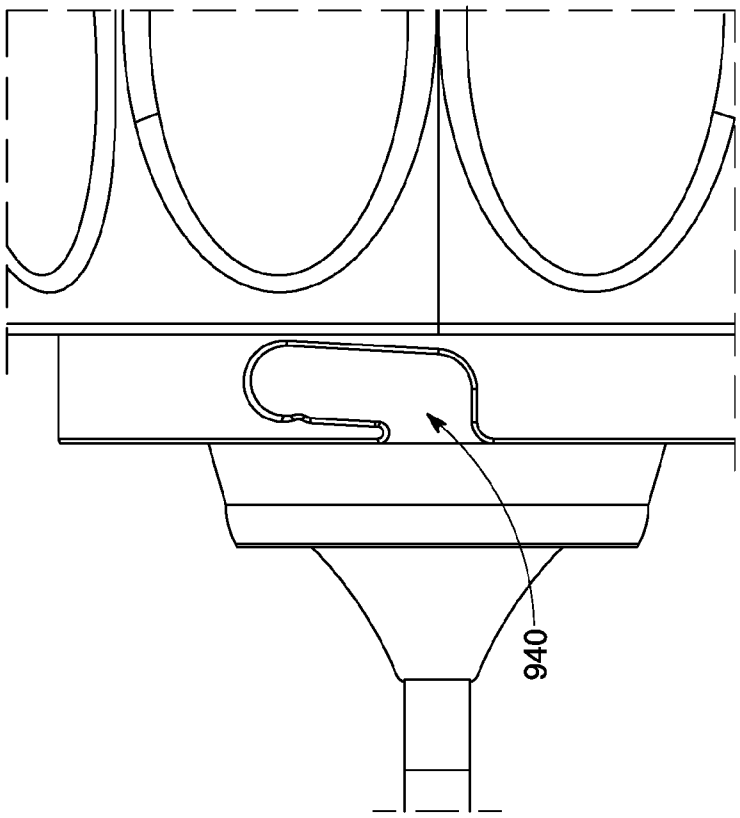


FIG. 7K

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2022/058030

A. CLASSIFICATION OF SUBJECT MATTER

A61B 1/00(2022.01)i; ***A61B 1/05***(2022.01)i; ***A61B 17/34***(2022.01)i
CPC:A61B 1/00066; A61B 1/00101; A61B 1/00105; A61B 1/00121; A61B 1/05; A61B 17/34

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 1/00; A61B 1/05; A61B 17/34
CPC:A61B 1/00066; A61B 1/00101; A61B 1/00105; A61B 1/00121; A61B 1/05; A61B 17/34

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)

Databases consulted: PatBase, Orbit, Similari (AI-based)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2019/0328217 A1 (DEKA PRODUCTS LTD. PARTNERSHIP [US])31 October 2019 (2019-10-31) paragraphs [0005], [0080], [0136], [0143], [0154], [0180], [0229]-[0237]; figures 3-5, 9B, 16-19, 23	1,4-7,13-18
X	US 2018/0168442 A1 (COOK MEDICAL TECHNOLOGIES LLC [US])21 June 2018 (2018-06-21) paragraphs [0002], [0070]-[0071], [0091], [0101], [0105], [0123]; figures 1-4, 7, 8	1,5-7
X	US 2019/0374095 A1 (PRISTINE SURGICAL LLC [US])12 December 2019 (2019-12-12) Abstract; paragraphs [[0015], [0027]; figures 1a,b, 4c	1,6,7
X	US 2020/0397232 A1 (KARL STORZ SE & CO. KG [DE])24 December 2020 (2020-12-24) paragraphs [0002], [0013], [0059]-[0063]; figure 1	1,6,7
A	WO 2021/161228 A1 (FISHER & PAYKEL HEALTHCARE LTD. [NZ])19 August 2021 (2021-08-19) the whole document	1-18

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"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
15 December 2022	**19 December 2022**

Name and mailing address of the ISA/IL
Israel Patent Office
Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel
Israel
Telephone No. **972-73-3927134**
Email: **pctoffice@justice.gov.il**

Authorized officer
SEGAL Liviu
Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2022/058030

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:

[0001] Invention/s 1 : Claim/s 1-7 : an endoscope, wherein the handle and its components being formed of biocompatible material and designed with no metal fasteners, no adhesives, and no detachable parts small enough to travel though fluid passages of the insertion shaft.

[0002] Invention/s 2 : Claim/s 8-12 : an endoscope, wherein the handle is formed of inner and outer shells concentric with each other.

[0003] Invention/s 3 : Claim/s 13-18 : an endoscope set comprising an endoscope, cannula and obturator.

[0004] The following separate inventions have been identified: Invention 1: Claims 1-7, which refer to an endoscope, wherein the handle and its components being formed of biocompatible material and designed with no metal fasteners, no adhesives, and no detachable parts small enough to travel though fluid passages of the insertion shaft. Invention 2: Claims 8-12, which refer to an endoscope, wherein the handle is formed of inner and outer shells concentric with each other. Invention 3: Claims 13-18, which refer to an endoscope set comprising an endoscope, cannula and obturator. The common matter between said inventions is an endoscope having a handle and an insertion shaft with a camera at its distal end, the handle having retained within a circuit board for control of and receipt signals from the camera. Devices showing these features are, however, well-known in the field (see for example, documents D1-D4). In conclusion, the claimed inventions are not linked by common or corresponding special technical features and define 3 different inventions not linked by a single inventive concept. Consequently, the requirement of unity is not fulfilled, according to Rules 13 PCT.

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 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.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2022/058030

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2019/0328217 A1	31 October 2019	US 2019328217 A1	31 October 2019
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		US 2021007584 A1	14 January 2021
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		CN 115397344 A	25 November 2022