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Garcia et al.

(54) **PORTABLE ENDOSCOPE FOR DIVERSE MEDICAL DISCIPLINES**

(75) Inventors: **Alexander M. Garcia**, Street, MD (US); **Karl Dallas Kirk, III**, New York City, NY (US); **Paul J. Mulhauser**, New York City, NY (US); **Lyndon Thomas Treacy**, Long Island City, NY (US)

Correspondence Address:
Ashok Tankha
36 Greenleigh Drive
Sewell, NJ 08080

(73) Assignee: **CANI Optical Systems, LLC**

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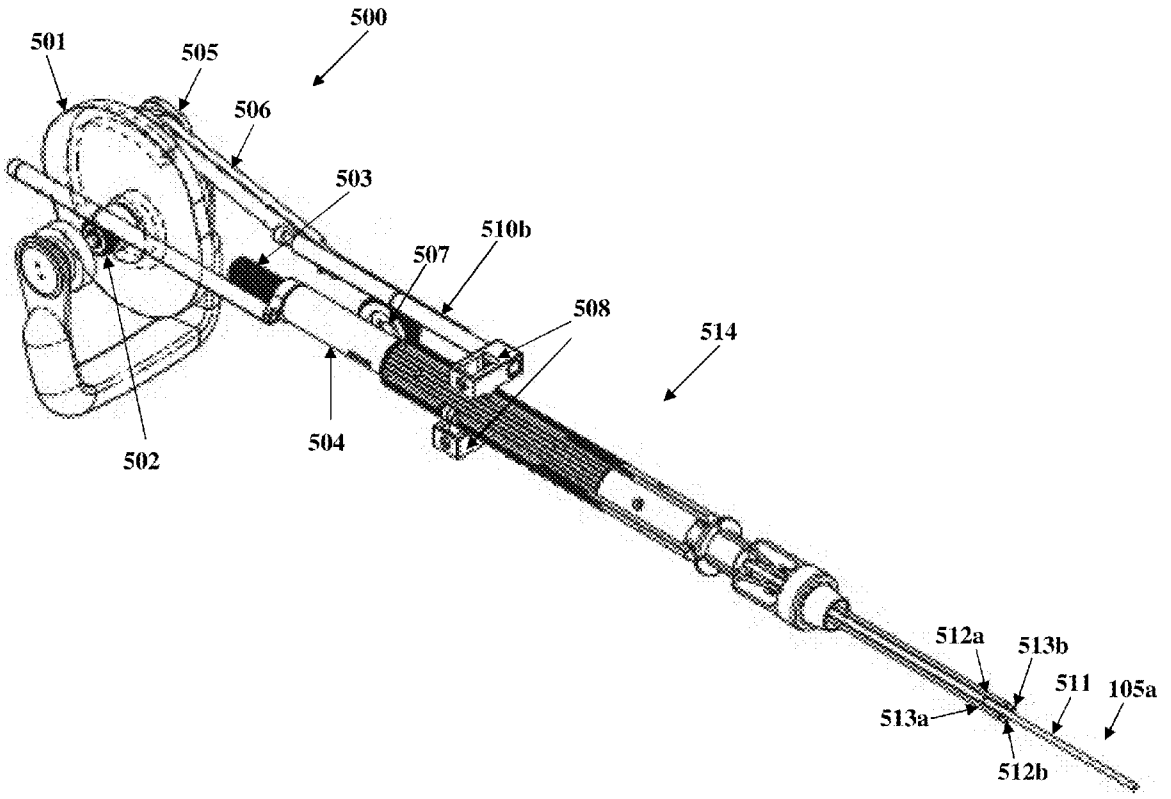
(57) **ABSTRACT**

Disclosed herein is a portable endoscope and kit for performing multiple medical procedures. The portable endoscope comprises a detachable operator control section assembly and one of multiple detachable and interchangeable flexible insertion shaft assemblies with a flexible distal end. The proximal end of a detachable and interchangeable flexible insertion shaft assembly is detachably connected to the detachable operator control section assembly. The detachable and interchangeable flexible insertion shaft assembly accommodates principal cable wires, proxy cable wires, an optical imaging system, and an illumination system. An internal cable wire control system integrated with the detachable operator control section assembly utilizes an adaptable drive transmission system for controlling the orientation and angular position of the flexible distal end using the principal cable wires or the proxy cable wires. The proxy cable wires may be engaged in an event of failure of the principal cable wires.



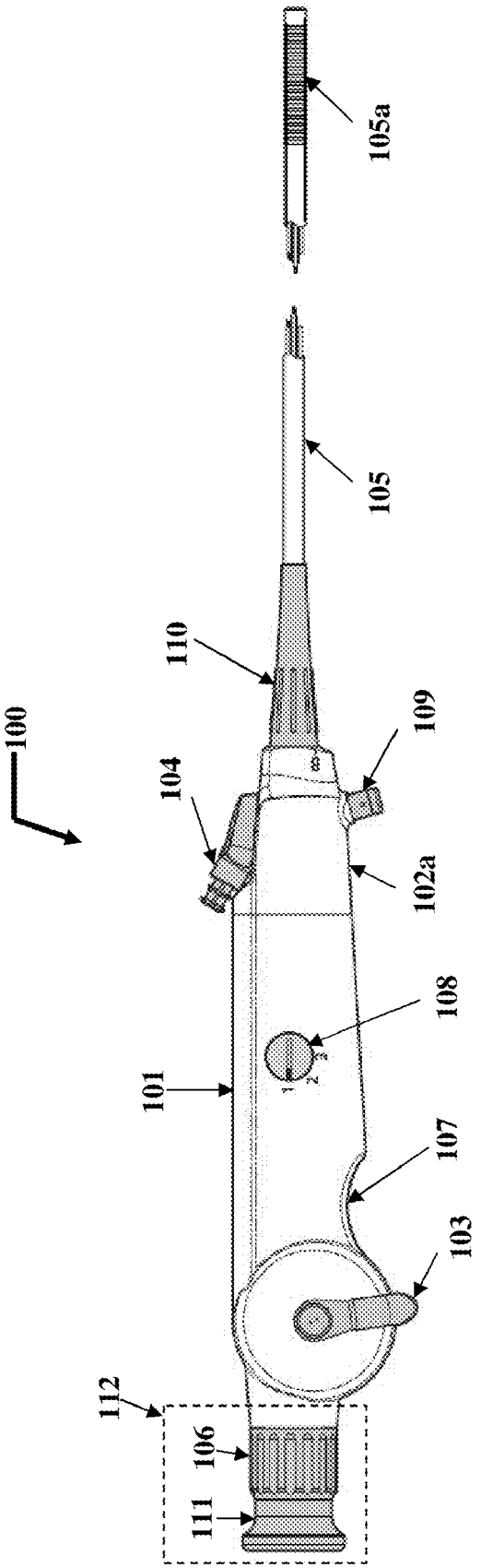


FIG. 1

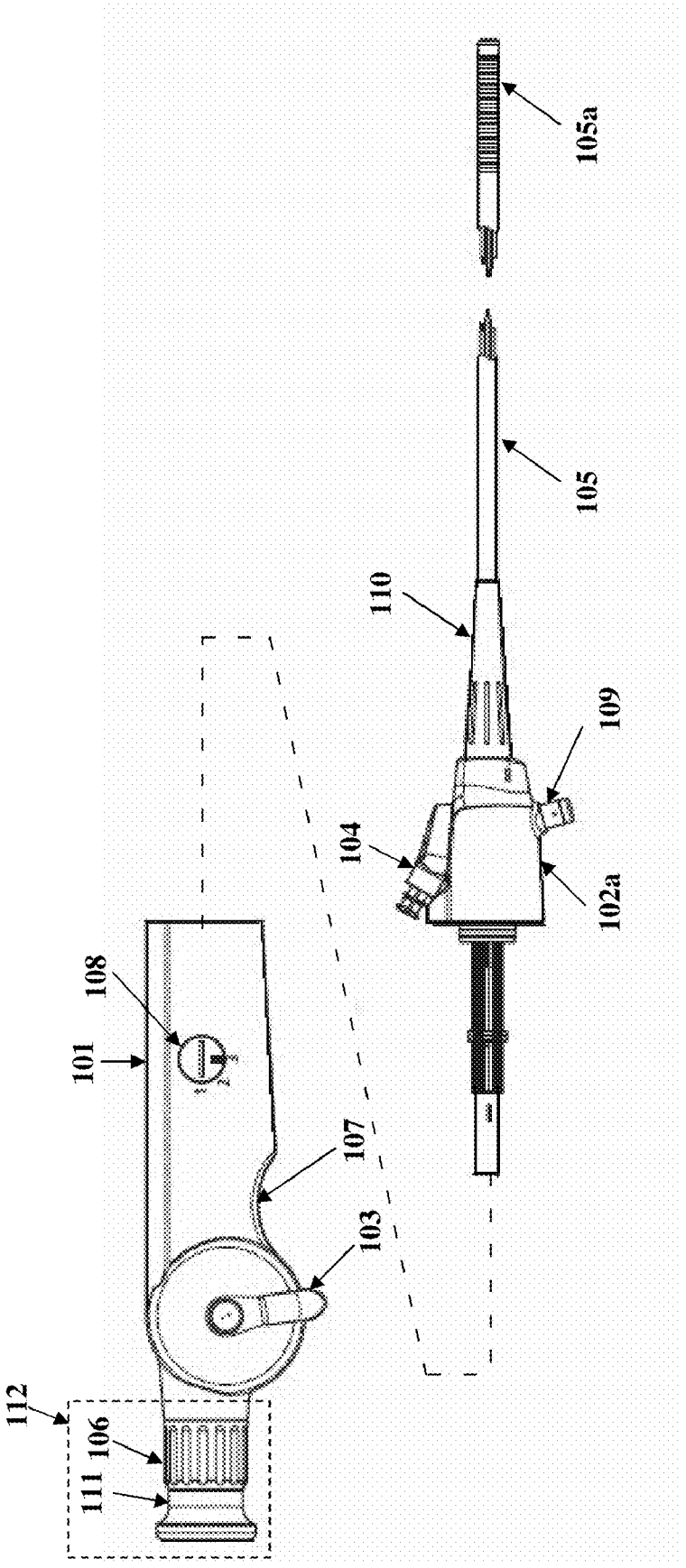


FIG. 2

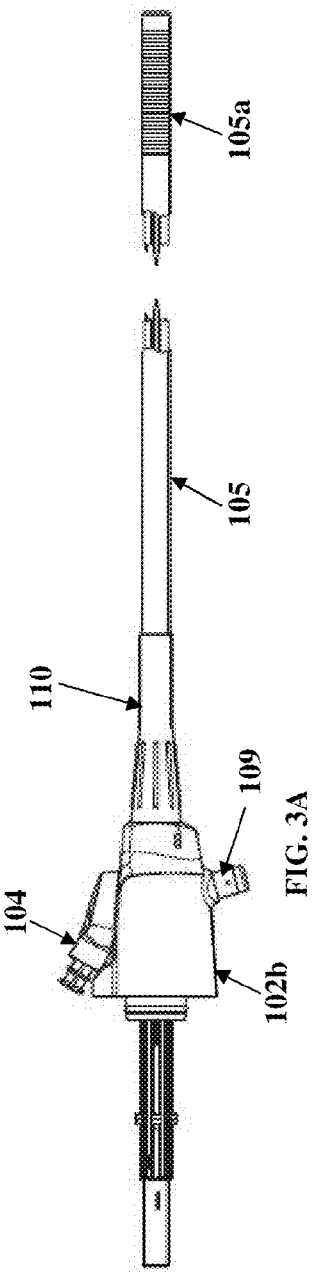


FIG. 3A

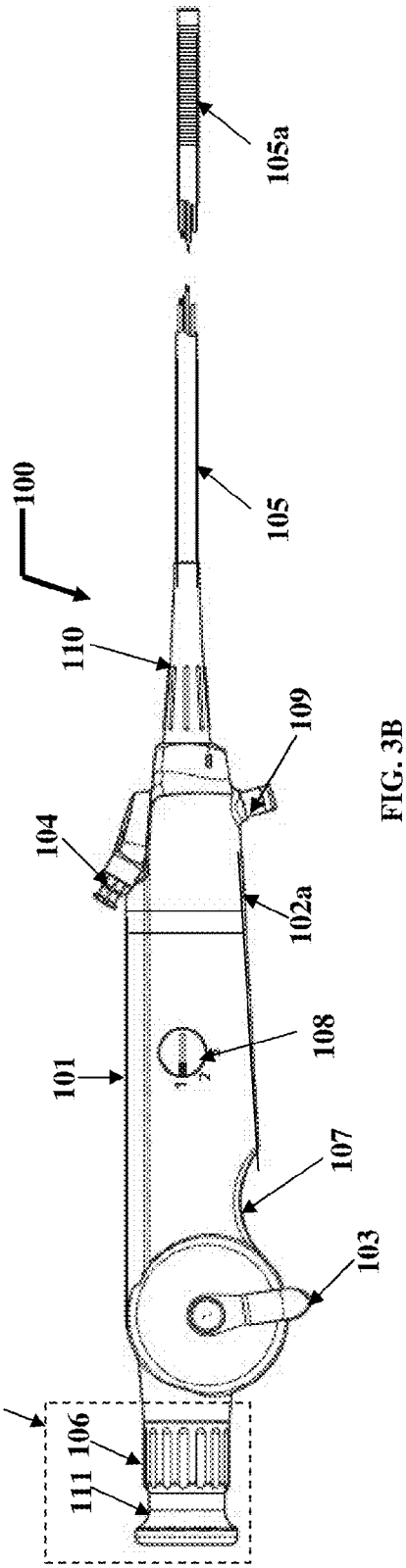


FIG. 3B

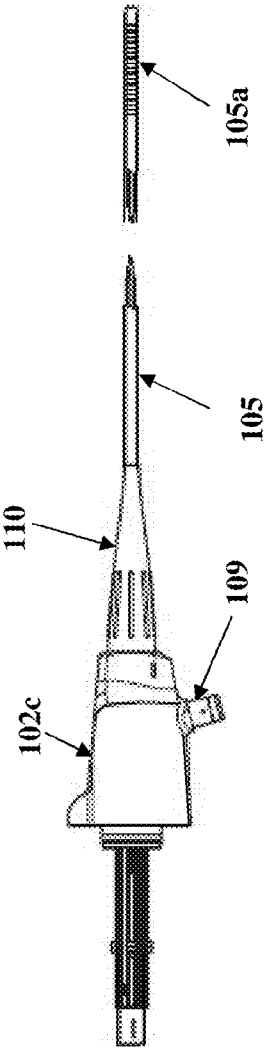
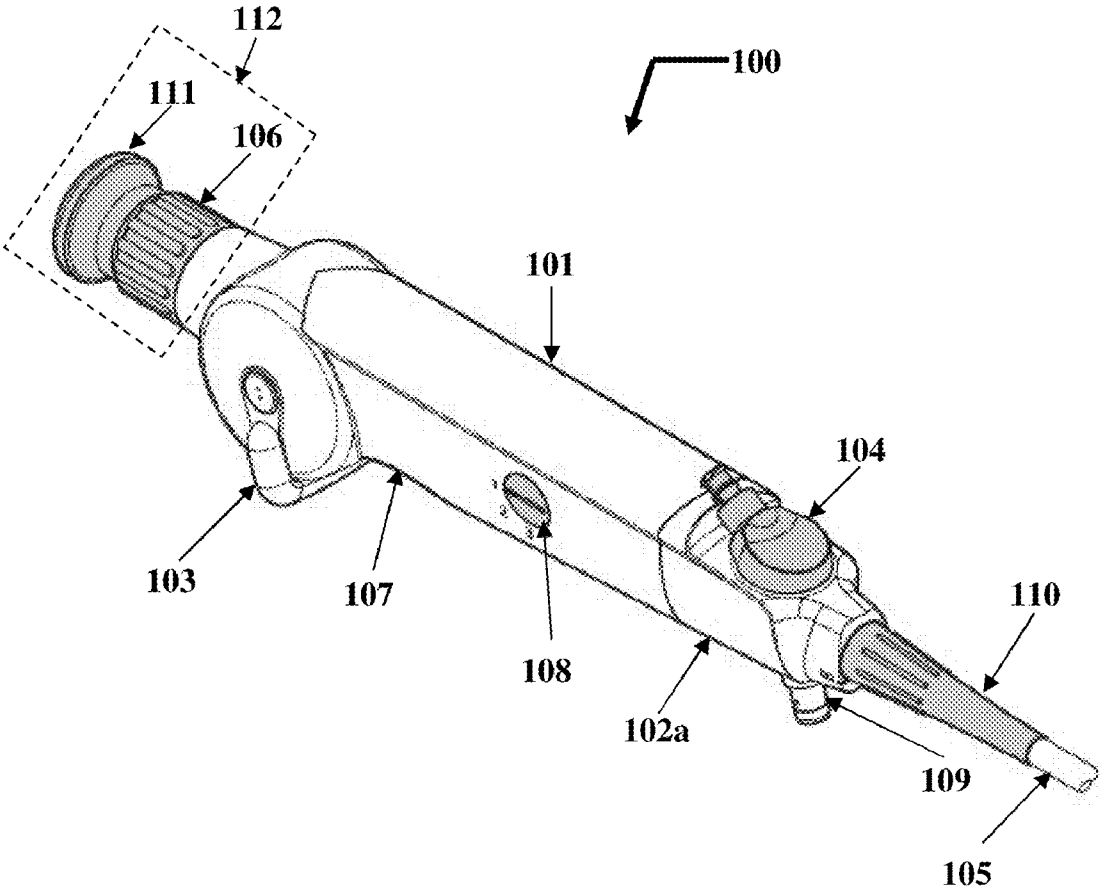


FIG. 3C



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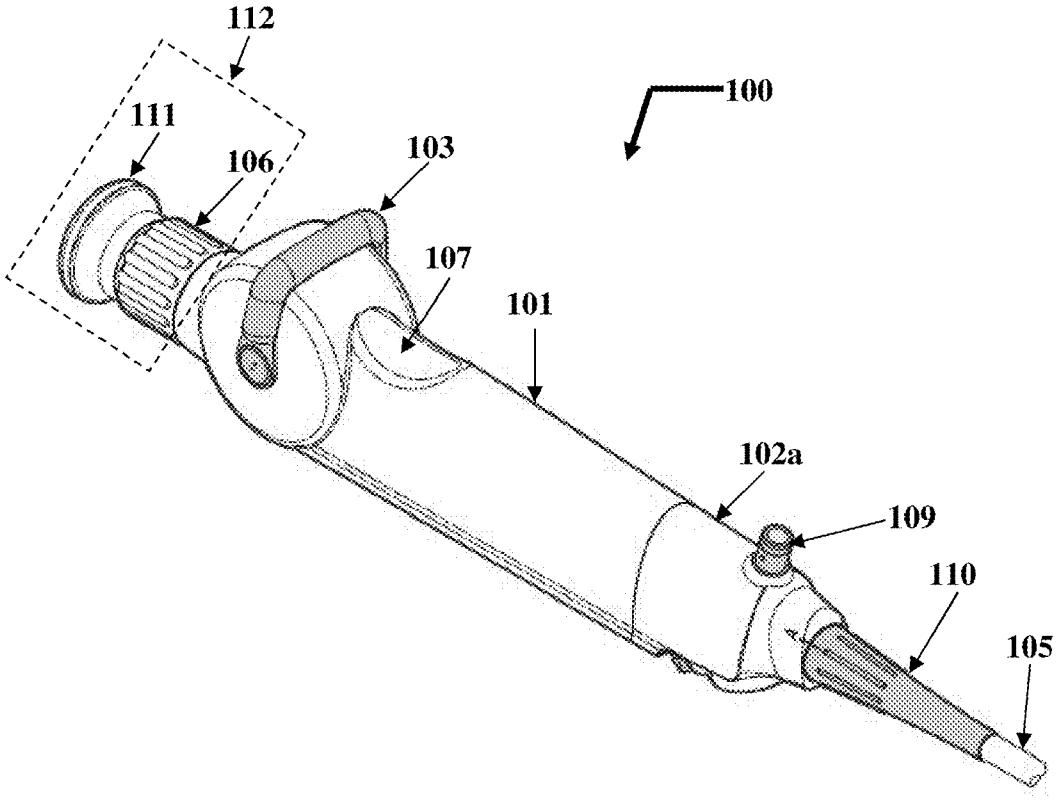
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FIG. 4B

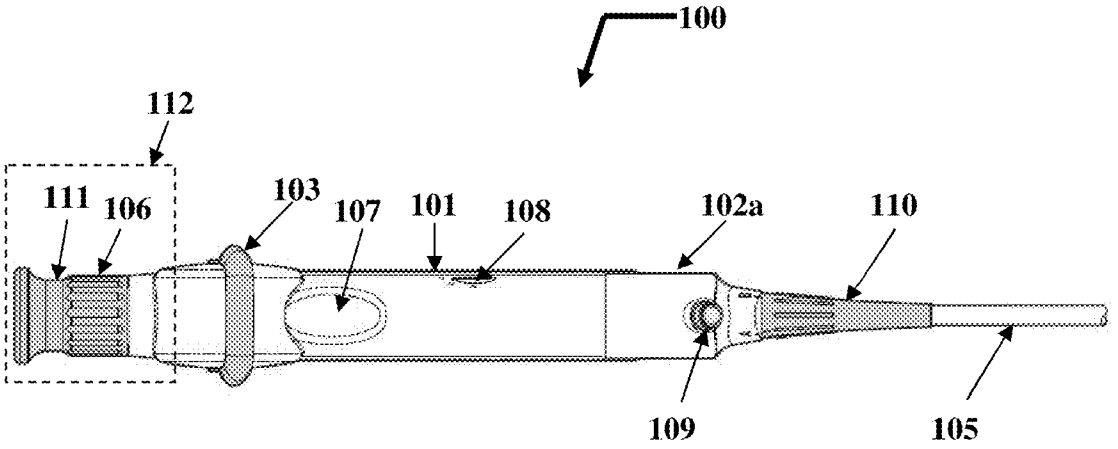
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FIG. 4C

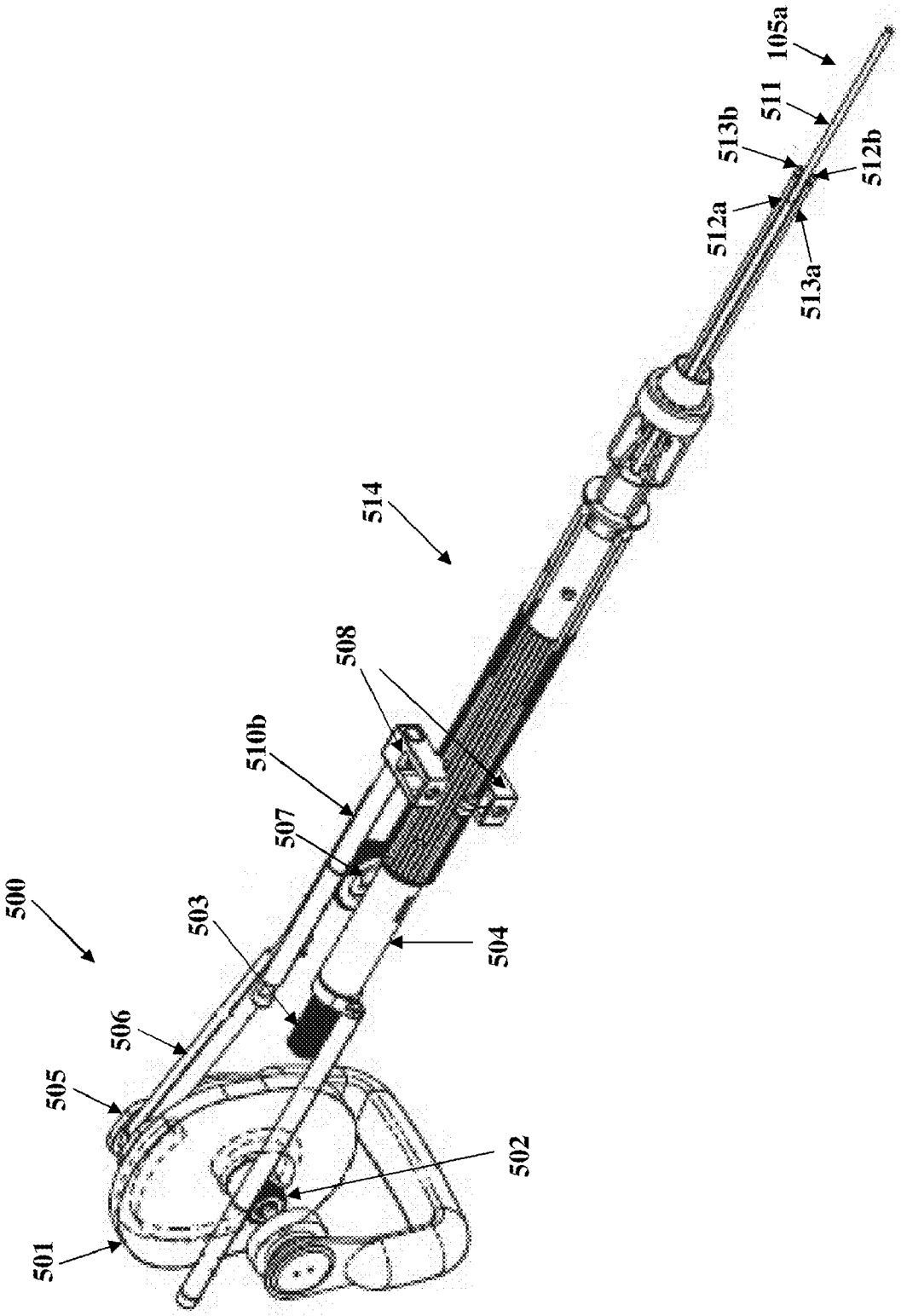
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FIG. 5A

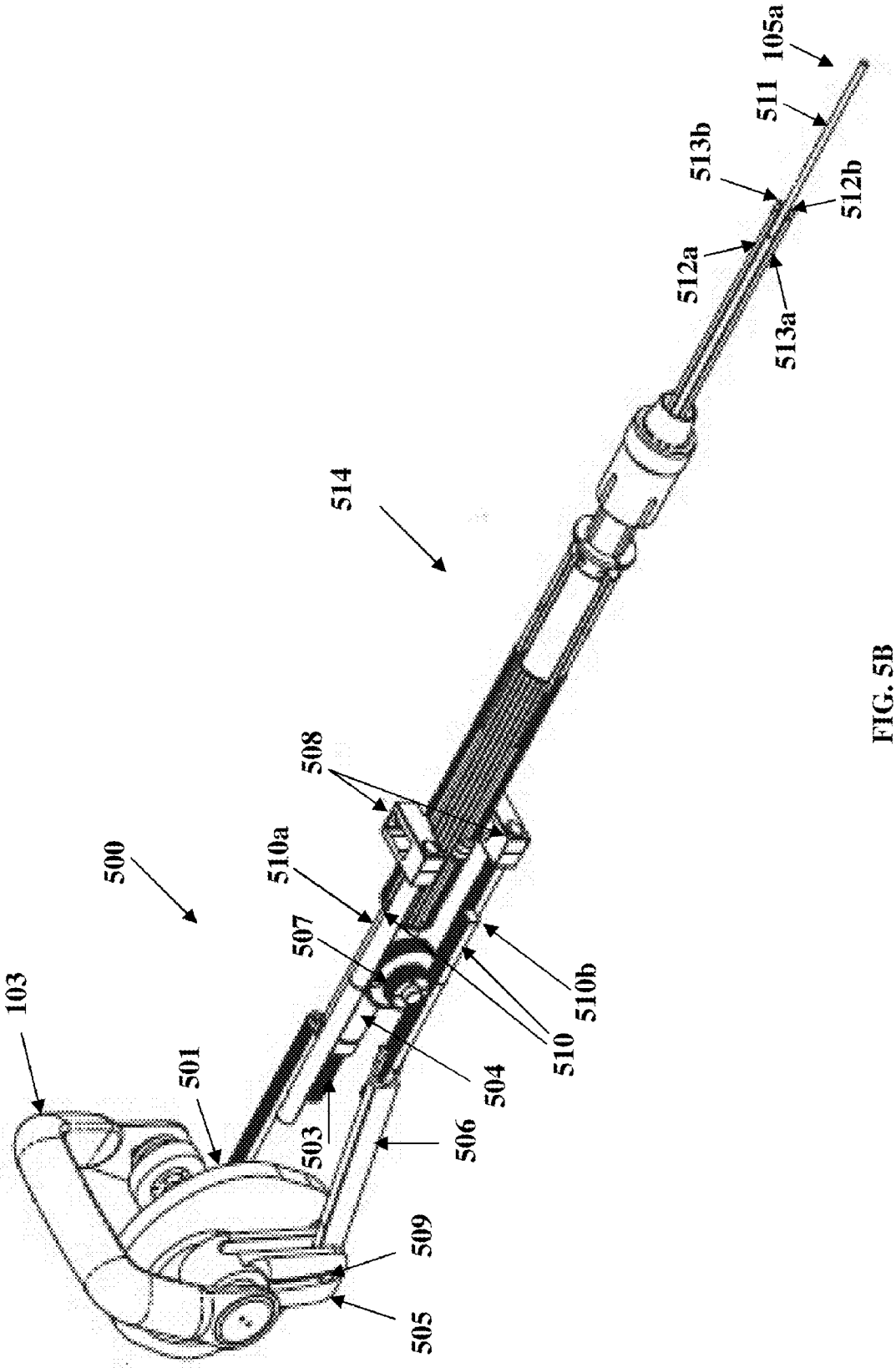
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FIG. 5B

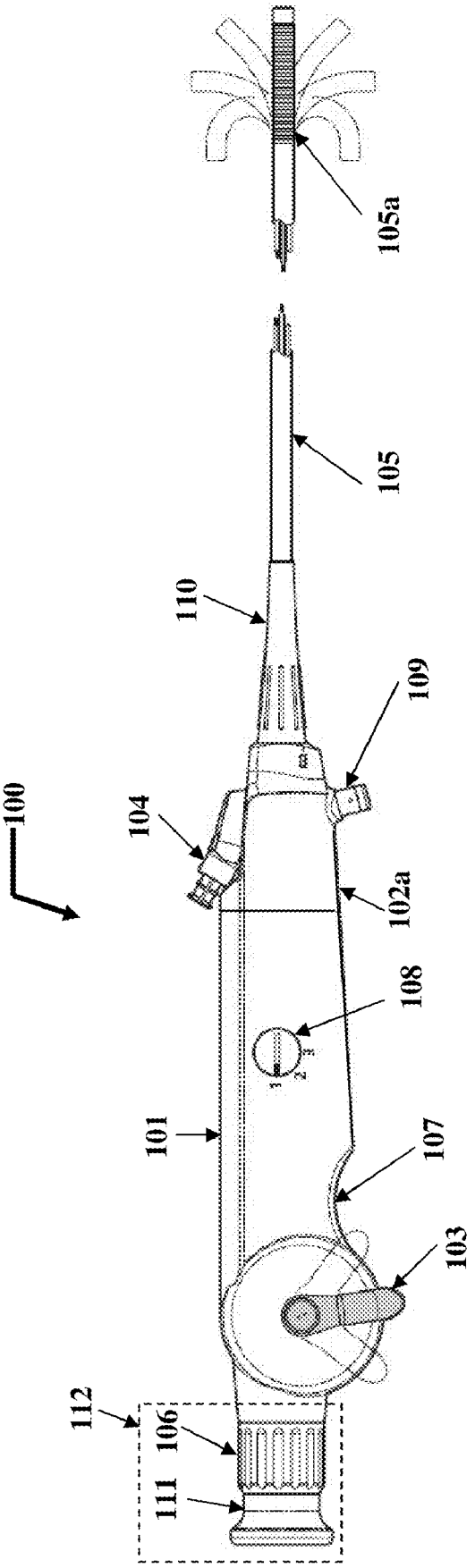

FIG. 6

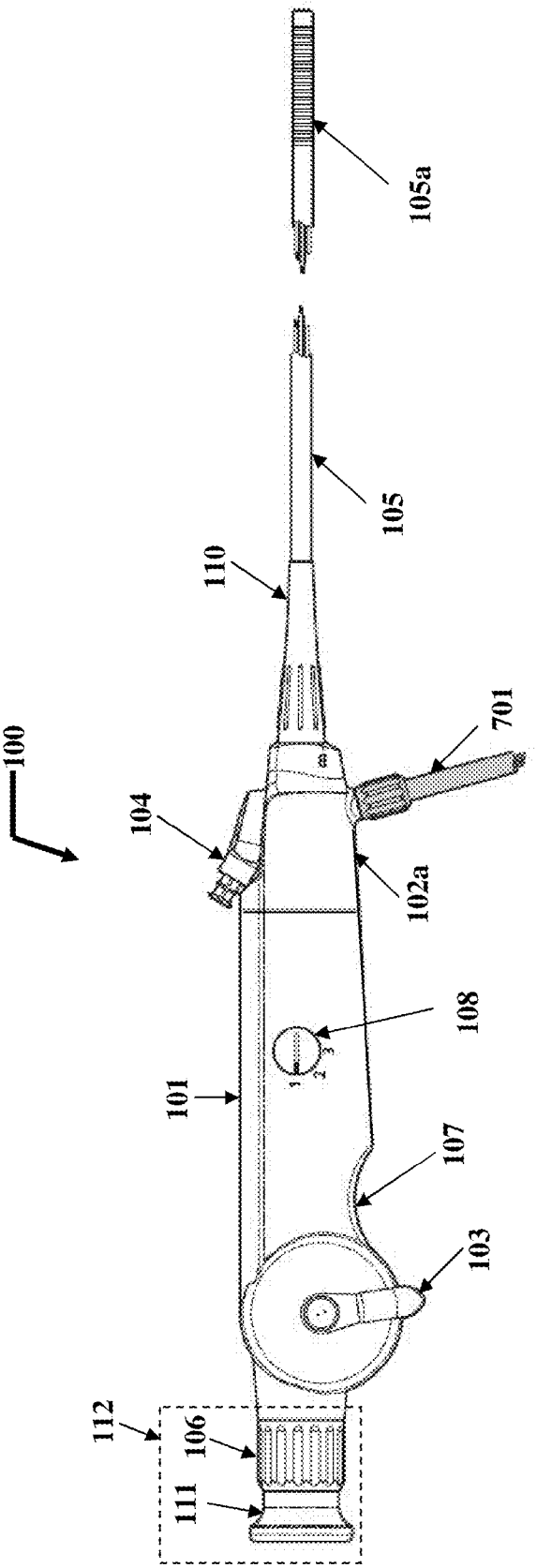

FIG. 7

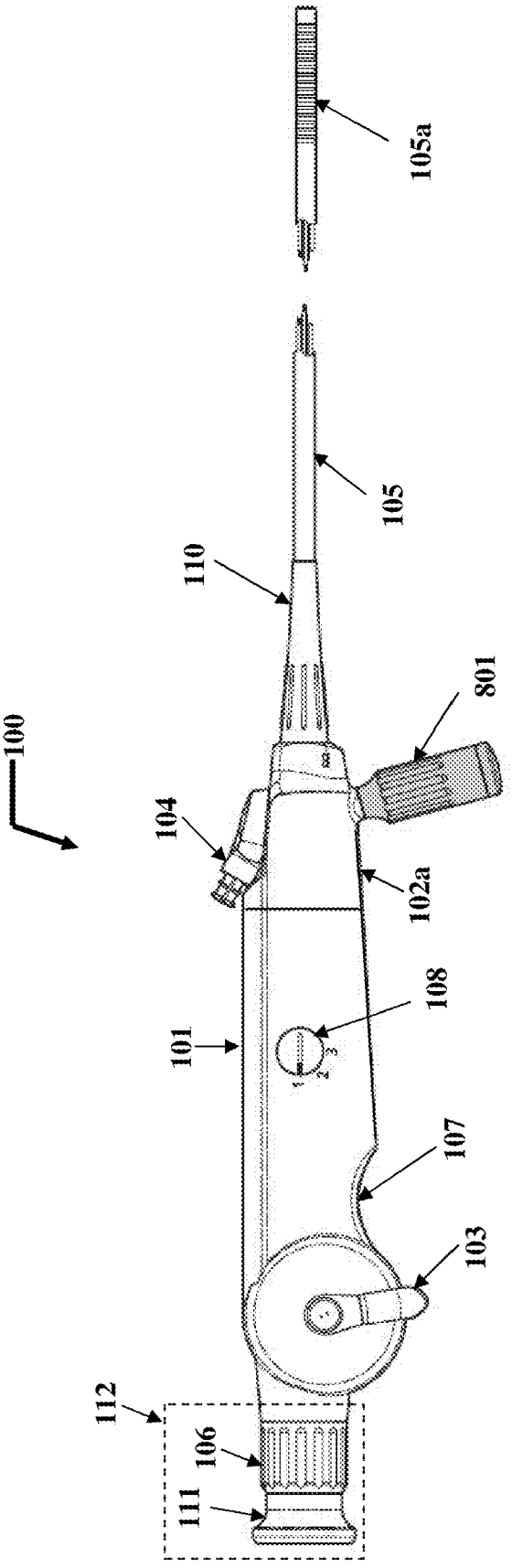

FIG. 8

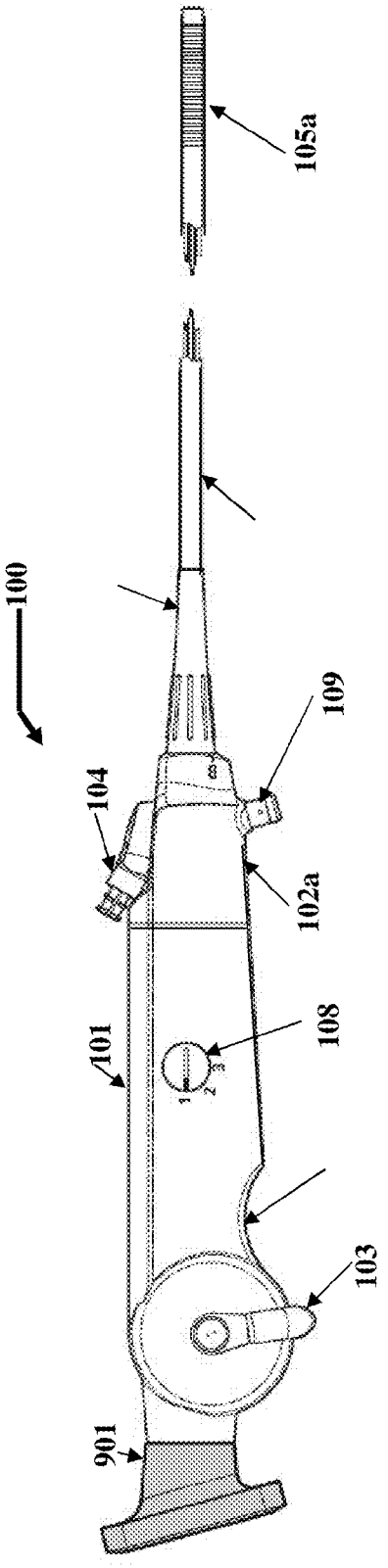

FIG. 9A

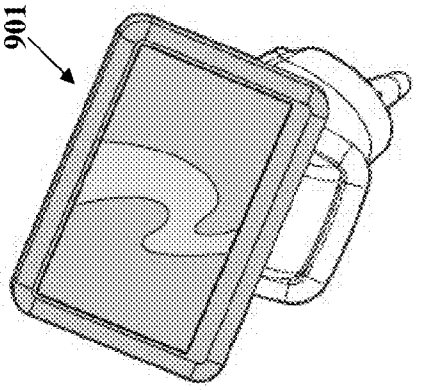

FIG. 9B

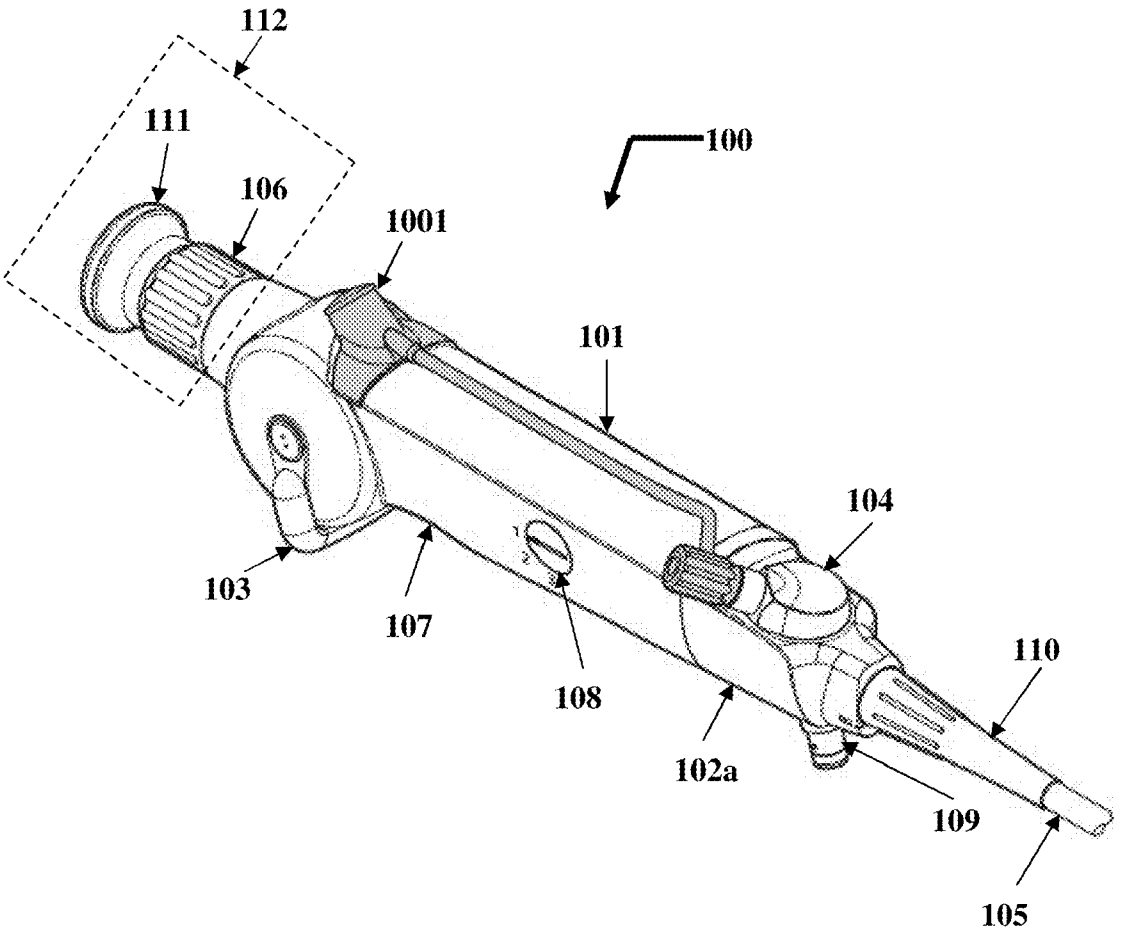

FIG. 10

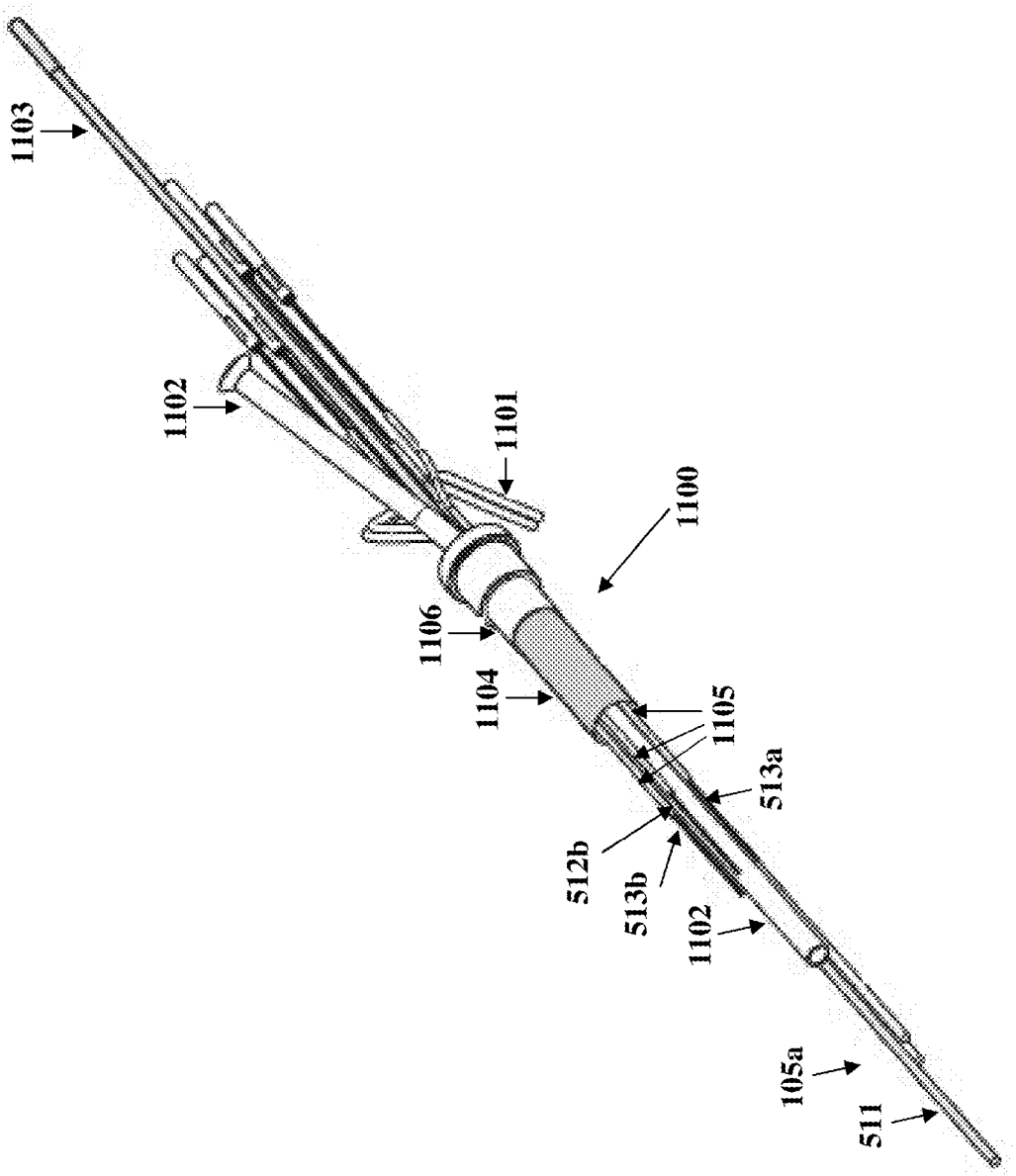
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FIG. 11

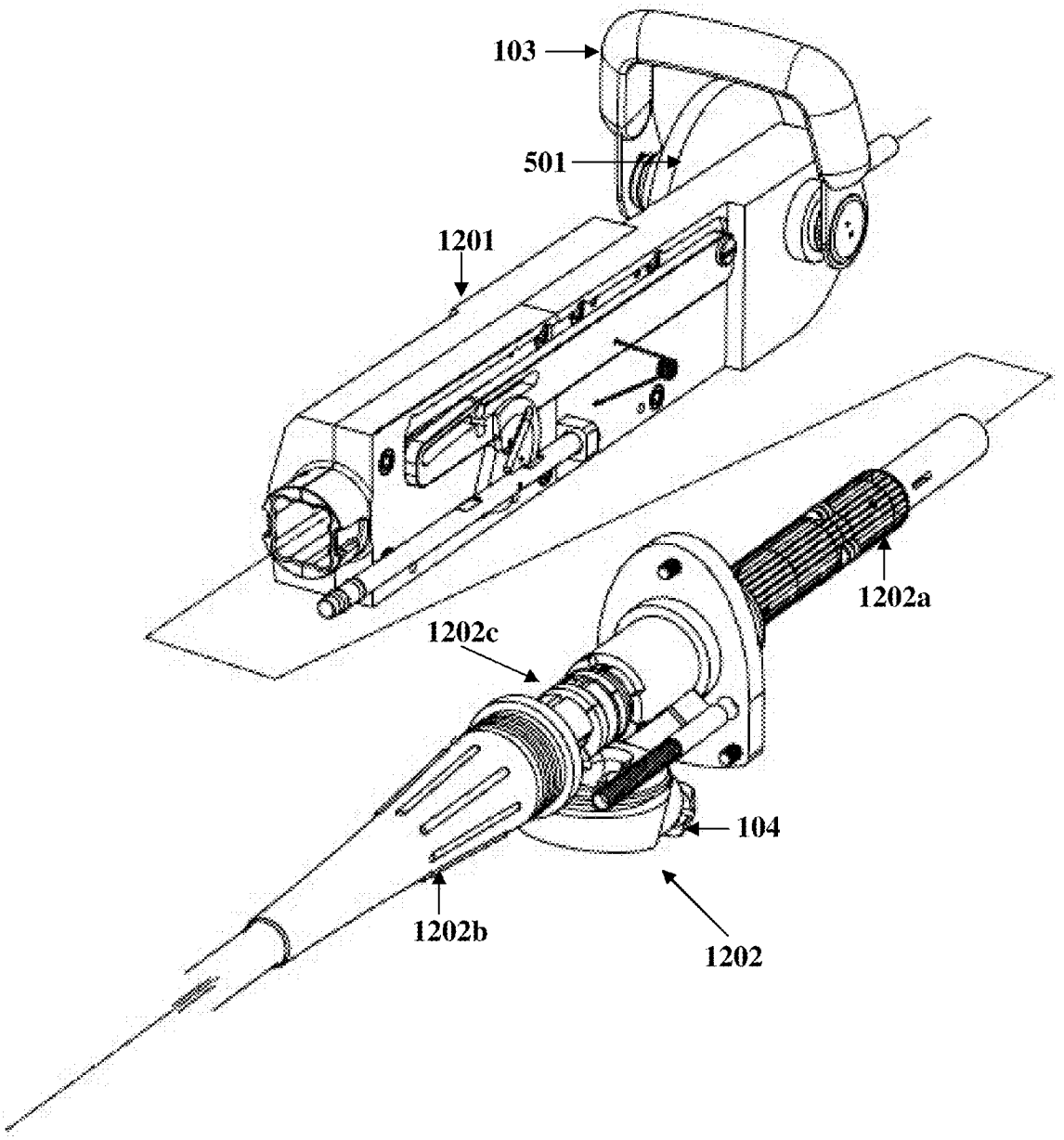

FIG. 12

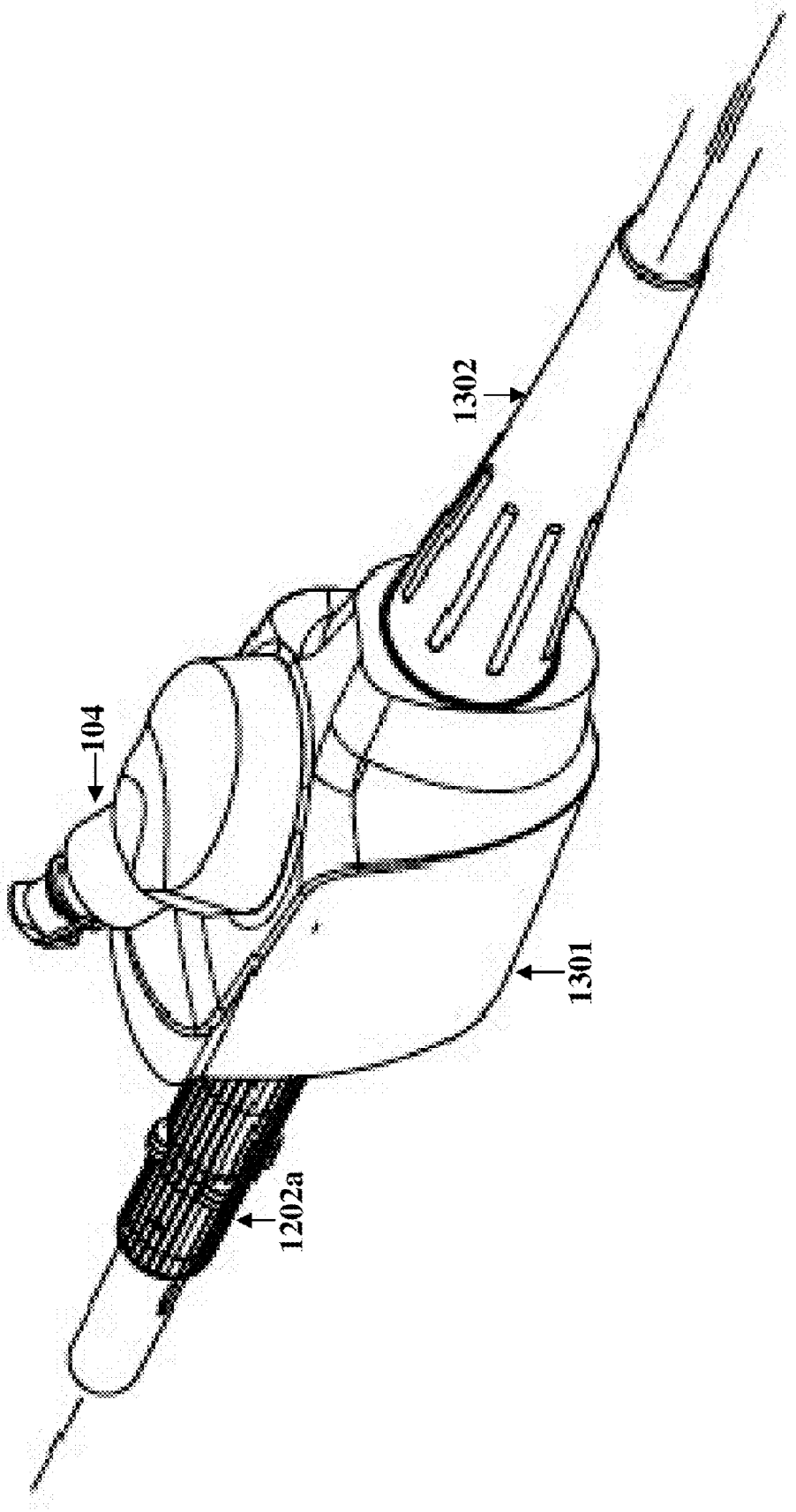

FIG. 13A

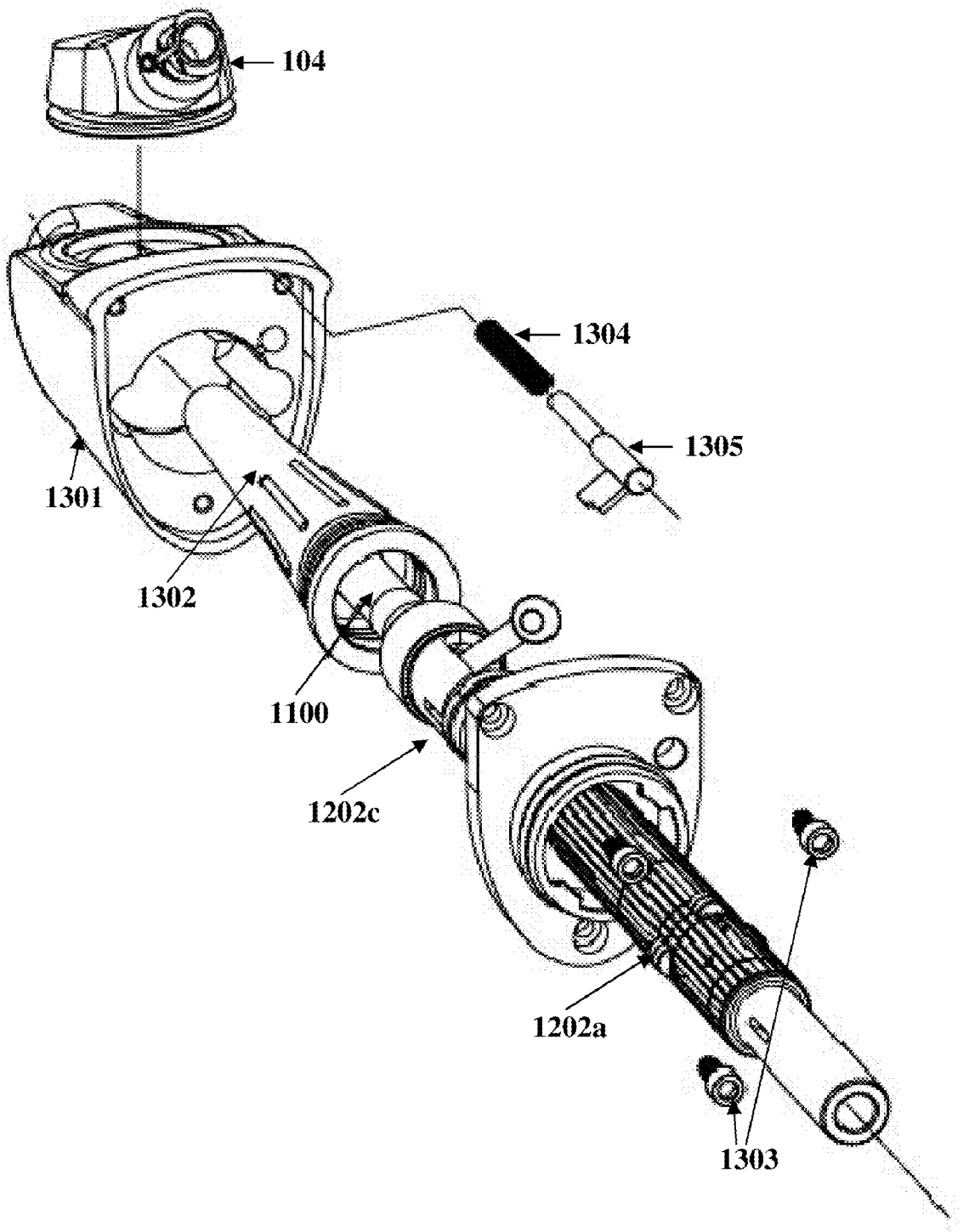

FIG. 13B

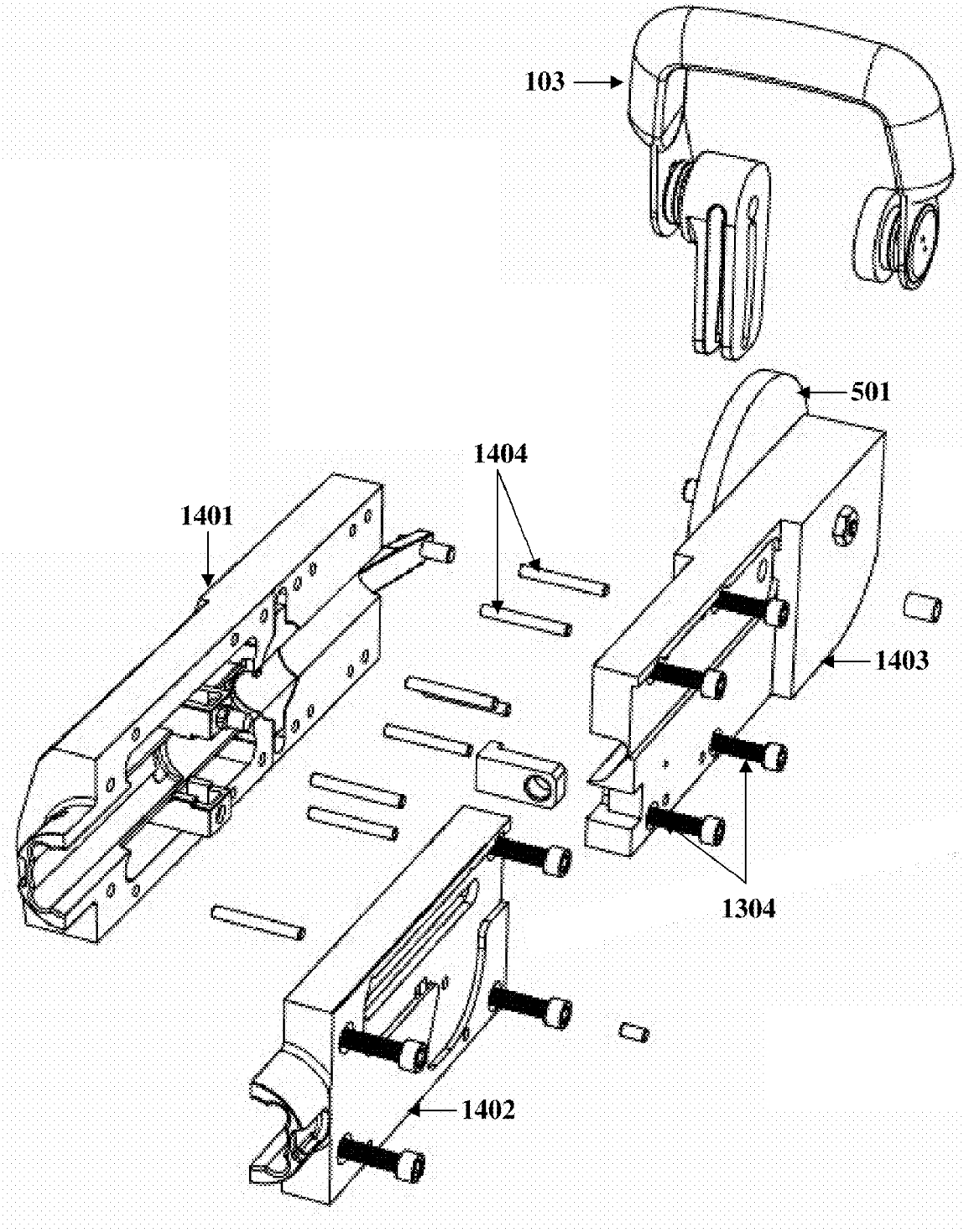

FIG. 14

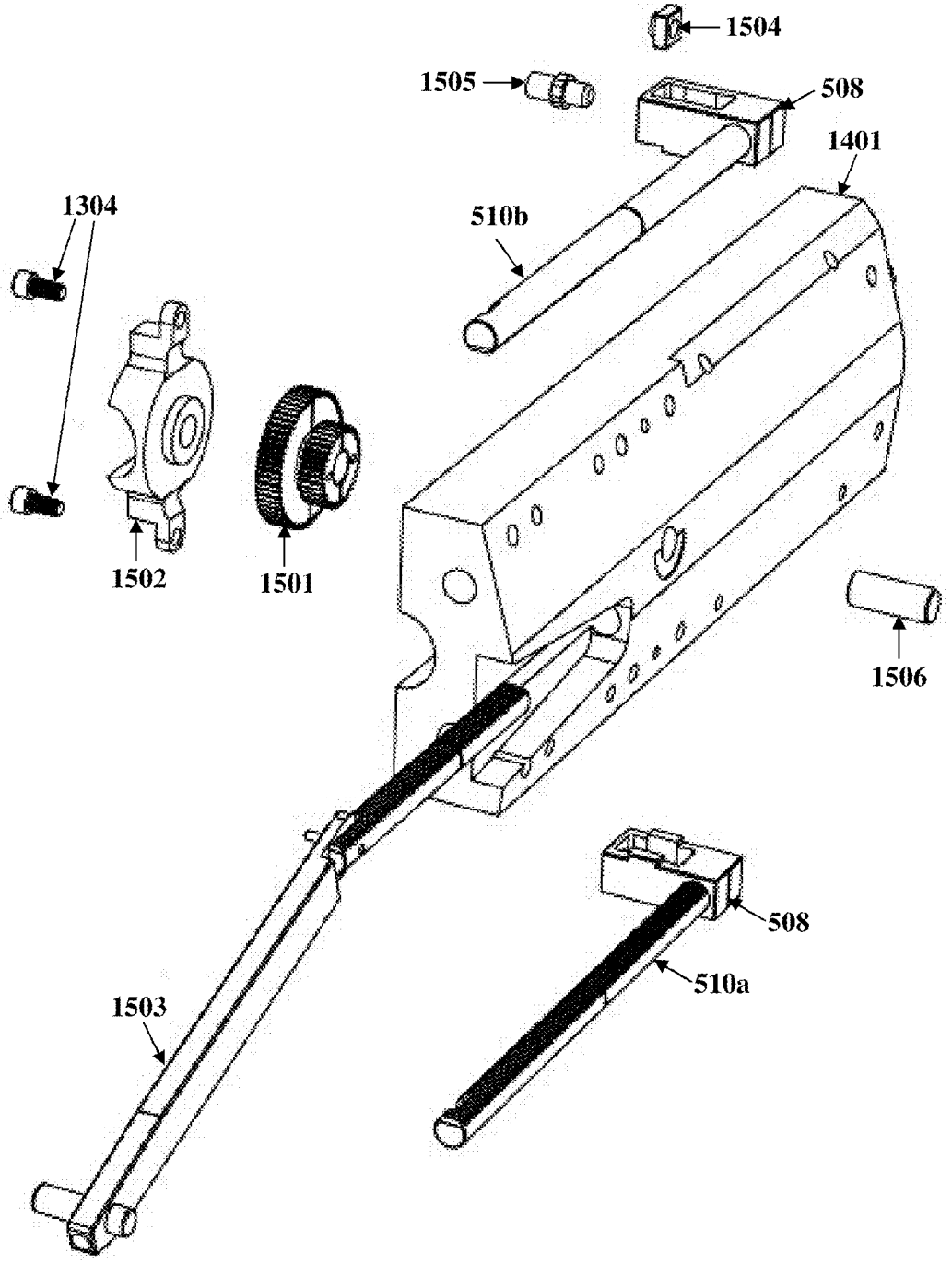

FIG. 15

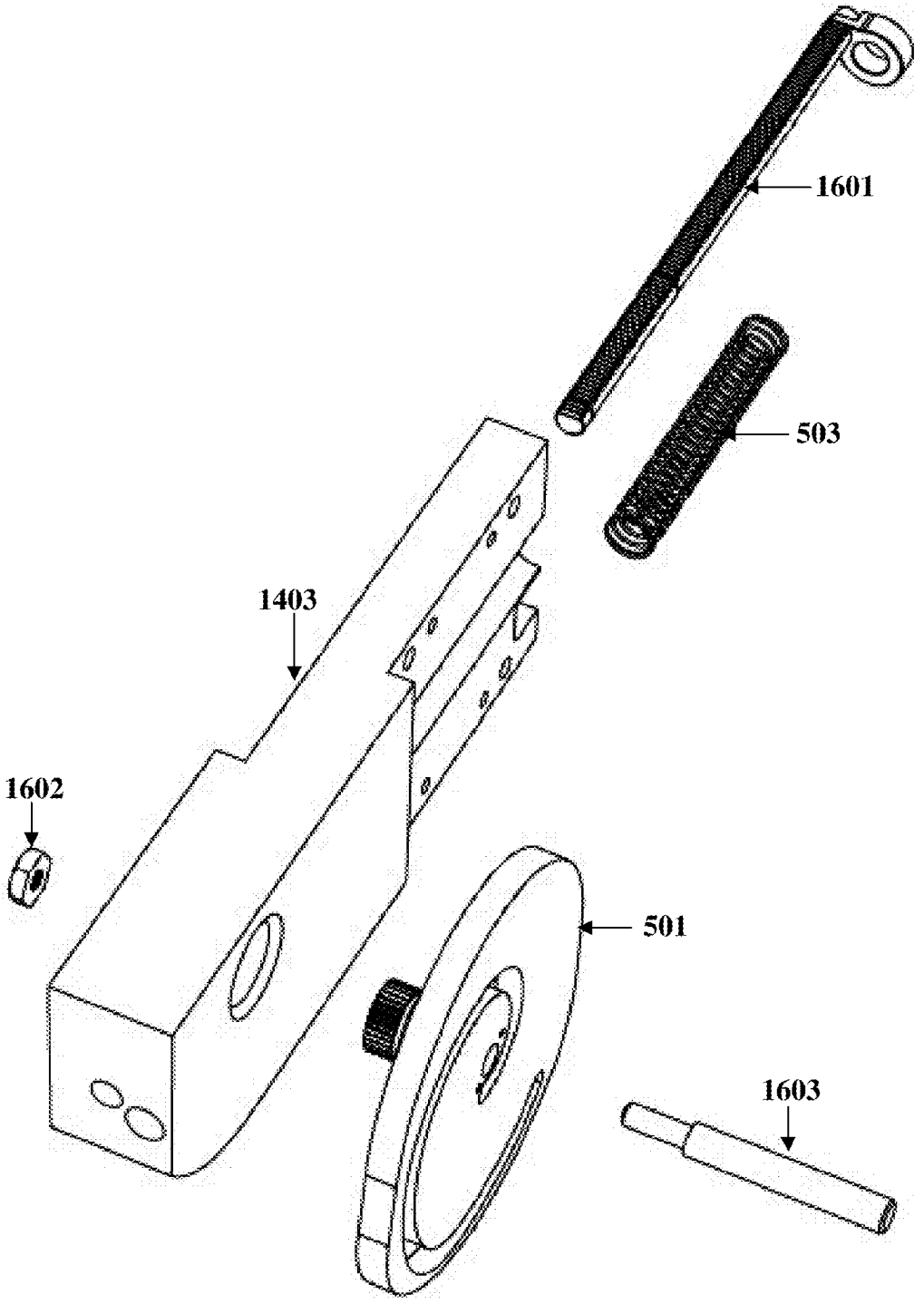

FIG. 16

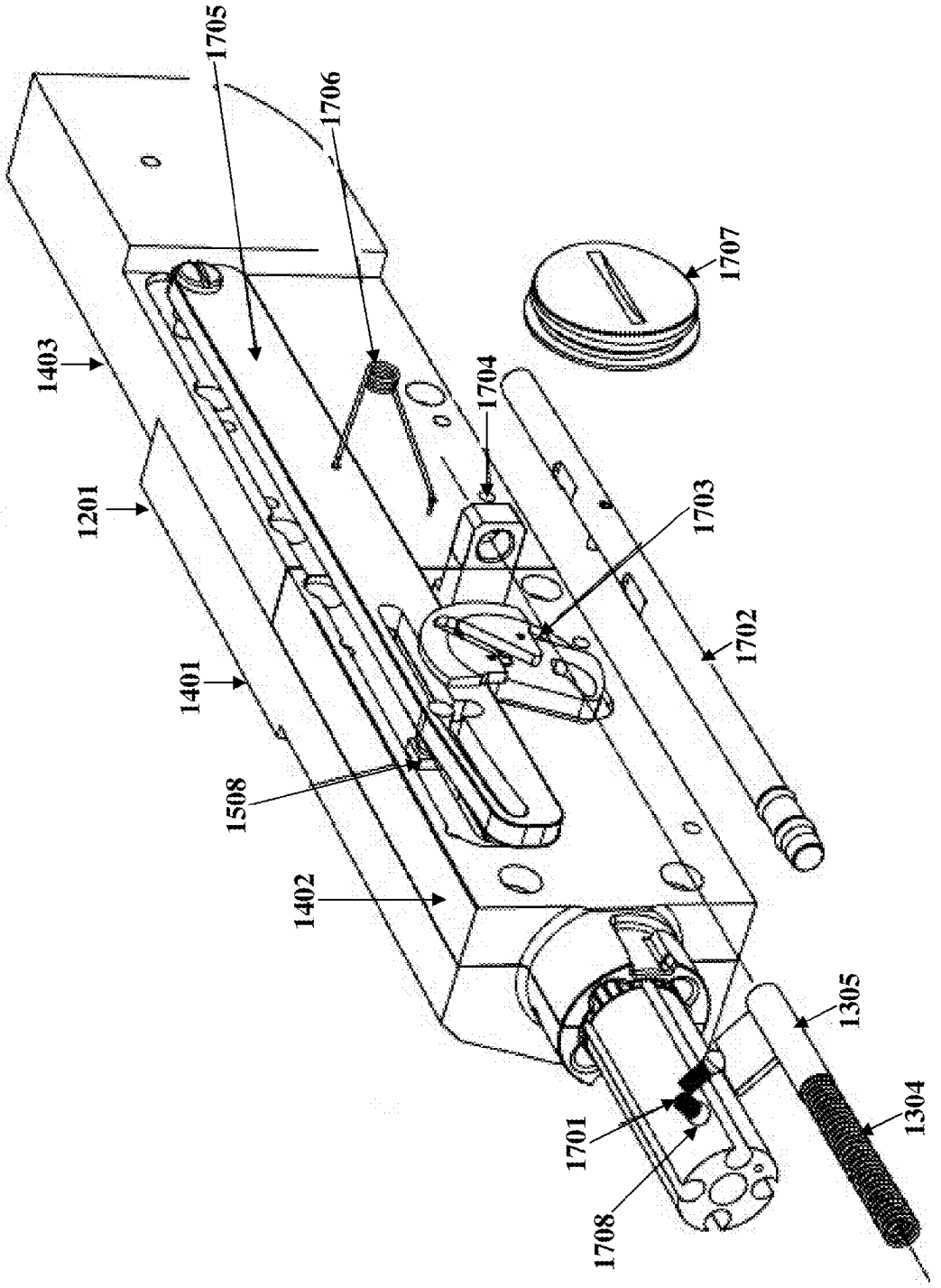
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FIG. 17

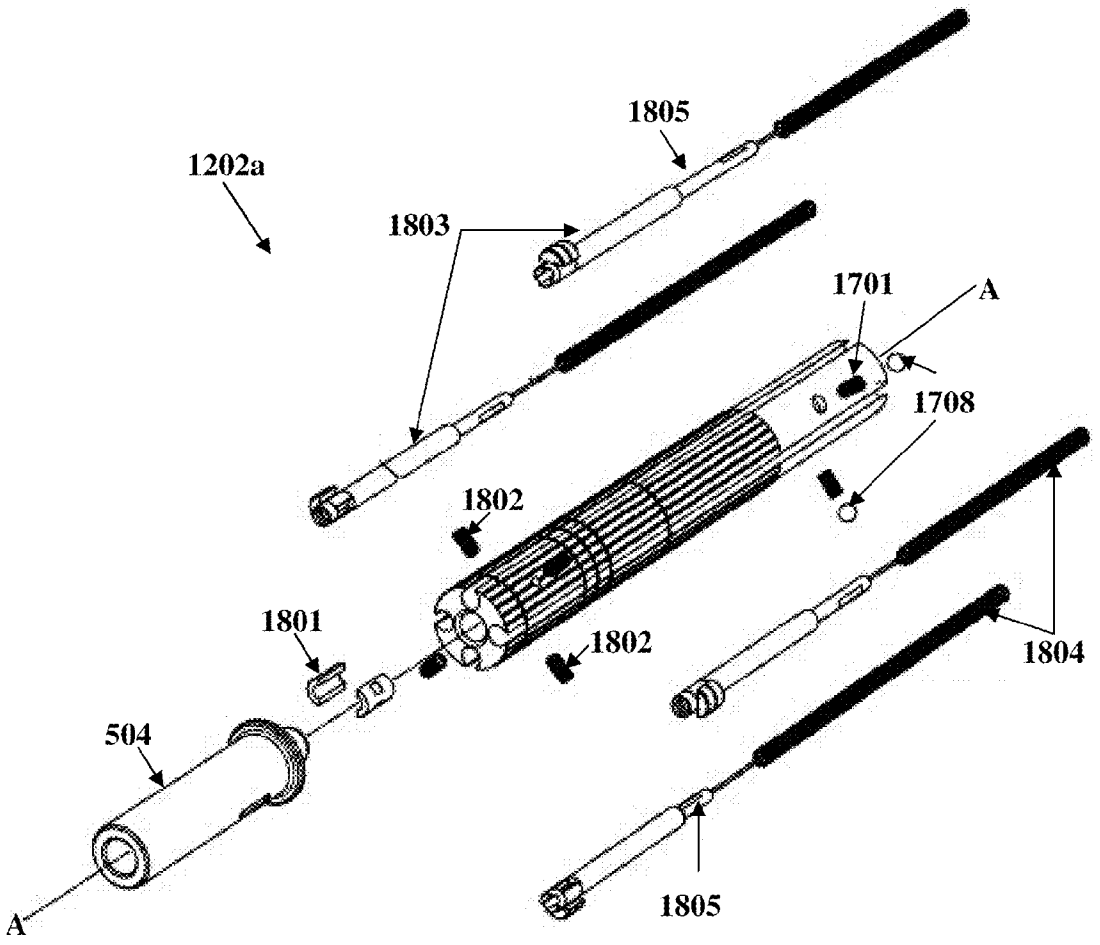

FIG. 18

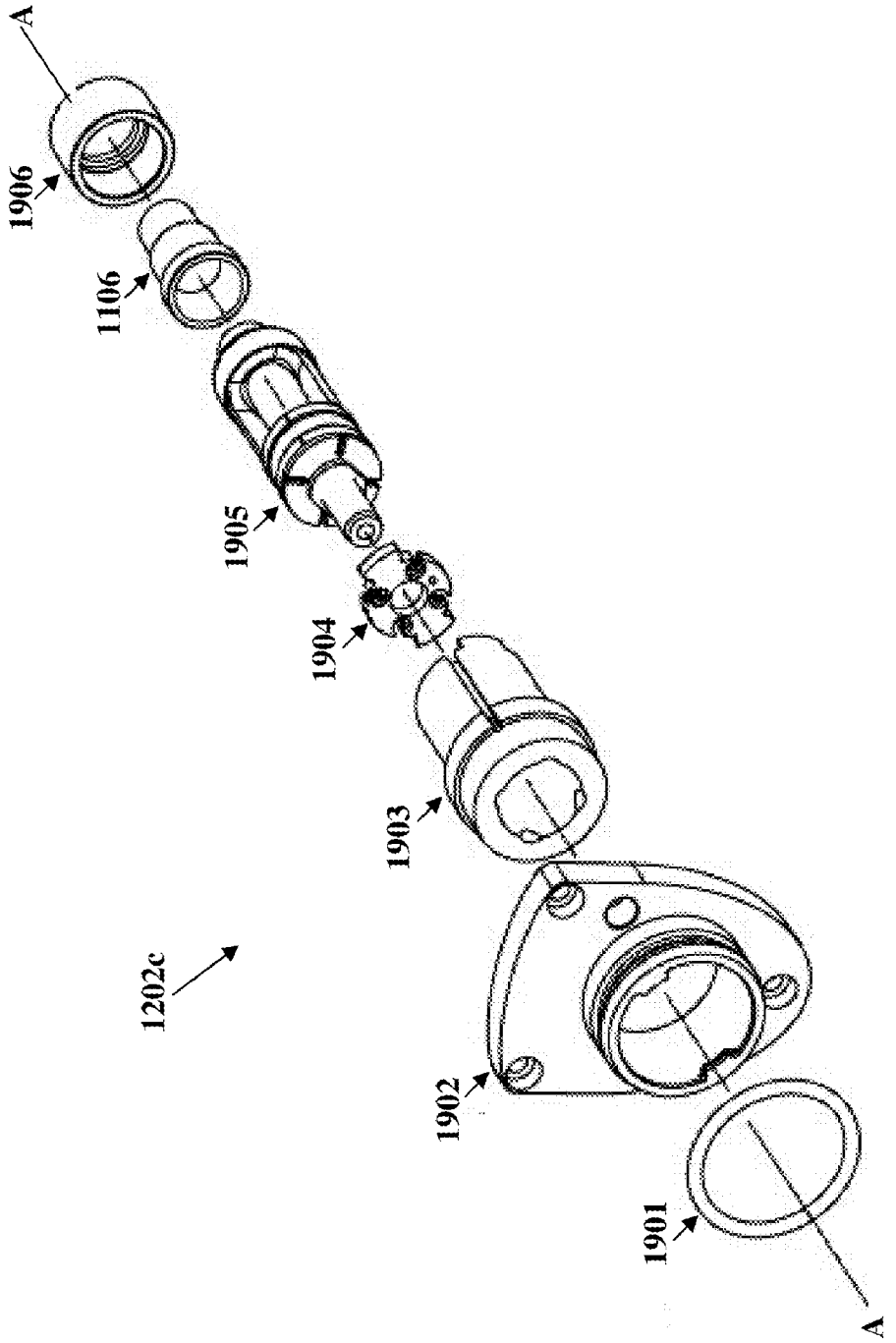

FIG. 19

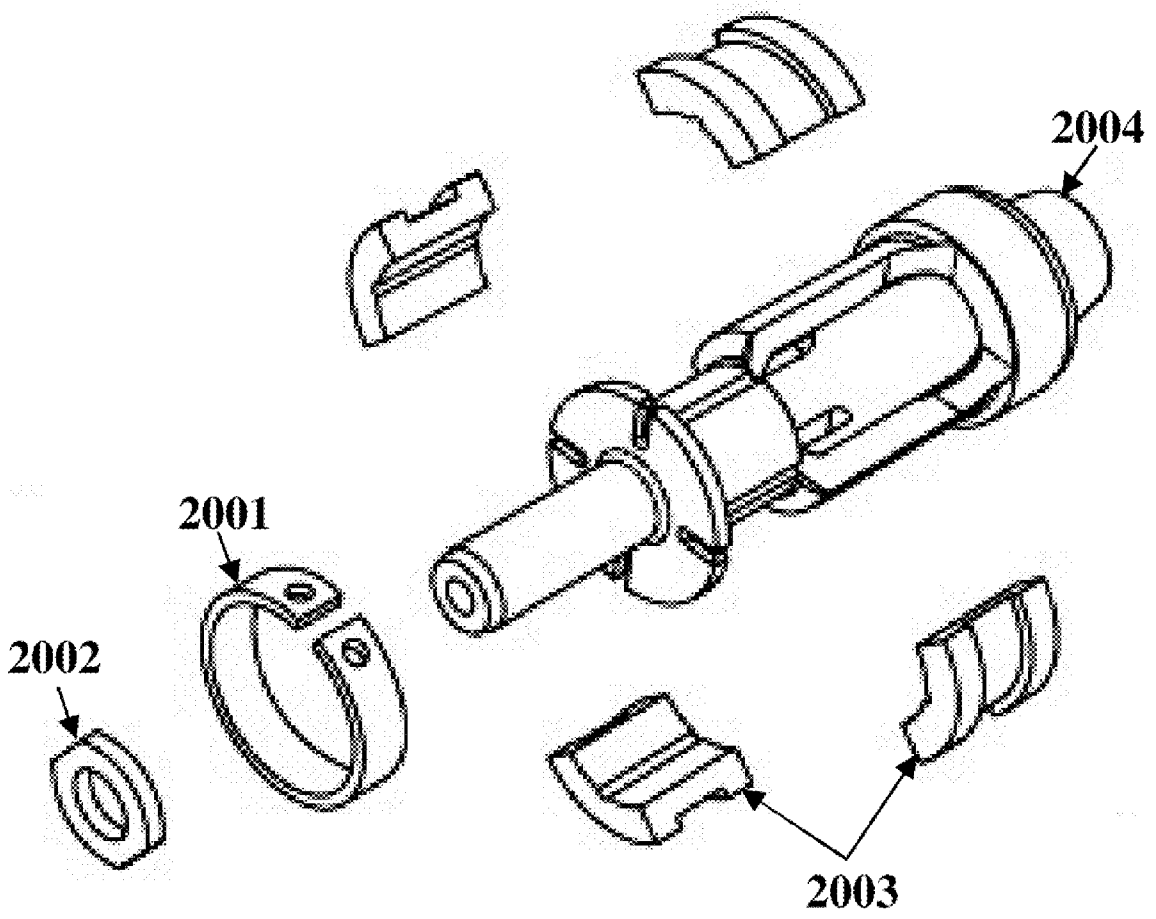

FIG. 20

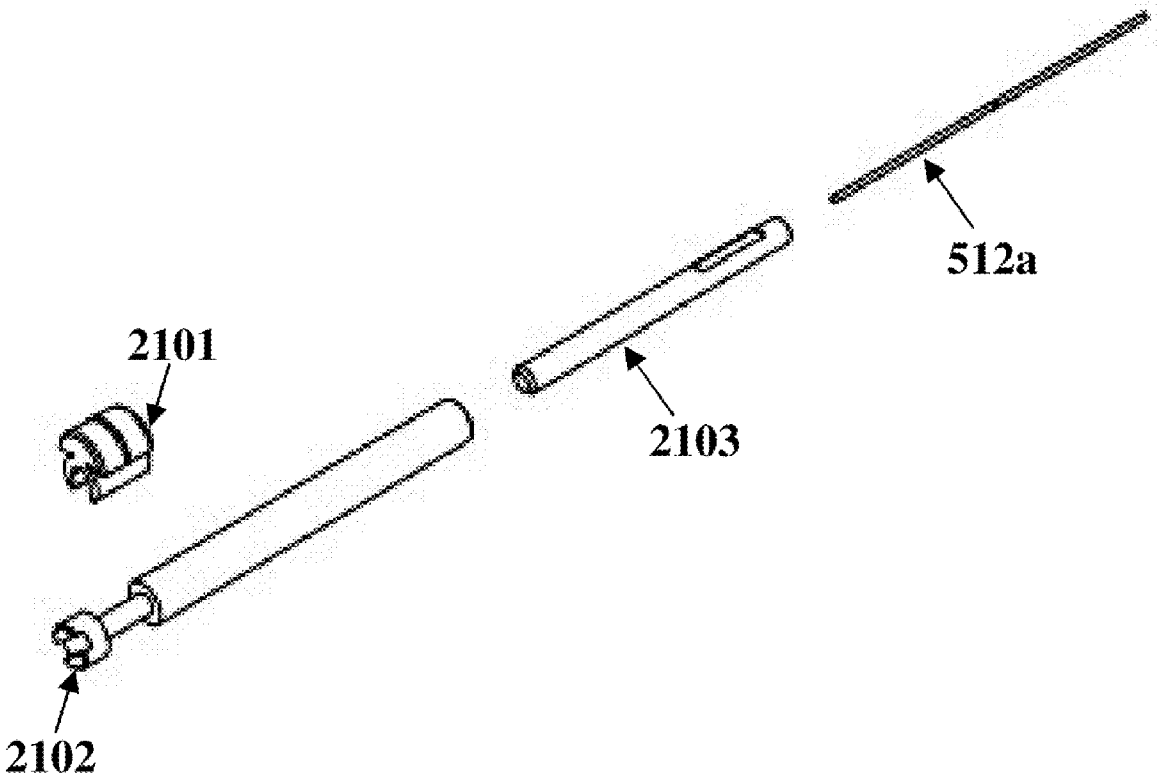

FIG. 21

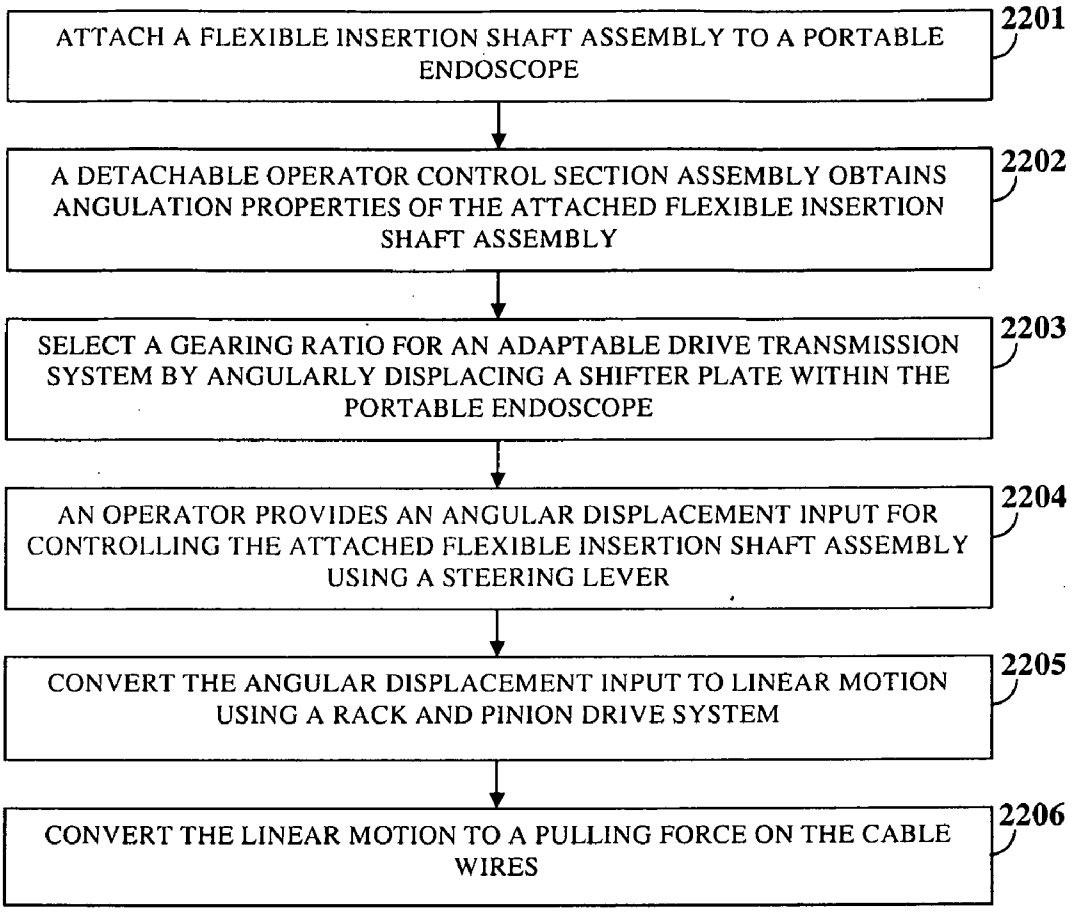
ATTACH A FLEXIBLE INSERTION SHAFT ASSEMBLY TO A PORTABLE ENDOSCOPE
2201
A DETACHABLE OPERATOR CONTROL SECTION ASSEMBLY OBTAINS ANGULATION PROPERTIES OF THE ATTACHED FLEXIBLE INSERTION SHAFT ASSEMBLY
2202
SELECT A GEARING RATIO FOR AN ADAPTABLE DRIVE TRANSMISSION SYSTEM BY ANGULARLY DISPLACING A SHIFTER PLATE WITHIN THE PORTABLE ENDOSCOPE
2203
AN OPERATOR PROVIDES AN ANGULAR DISPLACEMENT INPUT FOR CONTROLLING THE ATTACHED FLEXIBLE INSERTION SHAFT ASSEMBLY USING A STEERING LEVER
2204
CONVERT THE ANGULAR DISPLACEMENT INPUT TO LINEAR MOTION USING A RACK AND PINION DRIVE SYSTEM
2205
CONVERT THE LINEAR MOTION TO A PULLING FORCE ON THE CABLE WIRES
2206

FIG. 22

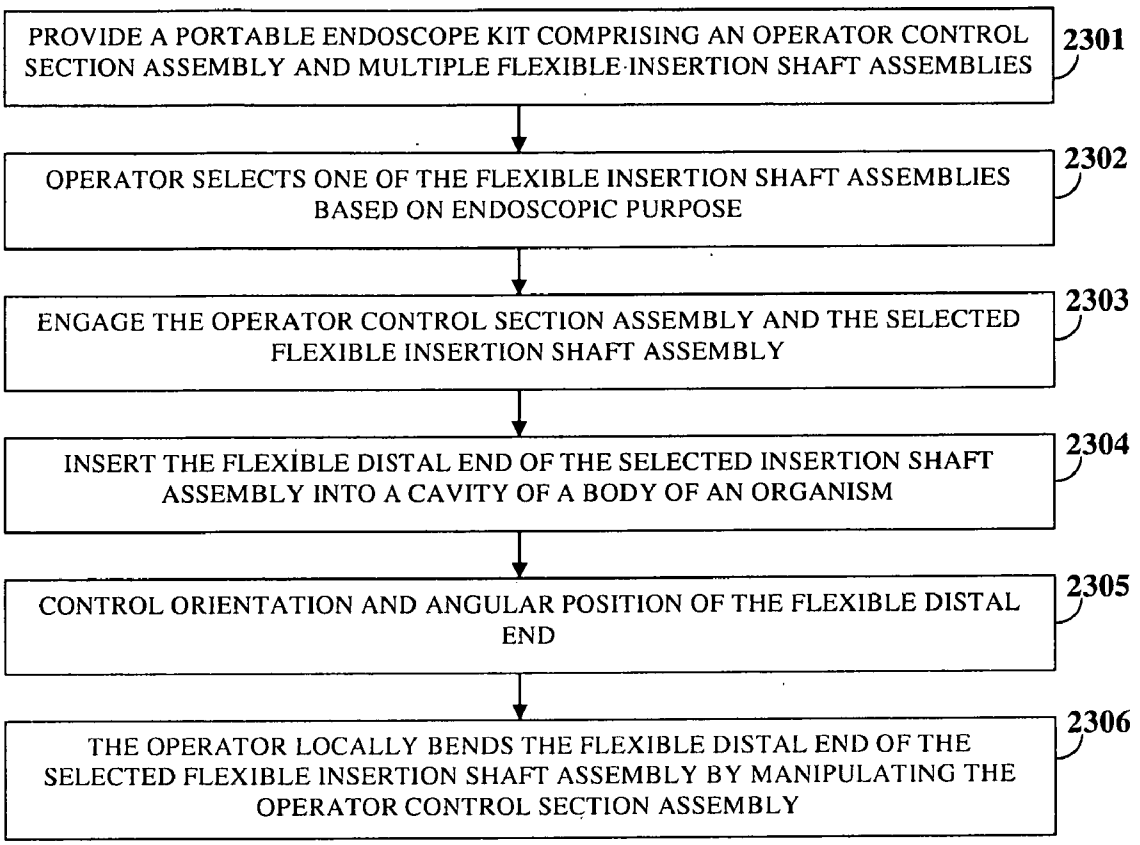
PROVIDE A PORTABLE ENDOSCOPE KIT COMPRISING AN OPERATOR CONTROL SECTION ASSEMBLY AND MULTIPLE FLEXIBLE INSERTION SHAFT ASSEMBLIES
2301
OPERATOR SELECTS ONE OF THE FLEXIBLE INSERTION SHAFT ASSEMBLIES BASED ON ENDOSCOPIC PURPOSE
2302
ENGAGE THE OPERATOR CONTROL SECTION ASSEMBLY AND THE SELECTED FLEXIBLE INSERTION SHAFT ASSEMBLY
2303
INSERT THE FLEXIBLE DISTAL END OF THE SELECTED INSERTION SHAFT ASSEMBLY INTO A CAVITY OF A BODY OF AN ORGANISM
2304
CONTROL ORIENTATION AND ANGULAR POSITION OF THE FLEXIBLE DISTAL END
2305
THE OPERATOR LOCALLY BENDS THE FLEXIBLE DISTAL END OF THE SELECTED FLEXIBLE INSERTION SHAFT ASSEMBLY BY MANIPULATING THE OPERATOR CONTROL SECTION ASSEMBLY
2306

FIG. 23

PORTABLE ENDOSCOPE FOR DIVERSE MEDICAL DISCIPLINES

BACKGROUND

[0001] This invention, in general, relates to an endoscope for viewing inaccessible cavity regions of a body. More particularly, this invention relates to a portable endoscope for diverse medical disciplines.

[0002] Typically, a medical specialty, for example, otolaryngology, urology, anesthesia, bronchoscopy, gastroenterology, hysteroscopy, etc. requires a unique endoscope to perform procedures in that medical specialty. This requires a medical establishment providing medical services to purchase, stock, and maintain endoscopes and parts of the endoscope for the medical specialties for which services are provided. Procurement and maintenance of such endoscopes increases the overhead cost of the medical establishment and the cost of such medical procedures. Partly because endoscope and endoscope parts used in different medical procedures are not interchangeable, dedicated endoscopes for each discipline are required to be inventoried. If different endoscopes are not maintained in an inventory at the medical establishment, obtaining them in a timely fashion for the performance of a procedure is also an issue.

[0003] Typically, endoscopes are characterized by different structural configurations that enable an operator of an endoscope to control angular movements of a flexible distal end of the endoscope. A typical endoscope comprises a single integrated functional unit with no detachable components. Endoscopes are generally structurally configured with external light cords or cables, connected to an external light source, a video processing source, or both. The cords and the cables may restrict the use of the endoscope at a desired location in the body, or limit the flexibility, movement, or maneuverability of the endoscopes for performing a medical procedure.

[0004] Typically, commercial endoscopes utilizing a portable battery pack, fiber optic cables, and cords have no or minimal detachable components. Over time and usage, components in the endoscopes, for example, the fiber optic cables, electrical components, components for controlling movements of the flexible distal end, etc. may wear, break, or experience a failure or become dysfunctional due to faulty use, or accidental breakage. When such a failure occurs, such endoscopes without detachable components may be difficult to repair and reuse and therefore require an entire replacement endoscope to be maintained in inventory.

[0005] When the components of an endoscope experience a failure during a medical procedure, the medical procedure generally requires the withdrawal of the endoscope inserted into the body of a patient. The medical practitioner may then need to procure a new endoscope and restart the medical procedure on the patient. The time delay involved in procuring the new endoscope and restarting the medical procedure may extend the time necessary to complete the medical procedure and cause medical complications and patient discomfort, for example, during reinsertion of the endoscope, etc. The time lag may also cause additional delays in prescheduled procedures. Also, in case of failure of an endoscope during a medical procedure, the endoscope may not be provided with a built-in or another alternative to continue or resume the procedure immediately. Hence the endoscopes may be inoperable in an event of failure during a medical procedure.

[0006] Conventional endoscopes of different sizes, lengths, and ranges of deflection or steering are used depending on the procedure to be performed, the orifice used to gain access, and the specific body cavity to be reached. Steering is achieved by pulling on one of multiple control lines that are embedded within the insertion shaft bundle. Pulling on the left control line causes the distal tip to deflect to the left, pulling on the right causes deflection to the right, on the top upward, and so forth. The amount of control line pull required to achieve a desired amount of distal tip deflection is directly proportional to the diameter of the insertion shaft bundle and the amount of deflection sought. In other words, the larger the endoscope, the greater pull required, plus the greater the deflection, the longer the required pull. For a typical endoscope, this pull requirement may, for example, deviate by ⅛ inches from neutral or smaller for the smallest endoscopes with limited steering, for example, from 90 degrees, to a deviation of ⅝ inches from neutral or larger, for example, 270 degrees for the largest endoscopes.

[0007] To steer an endoscope, a simple thumb lever is typically used to translate the sweep of the operator's thumb, moving from a neutral position to flexion and extension, into pull upon the appropriate control line. For an ordinary endoscope with a typical handgrip posture, this lever swing may be limited to 45 degrees to 50 degrees of thumb lever angulation. This coincides with the reach of an operator's thumb which is limited by length and the distance covered from full flexion to full extension.

[0008] In typical endoscopes where the flexible insertion shaft is integral and not detachable from the hand control, fixed internal gearing or levers may translate the thumb lever swing into a predetermined range of pull action that corresponds with the requirements and range of the integral flexible insertion shaft so that the entire swing of the thumb controls the entire range of steering.

[0009] Hence, there is a need for a portable endoscope comprising detachable components to eliminate dependency on external cords, cables, and related accessories required to perform the medical procedures. There is also a need for a portable endoscope with detachable components that is configurable for use in diverse medical specialties and disciplines and associated medical procedures. Furthermore, there is a need for an endoscope with internal back-up systems and redundancies to allow immediate remedy and recovery from component failures or break downs.

SUMMARY OF THE INVENTION

[0010] This summary is provided to introduce a selection of concepts in a simplified form that are further described in the detailed description of the invention. This summary is not intended to identify key or essential inventive concepts of the claimed subject matter, nor is it intended for determining the scope of the claimed subject matter.

[0011] The portable endoscope disclosed herein comprises a detachable operator control section assembly, with an internal cable wire control system, and one of multiple detachable and interchangeable flexible insertion shaft assemblies. An operator may select one of the flexible insertion shaft assemblies based on the endoscopic task to be performed. For example, the operator may select a small-diameter flexible insertion shaft assembly to inspect a paranasal sinus of a patient. Alternatively, the operator may select a relatively large-diameter flexible insertion shaft assembly to inspect the patient's gastrointestinal tract. The operator may attach the

selected flexible insertion shaft assembly to the operator control section assembly to form a complete portable endoscope ready to perform the needed endoscopic procedure.

[0012] The assembled portable endoscope comprises a pair of principal cable wires within the body of the flexible insertion shaft assembly. The principal cable wires are attached to opposing sides of the distal end of the flexible insertion shaft assembly and are selectably attached by an adaptable drive transmission system to a steering lever on the operator control section assembly. The operator manipulates the steering lever to pull on one of the principal cable wires and to push on the other of the principal cable wires, thus causing the distal end of the flexible insertion shaft assembly to deflect a controlled amount.

[0013] The amount of deflection is determined by the diameter of the flexible insertion shaft assembly and the amount of linear movement of the principal cable wires within the body of the flexible insertion shaft assembly. For example, a small-diameter flexible insertion shaft assembly will require less linear movement of the principal cable wires than a large-diameter flexible insertion shaft assembly for the same amount of deflection of the distal end of the flexible insertion shaft assembly.

[0014] The adaptable drive transmission system automatically selects the range of deflection of the distal end of the flexible insertion shaft assembly and automatically adapts to differences in diameter of the different flexible insertion shaft assemblies. The operator may select flexible insertion shaft assemblies so that a given deflection of the steering lever by the operator results in a similar deflection of the distal end of any flexible insertion shaft assembly, regardless of the diameter of the selected flexible insertion shaft assembly. In addition, the operator may select different ranges of deflection for flexible insertion shaft assemblies of the same diameter.

[0015] To accomplish the automatic selection of the range of deflection of the distal end of the flexible insertion shaft assembly, the steering lever is attached to a crank lever. The steering lever and the crank lever rotate about a common axis in response to movement of the steering lever by the operator. The crank lever moves a connecting rod to push and pull the principal cable wires. The effective length of the crank lever is changed automatically by a shifter plate that moves with the steering lever and the crank lever about the common axis of rotation. The shifter plate defines a spiral cam that defines the location of the connection between a crank arm and the crank lever and hence defines the effective length of the crank lever.

[0016] The rotational position of the shifter plate with respect to the crank lever, and hence the effective length of the crank lever, is defined by the selected flexible insertion shaft assembly. The selected flexible insertion shaft assembly defines a shifter rod on the proximal end of the flexible insertion shaft assembly. When the selected flexible insertion shaft assembly is attached to the operator control section assembly, the shifter rod bears upon a rack, which rotates a pinion attached to the shifter plate. Rotating the pinion causes the shifter plate, and hence the spiral cam, to turn with respect to the crank lever, thereby selecting the effective length of the crank lever. The length of the shifter rod of the selected insertion shaft assembly therefore determines the effective crank lever length and the amount of deflection of the distal end of the flexible insertion shaft assembly for a given movement of the steering lever by the operator.

[0017] The body of the flexible insertion shaft assembly accommodates the principal cable wires, proxy cable wires, an optical imaging system, and an illumination system. The flexible insertion shaft assembly may also incorporate a working channel. The proxy cable wires act as a backup for the principal cable wires and may be engaged in the event of failure of the principal cable wires.

[0018] The portable endoscope further comprises a cable wire switch integrated with the flexible insertion shaft assembly to engage the principal cable wires or the proxy cable wires with the adaptable drive transmission system. The internal cable wire control system comprises a steering lever for controlling angular movements of the flexible distal end of each of the flexible insertion shaft assemblies. The steering lever manipulates movement of the principal cable wires or the proxy cable wires engaged with the internal cable wire control system via the adaptable drive transmission system. The internal cable wire control system may utilize the proxy cable wires for operating the portable endoscope in the event of failure of the principal cable wires during one of the medical procedures in progress. In the event of failure of the principal cable wires, the cable wire switch disengages the principal cable wires from the adaptable drive transmission system and engages the proxy cable wires with the adaptable drive transmission system. The adaptable drive transmission system comprises an angulation and deflection gear system with gears and gear track subassemblies for matching operator input to steering output of the portable endoscope. The portable endoscope may further comprise a neutral lock-out system and a quick disconnect subassembly for facilitating engagement and disengagement of the principal cable wires and the proxy cable wires.

[0019] The portable endoscope further comprises an external light source in communication with the illumination system and the optical imaging system. The external light source provides light to the illumination system and the optical imaging system. The optical imaging system integrated with the portable endoscope captures and transmits visual images received from the flexible insertion shaft assembly. The optical imaging system may utilize the illumination system for illumination during the capture and transmission of the visual images. The visual images captured and transmitted by the optical imaging system may be displayed on a visual display unit provided on the operator control section assembly. Optionally, the visual images may also be displayed on an external visual display unit. The portable endoscope may further comprise a working channel turret integrated with the flexible insertion shaft assembly for aiding different medical procedures, for example, lavage, aspiration, biopsy, or manipulation. The portable endoscope may further comprise a suction and irrigation control system for controlling flow of fluids during a medical lavage or aspiration procedure. The suction and irrigation control system may be detachably attached to the detachable operator control section assembly.

[0020] The portable endoscope disclosed herein may be provided in a kit. The portable endoscope kit comprises component parts capable of being assembled in the field. The component parts are an operator control section assembly and multiple flexible insertion shaft assemblies. The flexible insertion shaft assemblies included in the kit may be used for different purposes. For example, a first flexible insertion shaft assembly selected from the flexible insertion shaft assemblies may be configured for an endoscopic purpose different from a second flexible insertion shaft assembly selected from the flexible insertion shaft assemblies. Each of the flexible insertion shaft assemblies comprises an elongated body with a

distal end and a proximal end. Each of the distal ends and each of the elongated bodies are configured for insertion into an internal cavity of a body of a living organism. The proximal end of each of the flexible insertion shaft assemblies is configured for selectable engagement between the proximal end and the operator control section assembly.

[0021] The operator control section assembly is configured to engage the proximal end of any one of the flexible insertion shaft assemblies. The distal end of each of the flexible insertion shaft assemblies is locally bendable. Each of the flexible insertion shaft assemblies and the operator control section assembly are configured so that the operator control section assembly selectably controls the local bending of the distal end of the flexible insertion shaft assembly when the flexible shaft assembly is in the selectable engagement with the operator control section assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The foregoing summary, as well as the following detailed description of the invention, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, exemplary constructions of the invention are shown in the drawings. However, the invention is not limited to the specific methods and instrumentalities disclosed herein.

[0023] FIG. **1** exemplarily illustrates a portable endoscope for diverse medical disciplines and associated medical procedures.

[0024] FIG. **2** exemplarily illustrates a detachable operator control section assembly and a detachable and interchangeable flexible insertion shaft assembly of a portable endoscope for diverse medical disciplines and associated medical procedures.

[0025] FIGS. **3**A-**3**C exemplarily illustrate different detachable and interchangeable flexible insertion shaft assemblies that may be used in conjunction with a detachable operator control section assembly of a portable endoscope based on predefined functional requirements of the portable endoscope specified for each of the medical disciplines and associated medical procedures.

[0026] FIG. **4**A exemplarily illustrates an isometric top view of a portable endoscope for diverse medical disciplines and associated medical procedures.

[0027] FIG. **4**B exemplarily illustrates an isometric bottom view of a portable endoscope for diverse medical disciplines and associated medical procedures.

[0028] FIG. **4**C exemplarily illustrates an orthographic bottom view of a portable endoscope for diverse medical disciplines and associated medical procedures.

[0029] FIGS. **5**A-**5**B exemplarily illustrate an internal cable wire control system and an adaptable drive transmission system of a portable endoscope for diverse medical disciplines and associated medical procedures.

[0030] FIG. **6** exemplarily illustrates flexible distal end movements of a portable endoscope corresponding to movements of a steering lever of the portable endoscope.

[0031] FIG. **7** exemplarily illustrates a portable endoscope with a light cable connected to the lighting channel.

[0032] FIG. **8** exemplarily illustrates a portable endoscope with a light stick connected to the lighting channel.

[0033] FIGS. **9**A-**9**B exemplarily illustrate a portable endoscope fitted with a portable visual display unit.

[0034] FIG. **10** exemplarily illustrates a portable endoscope fitted with a flow control valve.

[0035] FIG. **11** exemplarily illustrates internal components of the flexible insertion shaft bundle of the detachable and interchangeable flexible insertion shaft assembly.

[0036] FIG. **12** exemplarily illustrates a detachable operator control section assembly and a detachable and interchangeable shaft assembly of a portable endoscope for diverse medical disciplines and associated medical procedures without an external housing.

[0037] FIG. **13**A exemplarily illustrates an isometric view of the proximal end of the quick disconnect subassembly.

[0038] FIG. **13**B exemplarily illustrates an exploded view of the proximal end of the quick disconnect subassembly of the detachable and interchangeable flexible insertion shaft assembly of the portable endoscope.

[0039] FIG. **14** exemplarily illustrates an exploded view of a chassis subassembly within the operator control section assembly.

[0040] FIG. **15** exemplarily illustrates an exploded view of a main block of the chassis subassembly.

[0041] FIG. **16** exemplarily illustrates an exploded view of the tail block of the chassis subassembly.

[0042] FIG. **17** exemplarily illustrates an isometric view of the chassis subassembly with the main block, the side block, and the tail block assembled together highlighting the neutral lock-out system.

[0043] FIG. **18** exemplarily illustrates an exploded view of the proximal extreme section of the post subassembly at the proximal end of the detachable and interchangeable flexible insertion shaft assembly.

[0044] FIG. **19** exemplarily illustrates an exploded view of the mid proximal section of the post subassembly at the proximal end of the detachable and interchangeable flexible insertion shaft assembly.

[0045] FIG. **20** exemplarily illustrates an exploded view of the sheath anchor subassembly.

[0046] FIG. **21** exemplarily illustrates an exploded view of one of the control rod subassemblies.

[0047] FIG. **22** illustrates a method of adaptably driving a flexible insertion shaft assembly of a portable endoscope using an adaptable drive transmission system.

[0048] FIG. **23** illustrates a method of performing an endoscopic examination using a portable endoscope kit.

DETAILED DESCRIPTION OF THE INVENTION

[0049] FIG. **1** exemplarily illustrates a portable endoscope **100** for diverse medical disciplines and associated medical procedures. The portable endoscope **100** disclosed herein comprises a detachable operator control section assembly **101**, and a detachable and interchangeable shaft assembly **102***a* with a flexible distal end **105***a*. The detachable operator control section assembly **101** may be provided with a hand grip rim **107** to facilitate a stable and secure hand grip on the portable endoscope **100** during the medical procedures. The hand grip rim **107** is a configured surface provided on the body of the detachable operator control section assembly **101** for the hand grip. The detachable and interchangeable shaft assembly **102***a* and the detachable and interchangeable flexible insertion shaft assemblies **102***a*, **102***b*, and **102***c* are herein referred to as a "shaft assembly" and "shaft assemblies" respectively. An operator may select a shaft assembly **102***a* from the shaft assemblies **102***a*, **102***b*, and **102***c* for a particular medical discipline procedure based on the endoscopic procedure to be performed. For example, the operator may select a small-diameter shaft assembly to inspect a para-

nasal sinus of a patient. Alternatively, the operator may select a relatively large-diameter shaft assembly to inspect the patient's gastrointestinal tract.

[0050] The proximal end of the selected shaft assembly **102***a* is detachably connected to the detachable operator control section assembly **101**. The operator may attach the selected shaft assembly **102***a* to the detachable operator control section assembly **101** to form a complete portable endoscope **100** ready to perform the needed endoscopic procedure. The detachable operator control section assembly **101** and a shaft assembly **102***a* are exemplarily illustrated in FIG. **2**. Different shaft assemblies, for example, shaft assemblies **102***a*, **102***b*, and **102***c* may be interchangeably used in conjunction with the detachable operator control section assembly **101** of the portable endoscope **100** based on predefined functional requirements, the end use or application of the portable endoscope **100** as illustrated in FIGS. **3**A-**3**C. The medical disciplines may, for example, be otolaryngology, urology, intubations, anesthesia, bronchoscopy, gastroenterology, gynecology, hysteroscopy, etc. An isometric top view of the portable endoscope **100** for diverse medical disciplines and associated medical procedures is exemplarily illustrated in FIG. **4**A. An isometric bottom view of the portable endoscope **100** for diverse medical disciplines and associated medical procedures is exemplarily illustrated in FIG. **4**B. An orthographic bottom view of the portable endoscope **100** for diverse medical disciplines and associated medical procedures is exemplarily illustrated in FIG. **4**C. For a particular medical procedure or medical discipline, one of the shaft assemblies **102***a*, **102***b*, and **102***c* is attached to the detachable operator control section assembly **101**.

[0051] The shaft assembly **102***a* accommodates principal cable wires **512***a* and **512***b*, proxy cable wires **513***a* and **513***b*, an optical imaging system **112**, and an illumination system **1101**. The principal cable wires **512***a* and **512***b*, the proxy cable wires **513***a* and **513***b*, and the illumination system **1101** are exemplarily illustrated in FIG. **11**. The optical imaging system **112** is illustrated in FIG. **1** and FIG. **2**. The principal cable wires **512***a* and **512***b* and the proxy cable wires **513***a* and **513***b* are illustrated in FIGS. **5**A-**5**B. In FIG. **11**, the principal cable wire **512***a* is hidden behind the working channel **1102** and is therefore not visible. The operator may pull on one principal cable wire **512***a* and push on the other principal cable wire **512***b*, thus causing the flexible distal end **105***a* of the shaft assembly **102***a* to deflect a controlled amount. The amount of deflection is determined by the diameter of the shaft assembly **102***a* and the amount of linear movement of the principal cable wires **512***a* and **512***b* within the body of the shaft assembly **102***a*. For example, a small-diameter shaft assembly may require less linear movement of the principal cable wires **512***a* and **512***b* than a large-diameter shaft assembly for the same amount of deflection of the flexible distal end **105***a* of the shaft assembly **102***a*.

[0052] The shaft assembly **102***a* may also incorporate a working channel **1102** as exemplarily illustrated in FIG. **11**. The shaft assembly **102***a* comprises a flexible insertion shaft **105** with a deflecting and bending section. The flexible distal end **105***a* of the flexible insertion shaft **105** corresponds to the deflecting and bending section of the flexible insertion shaft **105**.

[0053] The portable endoscope **100** further comprises an internal cable wire control system **514** integrated with the detachable operator control section assembly **101**, as exemplarily illustrated in FIGS. **5**A-**5**B. The internal cable wire control system **514** controls orientation and angular position of the flexible distal end **105***a* of the shaft assembly **102***a*. The internal cable wire control system **514** may manipulate movements of the deflecting and bending section of the flexible insertion shaft **105** to control the orientation and the angular position of the flexible distal end **105***a*. The internal cable wire control system **514** utilizes a two way or a four way cable wire configuration for controlling the orientation and the angular position of the flexible distal end **105***a*. The two way cable wire configuration controls the upward and downward movements of flexible distal end **105***a*. The four way cable wire configuration controls the upward, downward, left side and right side movements of the flexible distal end **105***a*.

[0054] The internal cable wire control system **514** utilizes an adaptable drive transmission system **500** to control the orientation and angular position of the flexible distal end **105***a* for each of the shaft assemblies **102***a*, **102***b*, and **102***c* using the principal cable wires **512***a* and **512***b*, or the proxy cable wires **513***a* and **513***b*. The portable endoscope **100** further comprises a cable wire switch **110** integrated with the shaft assembly **102***a*, illustrated in FIG. **1**, for engaging, disengaging, or dissociating the principal cable wires **512***a* and **512***b*, or the proxy cable wires **513***a* and **513***b* with the adaptable drive transmission system **500**.

[0055] Since the portable endoscope **100** may be attached to different flexible insertion shafts **105**, each with potentially unique pull requirements, the detachable operator control section assembly **101** senses or reads the requirements for the flexible insertion shaft **105** being attached and adjusts the gearing and leverage so that the entire range of thumb motion of the operator controlling the steering lever **103** is used for the entire range of steering deflection.

[0056] The adaptable drive transmission system **500** automatically selects the range of deflection of the flexible distal end **105***a* of the shaft assembly **102***a* and automatically adapts to differences in diameter of the different shaft assemblies **102***a*, **102***b*, and **102***c*. The operator may select shaft assemblies **102***a*, **102***b*, and **102***c* so that a deflection input by the operator results in a similar deflection of the flexible distal end **105***a* of any shaft assembly **102***a*, **102***b*, or **102***c*, regardless of the diameter of the selected shaft assembly **102***a*. In addition, the operator may select different ranges of deflection for shaft assemblies **102***a*, **102***b*, and **102***c* of the same diameter.

[0057] Without the adaptable drive transmission system **500**, the detachable operator control section assembly **101** would need to be set for the largest possible output to control the largest endoscope. Setting the detachable operator control section assembly **101** for the largest possible output may lead to a disproportionate deflection of a small endoscope by the slightest movement of the steering lever **103**. Alternatively, the detachable operator control section assembly **101** would need to be set for the smallest possible output to control small endoscopes. Setting the detachable operator control section assembly **101** for the smallest possible output may lead to a circumstance where a large endoscope will not deflect fully. The large endoscope may only be deflected to a half-way point, which may be unacceptable to the operator. The adaptable drive transmission system **500** allows the automatic changing of the output according to the endoscope assembled by the operator. Hence, for a small endoscope, the adaptable drive transmission system **500** adjusts for small deflections. Similarly, for a large endoscope, the adaptable drive transmission system **500** adjusts for large deflections.

[0058] The internal cable wire control system **514** comprises a steering lever **103** for controlling angular movements of the flexible distal end **105***a* of each of the shaft assemblies **102***a*, **102***b*, and **102***c* as exemplarily illustrated in FIG. **6**. The steering lever **103** manipulates movement of the principal cable wires **512***a* and **512***b*, or the proxy cable wires **513***a* and **513***b* based on the engagement of the principal cable wires **512***a* and **512***b*, or the proxy cable wires **513***a* and **513***b* with the adaptable drive transmission system **500**. The steering lever **103** may be adjusted to obtain a predefined degree of angular movements of the flexible distal end **105***a* ranging from about 0 degrees to about 270 degrees.

[0059] In order to steer and deflect the flexible distal end **105***a* of the flexible insertion shaft **105**, the steering lever **103** is moved to pull the principal cable wires **512***a* and **512***b*, or proxy cable wires **513***a* and **513***b* within the shaft assembly **102***a* on either side of the deflecting and bending section of the flexible insertion shaft **105**. The amount of pull necessary to effect the deflection of the flexible distal end **105***a* is directly proportional to the amount of the deflection required during a medical procedure and the dimensional specifications of the flexible insertion shaft **105**. The amount of deflection of the flexible distal end **105***a* may vary depending on the dimensional specifications of the flexible insertion shaft **105** and the medical procedure. An operator may utilize a range of motions of the steering lever **103** to control the amount of deflection of the flexible distal end **105***a*. The range of motions of the steering lever **103** may enhance sensitivity of control of the flexible distal end **105***a* during a medical procedure and facilitate use of complete range of deflection of the flexible distal end **105***a*.

[0060] The adaptable drive transmission system **500** converts the motion of the steering lever **103** to linear movements of the principal cable wires **512***a* and **512***b*, or the proxy cable wires **513***a* and **513***b*. The adaptable drive transmission system **500** comprises an angulation and deflection gear system **502** with gears and gear track subassemblies for matching operator input to scope steering output of the portable endoscope **100**, as exemplarily illustrated in FIG. **5**A. The neutral lock-out system and the quick disconnect sub-assembly facilitate engagement or disengagement of the principal cable wires **512***a* and **512***b*, or the proxy cable wires **513***a* and **513***b* with the internal cable wire control system **514** using the control switch. The adaptable drive transmission system **500** further comprises a shifter rod **504**, a shifter plate **501**, a return spring **503**, a connecting rod **506**, and a crank lever **505** as illustrated in FIGS. **5**A-**5**C. An angular displacement of the steering lever **103** translates into angular movement of the crank lever **505**. The angular movement of the crank lever **505** translates into linear movement of the connecting rod **506**. The amount of linear displacement depends upon the rotational position of the shifter plate **501**.

[0061] The shifter rod **504** connects the proximal end of the shaft assembly **102***a* with the detachable operator control section assembly **101**. The length of the shifter rod **504** is dependent on cable wire requirements for a particular shaft assembly **102***a* attached to the detachable operator control section assembly **101**, which depends on the medical procedure. The shifter rod **504** makes contact with the angulation and deflection gear system **502** using a rack and pinion drive system **507**.

[0062] A rack and pinion drive is typically a gearing mechanism in which a pair of gears converts rotational motion into linear motion or vice-versa. Linear motion of the shifter rod **504** is translated by the circular pinion on the back of the shifter plate **501** into rotational motion of the shifter plate **501**. Further, the swing of the crank lever **505** is converted into linear motion of the connecting rod **506**, which in turn rotates a gear cluster **1501** of the rack and pinion drive system **507**. The rotation of the gear cluster **1501** is converted into linear motion of a pair of reciprocating racks **510**. The reciprocating racks **510** comprise a top driven rack subassembly **510***a* and a bottom driven rack subassembly **510***b*. The cable wire anchor boxes **508** connected to the ends of the reciprocating racks **510** then pull on the principal cable wires **512***a* and **512***b* or the proxy cable wires **513***a* and **513***b*, depending on which principal cable wires **512***a* and **512***b* and the proxy cable wires **513***a* and **513***b* are engaged.

[0063] The angulation and deflection gear system **502** rotates a shifter plate **501**. The amount of the rotation of the shifter plate **501** depends on the length of the shifter rod **504**. The shifter plate **501** comprises a spiral cam path for a pivot pin **509** through the end of the connecting rod **506** to traverse the spiral cam path corresponding to the rotation of the shifter plate **501**. The crank lever **505** is also connected to the pivot pin **509**. When the shifter plate **501** is rotated, the pivot pin **509** may be raised or lowered relative to the central axis of rotation of the adaptable drive transmission system **500**. The position of the shifter plate **501** defines the length of the crank lever arm of the crank lever **505**.

[0064] When the pivot pin **509** exemplarily illustrated in FIG. **5**B traverses the spiral cam path, the position of the pivot pin **509** relative to the central axis of the crank lever **505** changes along the spiral cam path. The closer the pivot pin **509** is to the central axis, the shorter is the effective arm length of the crank lever **505** acting upon the connecting rod **506**. Conversely, the farther the pivot pin **509** is from the central axis, the longer is the effective arm length of the crank lever **505** acting upon the connecting rod **506**. The shorter the effective arm length is the smaller is the overall linear travel of the connecting rod **506**. Conversely, the longer the effective arm length is, the greater is the overall linear travel of the connecting rod **506**.

[0065] The steering lever **103** may be rigidly attached to the crank lever **505**. As the steering lever **103** is moved forward and aft, the crank lever **505** drives the connecting rod **506** aft and forward by a proportional amount. The distal end of the connecting rod **506** is in contact with the rack and pinion drive system **507**. The movement of the connection rod **506** in turn causes a pair of reciprocating racks **510** to create a push-pull effect. The distal ends of the paired reciprocating racks **510** carry cable wire anchor boxes **508**. The cable wire anchor boxes **508** may house multiple cable wire anchors **1103** as illustrated in FIG. **11**. The cable wire anchor boxes **508** interface directly with the principal cable wires **512***a* and **512***b*, or the proxy cable wires **513***a* and **513***b* resulting in the deflection at the flexible distal end **105***a* of the shaft assembly **102***a*. When the flexible insertion shaft **105** is detached from the detachable operator control section assembly **101**, the return spring **503** resets the position of the angulation and deflection gear system **502** to a preset initial position.

[0066] To use the portable endoscope **100**, the cable wire switch **110** may be moved to engage the principal cable wires **512***a* and **512***b*, or proxy cable wires **513***a* and **513***b* with the adaptable drive transmission system **500**. The cable wire switch **110** may then be used to engage, for example, the principal cable wires **512***a* and **512***b* with the adaptable drive transmission system **500**. On engagement of the principal

cable wires **512***a* and **512***b*, the adaptable drive transmission system **500** secures the angulation and deflection gear system **502** with the shaft assembly **102***a*, as exemplarily illustrated in FIG. **5**A. The steering lever **103** may then be used to control the angular movements of the flexible distal end **105***a* of the shaft assembly **102***a*.

[0067] The internal cable wire control system **514** utilizes the proxy cable wires **513***a* and **513***b* for controlling the flexible distal end **105***a* of the shaft assembly **102***a* in an event of failure of the principal cable wires **512***a* and **512***b* during a medical procedure in progress. In the event of the failure of the principal cable wires **512***a* and **512***b*, the cable wire switch **110** disengages the principal cable wires **512***a* and **512***b* from the adaptable drive transmission system **500** and engages the proxy cable wires **513***a* and **513***b* with the adaptable drive transmission system **500**. The internal cable wire control system **514** may then utilize the proxy cable wires **513***a* and **513***b* for controlling the orientation and the angular movements of the flexible distal end **105***a*. The immediate engagement of the proxy cable wires **513***a* and **513***b* for use in an event of failure of the principal cable wires **512***a* and **512***b* may improve procedure completion rates and usability of the portable endoscope **100**. The principal cable wires **512***a* and **512***b* and the proxy cable wires **513***a* and **513***b* may be protected by multiple cable sheaths **1105**, as exemplarily illustrated in FIG. **11**.

[0068] The portable endoscope **100** may further comprise a safety switch **108** integrated with the detachable operator control section assembly **101**, as exemplarily illustrated in FIG. **1**. The safety switch **108** in a first operational position may allow normal operation of the portable endoscope **100** when the shaft assembly **102***a* is attached to the detachable operator control section assembly **101**. The safety switch **108** in a second operational position or a "neutral lockout" position may set the adaptable drive transmission system **500** in a neutral safety position and allow actuation of the cable wire switch **110** to disengage the principal cable wires **512***a* and **512***b*, or the proxy cable wires **513***a* and **513***b* from the adaptable drive transmission system **500**. The safety switch **108** in a third operational position may allow detachment of the shaft assembly **102***a* from the detachable operator control section assembly **101** without damaging the internal mechanisms and internal components of the portable endoscope **100**.

[0069] In the event of failure of the principal cable wires **512***a* and **512***b* during a medical procedure in progress, the safety switch **108** may first be set to the "neutral lockout" position, thus locking the adaptable drive transmission system **500** in the neutral position. The cable wire switch **110** may then be rotated 90 degrees clockwise to disengage and dissociate the principal cable wires **512***a* and **512***b* from the adaptable drive transmission system **500**. The control rod tabs corresponding to the principal cable wires **512***a* and **512***b* are disengaged from the cable wire anchor boxes **508**. The control rod tabs corresponding to the principal cable wires **512***a* and **512***b* are engaged with fixed pockets provided within the chassis subassembly **1201**. The control rod tabs corresponding to the proxy cable wires **513***a* and **513***b* are engaged with the cable wire anchor boxes **508** vacated by the principal cable wires **512***a* and **512***b*. The operator then resets the safety switch **108** to the first operational position and may continue using the portable endoscope **100** with the proxy cable wires **513***a* and **513***b*.

[0070] The safety switch **108** sets the adaptable drive transmission system **500** in the neutral safety position prior to facilitating the disengagement and the dissociation of the principal cable wires **512***a* and **512***b*. The adaptable drive transmission system **500** may then be engaged with the proxy cable wires **513***a* and **513***b* using the cable wire switch **110**. An operator, for example, a physician, may then continue to use the portable endoscope **100** with the proxy cable wires **513***a* and **513***b* engaged resulting in minimal interruption of the medical procedure. The proxy cable wires **513***a* and **513***b* may also be engaged with the adaptable drive transmission system **500** for use in place of the principal cable wires **512***a* and **512***b* without limitation to the use of the proxy cable wires **513***a* and **513***b* corresponding to the failure of the principal cable wires **512***a* and **512***b*.

[0071] The portable endoscope **100** further comprises an external light source in communication with the illumination system **1101** and the optical imaging system **112**. The external light source provides light to the illumination system **1101** and the optical imaging system **112** of the portable endoscope **100**. Multiple fiber optic bundles may be used as optical illumination cables in the illumination system **1101**. The fiber optic bundle emits light from the flexible distal end **105***a* of the shaft assembly **102***a* on illumination. The shaft assembly **102***a* may be provided with a lighting channel **109** to facilitate the communication of the external light source with the illumination system **1101** and the optical imaging system **112**. The external light source may comprise a remote light box in communication with the illumination system **1101** and the optical imaging system **112** through a light cable **701** connected to the lighting channel **109** as exemplarily illustrated in FIG. **7**. The remote light box may, for example, be an alternating current powered high lumen output unit.

[0072] The external light source may also comprise a detachable and portable light stick **801** connected to the lighting channel **109** as exemplarily illustrated in FIG. **8**. The detachable and portable light stick **801** is a battery powered flashlight used to provide light energy to the illumination system **1101** and the optical imaging system **112** directly through the lighting channel **109**. The detachable and portable light stick **801** eliminates the use of external electrical connecting cords and the external light cables for providing light to the portable endoscope **100**. The detachable and portable light stick **801** facilitates freedom of movement of the portable endoscope **100** by an operator during a medical procedure.

[0073] The optical imaging system **112** integrated with the portable endoscope **100** captures and transmits visual information, for example, images, received from the shaft assembly **102***a*, of body regions scanned or accessed by the portable endoscope **100**. The optical imaging system **112** may utilize the illumination system **1101** for illumination during the capture and transmission of the visual images. The optical imaging system **112** receives visual information of the body regions illuminated by the illumination system **1101** from the illumination cables of the illumination system **1101**.

[0074] The optical imaging system **112** may comprise a standard eyepiece **111** for viewing the visual images gathered by an optical objective lens system provided at the flexible distal end **105***a*. The visual images gathered by the optical objective lens system are transmitted to the standard eyepiece **111** via a fiber optic cable through the flexible insertion shaft **105**. The optical imaging system **112** comprises an optical focus mechanism. The optical focus mechanism may be pro-

vided on the detachable operator control section assembly **101**, or the shaft assembly **102***a*. The optical focus mechanism utilizes a focus ring **106** to adjust optical focus of the optical imaging system **112**. The focus ring **106** adjusts the optical focus of the visual images captured or transmitted from the shaft assembly **102***a* to the standard eyepiece **111** of the optical imaging system **112**.

[0075] The flexible distal end **105***a* of the shaft assembly **102***a* comprises varied optical layout configurations of the optical objective lens system and different illumination outputs. In order to capture the visual images captured or transmitted to the standard eyepiece **111**, a digital or an analog camera may be placed in communication with the standard eyepiece **111**. The optical imaging system **112** further comprises an image bundle **511** as illustrated in FIGS. **5**A-**5**B and FIG. **11**, for transmitting the captured visual images from the flexible distal end **105***a* of the shaft assembly **102***a* to the standard eyepiece **111**. The image bundle **511** may be a fiber optic image bundle. The image bundle **511** may also be a videoscope.

[0076] The portable endoscope **100** further comprises an image capturing system integrated with the detachable operator control section assembly **101**. The image capturing system may comprise image sensors provided at the flexible distal end **105***a* of the shaft assembly **102***a* and a visual display unit **901**. The image sensors may comprise a charged coupled device (CCD), a complementary metal oxide semiconductor (CMOS) image sensor, or a contact image sensor (CIS). The visual display unit **901** may be detachably attached to the detachable operator control section assembly **101**. The images sensors capture and transmit the visual images to the visual display unit **901**. The visual images captured by the image sensors are converted into an electric signal and then transmitted to the visual display unit **901**.

[0077] The visual display unit **901** then displays the captured and transmitted visual images. For example, the detachable operator control section assembly **101** and the shaft assembly **102***a* provided with a CCD chip as an image sensor may be used as a "hybrid video-fiberscope" for capturing video content on the portable endoscope **100**. The hybrid video-fiberscope may be an alternative to a dedicated videoscope which requires the external cords or the cables connected to an external display unit **901** for capturing the video content through the dedicated videoscope.

[0078] The hybrid video-fiberscope may also be an alternative to a fiberscope. Typically, the fiberscope comprises an external video camera converter attached to a standard eyepiece **111** of the fiberscope. The external cords or the cables may need to be connected to the fiberscope from the external video camera converter to capture the video content. The hybrid video-fiberscope may comprise an image capturing device integrated with the flexible distal end **105***a* of the shaft assembly **102***a* to capture the video image content. The detachable operator control section assembly **101** of the hybrid video-fiberscope with an integrated portable visual display unit **901** may be used to display the video content as illustrated in FIGS. **9**A-**9**B. The image capturing system may also be provided with an optional visual display unit **901** detachably attached to the detachable operator control section assembly **101** for displaying the captured and transmitted images received from the image capturing system. The visual images may also be displayed on an external visual display unit **901** by wired or a wireless communication.

[0079] The portable endoscope **100** may further comprise a working channel **1102** facilitated through the shaft assembly **102***a* and a working channel turret **104** integrated with the shaft assembly **102***a*. The working channel turret **104** provides access to the working channel **1102** within the shaft assembly **102***a* and aids different medical procedures, for example, lavage, aspiration, biopsy, or manipulation. The operator, for example, a physician, may use the working channel turret **104** to lavage field of view in the optical imaging system **112**, or the image capturing system, aspirate fluids and debris, insert tools for manipulation of tissues or structures, and collect biological body samples for biopsy. The working channel turret **104** may be provisioned to rotate laterally in order to facilitate left handed and right handed use of the portable endoscope **100**. Internal components of the flexible insertion shaft bundle **1100** with the working channel **1102** are exemplarily illustrated in FIG. **11**. As illustrated in FIG. **11**, the internal components of the portable endoscope **100** are protected by an endoscope sheath **1104**. FIG. **11** further illustrates a ferrule **1106** which is used to attach the flexible insertion shaft bundle **1100** within the shaft assembly **102***a*.

[0080] A suction and irrigation control system in communication with the working channel turret **104** and the working channel **1102** may be used in medical lavage or aspiration procedures and may be employed simultaneously along with the portable endoscope **100**. The suction and irrigation control system may be detachably attached to the detachable operator control section assembly **101** and affixed to the working channel turret **104** provided on the shaft assembly **102***a*. The suction and irrigation control system may comprise a flow control valve **1001** affixed to the working channel turret **104** provided on the shaft assembly **102***a* as illustrated in FIG. **10**. The flow control valve **1001** may be connected to the working channel turret **104** via a flexible tubing to accommodate the lateral rotary movement of the working channel turret **104**. The flow control valve **1001** may be used to control flow of fluids and air within the working channel **1102** during the medical lavage or aspiration procedure. The suction and irrigation control system may also remove body fluids. Components of the suction and irrigation control system such as a cylinder base, internal tubings and fittings may be detachable from the portable endoscope **100**.

[0081] FIG. **12** exemplarily a detachable operator control section assembly **101** and a shaft assembly **102***a* of the portable endoscope **100** for diverse medical disciplines and associated medical procedures without an external housing. FIG. **12** illustrates a chassis subassembly **1201** and a post subassembly **1202**. The post subassembly **1202** comprises a proximal extreme section **1202***a*, a frontal section **1202***b*, and a mid proximal section **1202***c*. FIG. **18** exemplarily illustrates an exploded view of the proximal extreme section **1202***a* of the post subassembly **1202**. The proximal extreme section **1202***a* of the post subassembly **1202** comprises the shifter rod **504**, multiple image bundle collets **1801**, multiple collet set screws **1802**, multiple control rod subassemblies **1803**, multiple neutral springs **1804**, multiple neutral lockout (NLO) balls **1708**, and multiple NLO springs **1701**.

[0082] The image bundle collets **1801** center the image bundle **511**, using the collet set screws **1802**, on the central axis of the post subassembly **1202** at the proximal end of the shaft assembly **102***a*. The control rod subassemblies **1803** create anchors at the proximal ends of the cable wires that are used to steer or deflect the flexible distal end **105***a* of the shaft

assembly **102***a*, so that the cable wires may easily be grasped by the adaptable drive transmission system **500**. The control rod subassemblies **1803** also enable fine-tune adjusting of cable wire length using a telescoping screw **1805**. The neutral springs **1804** act upon the cable wire anchors **1103** to return the cable wires to a neutral position within the adaptable drive transmission system **500**. The NLO balls **1708** and the NLO springs **1701** together form a detent for rotation of the post subassembly **1202**. The proximal extreme section **1202***a* of the post subassembly **1202** attaches to the mid proximal section **1202***c* of the post subassembly **1202** along the axis A-A illustrated in FIG. **18**.

[0083] FIG. **19** exemplarily illustrates an exploded view of the mid proximal section **1202***c* of the post subassembly **1202**. The mid proximal section **1202***c* of the post subassembly **1202** comprises an "O" shaped ring **1901**, a locking collar **1902**, a rotation stop **1903**, a spring plate **1904**, a sheath anchor subassembly **1905**, the ferrule **1106**, and a ferrule nut **1906**. The "O" shaped ring **1901** creates a seal between the housings of the shaft assembly **102***a* and operator control section assembly **101** to maintain the sterility of the internal workings. The locking collar **1902** is the female portion of a quarter-turn bayonet connection for coupling the shaft assembly **102***a* to the operator control section assembly **101**. The rotation stop **1903** limits rotation of the post subassembly **1202** during selection of the principal cable wires **512***a* and **512***b* or the proxy cable wires **513***a* and **513***b*. The spring plate **1904** acts as a backstop for the NLO springs **1701** that act upon the cable wire anchors **1103**. The sheath anchor subassembly **1905** is used to fix the proximal ends of the cable sheaths **1105**. The ferrule **1106** and the ferrule nut **1906** enable attachment of the flexible insertion shaft bundle **1100** (not shown in FIG. **19**) of the shaft assembly **102***a* to the post subassembly **1202**. The mid proximal section **1202***c* of the post subassembly **1202** attaches to the proximal extreme section **1202***a* of the post subassembly **1202** along the axis A-A illustrated in FIG. **19**.

[0084] FIG. **13**A exemplarily illustrates an isometric view of the proximal end of the quick disconnect subassembly of the portable endoscope **100**. FIG. **13**B exemplarily illustrates an exploded view of the quick disconnect subassembly. The quick disconnect subassembly comprises the working channel turret **104**, a disconnect housing **1301**, a rotation tip boot **1302**, the flexible insertion shaft bundle **1100** portion of the shaft assembly **102***a*, a neutral lockout (NLO) key **1305**, an NLO key spring **1304**, and the post subassembly **1202**. The NLO key spring **1304** is a return spring for the NLO key **1305**.

[0085] The quick disconnect subassembly enables the shaft assembly **102***a* and operator control section assembly **101** to be connected or separated. The rotation tip boot **1302** forms a covering for sealing the sheath anchor subassembly **1905** and provides grip to enable rotation of the post subassembly **1202** for switching between the principal cable wires **512***a* and **512***b* and the proxy cable wires **513***a* and **513***b*. The NLO key **1305** controls position and engagement of the NLO balls **1708** and therefore ability to rotate the post subassembly **1202**. The post subassembly **1202** provides tracks for controlling linear movement of the cable wire anchors **1103**. Multiple bolts **1303** or other fastening means may be used to secure the different components of the quick disconnect assembly.

[0086] FIG. **14** exemplarily illustrates an exploded view of the chassis subassembly **1201** within the operator control section assembly **101**. The chassis subassembly **1201** comprises a main block **1401**, a side block **1402**, a tail block **1403**, the shifter plate **501**, and the steering lever **103**. The chassis subassembly **1201** is made of the main block **1401**, the side block **1402**, and the tail block **1403** to enable the internal components to be machined and to allow for insertion of internal components. The chassis subassembly **1201** provides a structure within which the internal components function. The shifter plate **501** is used by the adaptable drive transmission system **500**. The steering lever **103** is used by the operator to control the portable endoscope **100**. The main block **1401**, the side block **1402**, and the tail block **1403** may be secured using multiple bolts **1303** and locating pins **1404**, or other fastening means.

[0087] FIG. **15** exemplarily illustrates an exploded view of the main block **1401** of the chassis subassembly **1201**. The main block **1401** comprises a gear cluster **1501**, a gear cover **1502**, a drive rack subassembly **1503**, a bottom driven rack subassembly **510***b*, cable wire anchor boxes **508**, and a top driven rack subassembly **510***a*. The gear cluster **1501** adds gain to the system to amplify the input from the drive rack subassembly **1503**. The gear cover **1502** retains the gear cluster **1501** within the chassis subassembly **1201**. The drive rack subassembly **1503** transfers linear movement of the connection rod **506** to the gear cluster **1501**. The top driven rack subassembly **510***a* and the bottom driven rack subassembly **510***b* together are output shafts of the adaptable drive transmission system **500**. The cable wire anchor boxes **508** enables connection of the cable wire anchors **1103** to the adaptable drive transmission system **500** via the top driven rack subassembly **510***a* and the bottom driven rack subassembly **510***b*. Secured to the top driven rack subassembly **510***a* may be an NLO post **1504** and a t-nut **1505** for interfacing the adaptable drive transmission system **500** to the neutral lock-out system. The main block **1401** further comprises a first axle **1506**. The first axle **1506** acts as a pivot for the gear cluster **1501**.

[0088] FIG. **16** exemplarily illustrates an exploded view of the tail block **1403** of the chassis subassembly **1201**. The tail block **1403** comprises the shifter plate **501**, the return spring **503**, and a shifter rack subassembly **1601**. The shifter plate **501** rotates upon a second axle **1603**. The second axle **1603** may be secured to the tail block **1403** with an axle nut **1602**. The shifter rack subassembly **1601** translates the length of the shifter rod **504** into rotation of the shifter plate **501**.

[0089] FIG. **17** exemplarily illustrates an isometric view of the chassis subassembly **1201** with the main block **1401**, the side block **1402**, and the tail block **1403** assembled together highlighting the neutral lock-out system. The chassis subassembly **1201** may further incorporate a neutral lock-out system comprising one or more NLO balls **1708**, one or more NLO springs **1701**, an NLO drive rod subassembly **1702**, an NLO cam subassembly **1703**, an NLO drive rod steady **1704**, an NLO gate **1705**, an NLO gate spring **1706**, and an NLO knob subassembly **1707**.

[0090] The NLO drive rod subassembly **1702** pins the housings of the shaft assembly **102***a* and the operator control section assembly **101** together and to restrict relative rotation. This NLO drive rod subassembly **1702** is withdrawn to release the quarter-turn bayonet for disconnecting the shaft assembly **102***a* and the operator control section assembly **101**. The NLO cam subassembly **1703** controls the position of the NLO drive rod subassembly **1702**. The NLO gate **1705** reads the position of the NLO post **1504** attached to the adaptable drive transmission system **500** and restricts rotation of the NLO cam subassembly **1703**. The NLO gate spring

1706 provides tension to the NLO gate **1705** to maintain contact with the NLO post **1504**. The NLO knob subassembly **1707** enables the operator to rotate the NLO cam subassembly **1703**. The NLO balls **1708** and the NLO springs **1701** together form a detent for rotation of the post subassembly **1202**.

[0091] FIG. **20** exemplarily illustrates an exploded view of the sheath anchor subassembly **1905**. The sheath anchor subassembly **1905** comprises a clamp ring **2001**, a jam nut **2002**, multiple sheath anchor collets **2003**, and a sheath anchor **2004**. The clamp ring **2001** secures the sheath anchor collets **2003**. The jam nut **2002** locks the threaded end of the sheath anchor **2004** when screwed into the post subassembly **1202**. The sheath anchor collets **2003** are individual pieces for holding the proximal ends of the cable sheaths **1105** against the anchor.

[0092] FIG. **21** exemplarily illustrates an exploded view of one of the control rod subassemblies **1803**. Each of the control rod subassemblies **1803** comprises a control rod tab **2101**, a female control line anchor **2102**, a male control line anchor **2103**, and a principal cable wire **512***a* or **512***b* or a proxy cable wire **513***a* or **513***b*. For purposes of illustration, FIG. **21** exemplarily illustrates a principal cable wire **512***a*. The male control line anchor **2103** enables attachment of the control rod subassembly to a free end of the cable wires. The female control line anchor **2102** forms the telescoping screw **1805** in conjunction with the male control line anchor **2103** that enables fine-tune adjustment of the working length of the cable wires. The principal cable wire **512***a* or **512***b* or the proxy cable wire **513***a* or **513***b* provides interfacing features for connecting the control rod subassembly to the adaptable drive transmission system **500**.

[0093] The control rod tab **2101** allows the shaft assembly **102***a* to be separated from the operator control section assembly **101**. Multiple control rod tabs may be provided in different channels of the post **1504**. The control rod tabs may be arrayed at 90 degrees from each other. When the portable endoscope **100** is assembled, two of the control rod tabs, for example, the control rod tabs corresponding to the principal cable wires **512***a* and **512***b*, may be engaged with the cable wire anchor boxes **508** at the ends of the top driven rack subassembly **510***a* and the bottom driven rack subassembly **510***b*, which are connected to the adaptable drive transmission **500**. Two other control rod tabs, for example, the control rod tabs corresponding to the proxy cable wires **513***a* and **513***b*, may be locked in fixed pockets and not allowed to move. In the neutral position the control rod tabs are aligned and the post subassembly **1202** may be rotated so that the control rod tabs may be disengaged from the cable wire anchor boxes **508** of the top driven rack subassembly **510***a* and the bottom driven rack subassembly **510***b*, and the fixed pockets. When the post subassembly **1202** is rotated by 90 degrees clockwise, the control rod tabs corresponding to the principal cable wires **512***a* and **512***b* exchange places with the control rod tabs corresponding to the proxy cable wires **513***a* and **513***b*. When the post subassembly **1202** is rotated by 45 degrees counter clockwise, the control rod tabs are simultaneously disengaged but aligned with respective exit paths provided within the chassis subassembly **1201** for allowing the post subassembly **1202** to be withdrawn axially from the operator control section assembly **101**.

[0094] To change the shaft assembly **102***a*, the operator first sets the portable endoscope **100** to the neutral position by moving the steering lever **103** to a neutral position. The operator then sets the safety switch **108** to the third operational position, causing the adaptable drive transmission **500** to be locked in a neutral position. The quick disconnect subassembly is unlocked from the operator control section assembly **101**. The operator then rotates the quick disconnect subassembly by 45 degrees in a counter-clockwise direction relative to the operator control section assembly **101**, causing the control rod tabs to be disengaged from the cable wire anchor boxes **508**. The operator may then withdraw the post subassembly **1202** from the operator control section assembly **101**. The operator may select an alternative shaft assembly **102***a* and reverse the procedure described above to reassemble the portable endoscope **100** with the alternative shaft assembly **102***a*.

[0095] The portable endoscope **100** disclosed herein may be included in a portable endoscope kit with component parts capable of being assembled in the field. The portable endoscope kit comprises an operator control section assembly **101** and multiple shaft assemblies **102***a*, **102***b*, and **102***c*. A first shaft assembly **102***a*, **102***b*, or **102***c* from the shaft assemblies **102***a*, **102***b*, and **102***c* is configured for an endoscopic purpose different from a second shaft assembly **102***a*, **102***b*, or **102***c* from the shaft assemblies **102***a*, **102***b*, and **102***c*. Each of the shaft assemblies **102***a*, **102***b*, and **102***c* comprises an elongated body with a flexible distal end **105***a* and a proximal end. Each of the flexible distal ends and each of the elongated bodies are configured for insertion into an internal cavity of a body of an organism, or a similarly otherwise inaccessible internal space. The proximal end of each of the shaft assemblies **102***a*, **102***b*, and **102***c* is configured for selectable engagement between the proximal end and the operator control section assembly **101**. The operator control section assembly **101** is configured to engage the proximal end of any one of the shaft assemblies **102***a*, **102***b*, and **102***c*. The flexible distal end **105***a* of each of the shaft assemblies **102***a*, **102***b*, and **102***c* is locally bendable. Each of the shaft assemblies **102***a*, **102***b*, and **102***c* and the operator control section assembly **101** are configured so that the operator control section assembly **101** selectably controls the local bending of the flexible distal end **105***a* of the shaft assembly **102***a*, **102***b*, or **102***c* when the shaft assembly **102***a*, **102***b*, or **102***c* is in the selectable engagement with the operator control section assembly **101**.

[0096] The portable endoscope kit further comprises an internal cable wire control system **514** integrated with the operator control section assembly **101**. The internal cable wire control system **514** utilizes an adaptable drive transmission system **500** for controlling orientation and angular position of the flexible distal end **105***a* of the shaft assembly **102***a* using principal cable wires **512***a* and **512***b* and proxy cable wires **513***a* and **513***b*. The adaptable drive transmission system **500** comprises an angulation and deflection gear system **502** comprising gears and gear track subassemblies for matching operator input to steering output of the portable endoscope **100**. The neutral lock-out system and the quick disconnect subassembly facilitate engagement and disengagement of the principal cable wires **512***a* and **512***b* and the proxy cable wires **513***a* and **513***b*.

[0097] The portable endoscope kit may further comprise an optical imaging system **112** and an illumination system **1101**. The portable endoscope kit may further comprise an external light source in communication with the illumination system **1101** and the optical imaging system **112**. The external light source provides light to the illumination system **1101** and the

optical imaging system **112**. The portable endoscope kit may further comprise a cable wire switch **110** integrated with the shaft assemblies **102***a*, **102***b*, and **102***c* to engage the principal cable wires **512***a* and **512***b* or the proxy cable wires **513***a* and **513***b*.

[0098] The portable endoscope kit may further comprise an image capturing system integrated with detachable operator control section assembly **101**, wherein the image capturing system comprises image sensors for capturing and transmitting visual images. The image sensors may, for example, comprise a charge coupled display, a complementary metal oxide semiconductor image sensor, or a contact image sensor. The portable endoscope kit may further comprise a working channel turret **104** integrated with the shaft assembly **102***a* for aiding medical lavage, aspiration, biopsy, or manipulation procedures. The portable endoscope kit may further comprise a suction and irrigation control system for controlling flow of fluids during a medical lavage or aspiration procedure. The suction and irrigation control system may be detachably attached to the operator control section assembly **101**.

[0099] FIG. **22** illustrates a method of adaptably driving a shaft assembly **102***a* of a portable endoscope **100** using an adaptable drive transmission system **500** of the portable endoscope **100**. The shaft assembly **102***a* is attached **2201** to the portable endoscope **100**. The attached shaft assembly **102***a* is connected to principal cable wires **512***a* and **512***b* and proxy cable wires **513***a* and **513***b*. The detachable operator control section assembly **101** obtains **2202** angulation properties of the attached shaft assembly **102***a*. As used herein, the angulation properties of a shaft assembly **102***a* refers to properties of the shaft assembly **102***a* relating to the deflection of the flexible distal end **105***a* of the shaft assembly **102***a*. For example, the angulation properties may be maximum angle of deflection, optimum range of deflection, etc. of the flexible distal end **105***a* of the shaft assembly **102***a*.

[0100] A gearing ratio for the adaptable drive transmission system **500** is selected **2203** by angularly displacing a shifter plate **501** within the portable endoscope **100**. The amount of angular displacement is based on the angulation properties and determines the selected gearing ratio. An operator provides **2204** an angular displacement input for controlling the attached shaft assembly **102***a* using a steering lever **103** of the portable endoscope **100**. An angulation and deflection gear system **502** connected to the steering lever **103** converts **2205** the angular displacement input to linear motion using a rack and pinion drive system **507**. The amount of the linear motion obtained relative to the angular displacement input is determined by the selected gearing ratio. For example, if a high gearing ratio is selected, a small angular displacement of the steering lever **103** may be translated to a large amount of linear motion. If a low gearing ratio is selected, the same amount of angular displacement of the steering lever **103** may be translated to a small amount of linear motion. The linear motion is converted **2206** to a pulling force on the principal cable wires **512***a* and **512***b* and the proxy cable wires **513***a* and **513***b*. The amount of the pulling force is based on the amount of the linear motion. The attached shaft assembly **102***a* is thus adaptably driven by the pulling force.

[0101] FIG. **23** illustrates a method of performing an endoscopic examination using a portable endoscope kit. The portable endoscope kit capable of being assembled by an operator is provided **2301**. The portable endoscope kit comprises an operator control section assembly **101** and multiple shaft assemblies **102***a*, **102***b*, and **102***c*. A first shaft assembly **102***a*, **102***b*, or **102***c* from the shaft assemblies **102***a*, **102***b*, and **102***c* is configured for an endoscopic purpose different from a second shaft assembly **102***a*, **102***b*, or **102***c* from the shaft assemblies **102***a*, **102***b*, and **102***c*. Each of the shaft assemblies **102***a*, **102***b*, and **102***c* comprises an elongated body with a locally bendable flexible distal end **105***a*. The operator selects **2302** one of the shaft assemblies **102***a*, **102***b*, and **102***c* based on the endoscopic purpose.

[0102] The operator engages **2303** the operator control section assembly **101** and the selected shaft assembly **102***a*. The operator control section assembly **101** controls bending of the flexible distal end **105***a* of the selected shaft assembly **102***a*. The flexible distal end **105***a* of the selected shaft assembly **102***a* is inserted **2304** into a cavity of a body of an organism, or a similarly otherwise inaccessible internal space. The operator controls **2305** orientation and angular position of the flexible distal end **105***a* using the principal cable wires **512***a* and **512***b* or the proxy cable wires **513***a* and **513***b*. The principal cable wires **512***a* and **512***b* and the proxy cable wires **513***a* and **513***b* are controlled using an adaptable drive transmission system **500**. The operator locally bends **2306** the flexible distal end **105***a* of the elongated body of the selected shaft assembly **102***a* by manipulating the operator control section assembly **101**.

[0103] The foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present invention. While the invention has been described with reference to various embodiments, it is understood that the words, which have been used herein, are words of description and illustration, rather than words of limitation. Further, although the invention has been described herein with reference to particular means, materials and embodiments, the invention is not intended to be limited to the particulars disclosed herein; rather, the invention extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims. Those skilled in the art, having the benefit of the teachings of this specification, may effect numerous modifications thereto and changes may be made without departing from the scope and spirit of the invention in its aspects.

We claim:

1. A portable endoscope for performing a plurality of medical procedures, comprising:

a detachable operator control section assembly;

one of a plurality of detachable and interchangeable flexible insertion shaft assemblies with a flexible distal end, wherein said detachable and interchangeable flexible insertion shaft assembly accommodates principal cable wires, proxy cable wires, an optical imaging system, and an illumination system, wherein proximal end of the detachable and interchangeable flexible insertion shaft assembly is detachably connected to said detachable operator control section assembly; and

an internal cable wire control system integrated with the detachable operator control section assembly, wherein said internal cable wire control system utilizes an adaptable drive transmission system for controlling orientation and angular position of said flexible distal end of the detachable and interchangeable flexible insertion shaft assembly using one of said principal cable wires and said proxy cable wires.

2. The portable endoscope of claim **1**, further comprising an external light source in communication with said illumination system and said optical imaging system, wherein said

external light source provides light to the illumination system and the optical imaging system.

3. The portable endoscope of claim **1**, further comprising a cable wire switch integrated with the detachable and interchangeable flexible insertion shaft assembly to engage one of the principal cable wires and the proxy cable wires with said adaptable drive transmission system.

4. The portable endoscope of claim **3**, wherein the internal cable wire control system further comprises a steering lever for controlling angular movements of the flexible distal end of each of the detachable and interchangeable flexible insertion shaft assemblies, wherein said steering lever manipulates movement of one of the principal cable wires and the proxy cable wires via the adaptable drive transmission system based on said engagement of one of the principal cable wires and the proxy cable wires by said cable wire switch.

5. The portable endoscope of claim **3**, wherein the internal cable wire control system utilizes the proxy cable wires for controlling the flexible distal end of the detachable and interchangeable flexible insertion shaft assembly in an event of failure of the principal cable wires during one of the medical procedures in progress, wherein said cable wire switch disengages the principal cable wires from the adaptable drive transmission system and engages the proxy cable wires with the adaptable drive transmission system.

6. The portable endoscope of claim **1**, wherein said adaptable drive transmission system comprises an angulation and deflection gear system comprising gears and gear track subassemblies for matching operator input to scope steering output.

7. The portable endoscope of claim **1**, further comprising a neutral lock-out system and a quick disconnect subassembly for facilitating engagement and disengagement of the principal cable wires and the proxy cable wires.

8. The portable endoscope of claim **1**, wherein said optical imaging system captures and transmits visual information, wherein the optical imaging system receives said visual information from illumination cables of said illumination system.

9. The portable endoscope of claim **1**, wherein said optical imaging system comprises an optical focus mechanism for adjusting optical focus of the optical imaging system, wherein said optical focus mechanism is provided on one of the detachable operator control section assembly and the detachable and interchangeable flexible insertion shaft assembly.

10. The portable endoscope of claim **1**, further comprising an image capturing system integrated with the detachable operator control section assembly, wherein said image capturing system comprises one of a plurality of image sensors for capturing and transmitting visual images, further wherein said image sensors comprise a charge coupled display, a complementary metal oxide semiconductor image sensor, and a contact image sensor.

11. The portable endoscope of claim **10**, wherein the image capturing system is provided with an optional visual display unit detachably attached to the detachable operator control section assembly for displaying said captured and transmitted images received from the image capturing system.

12. The portable endoscope of claim **11**, wherein the image capturing system is provided with an external visual display unit for displaying the captured and transmitted images received from the image capturing system by one of wired communication and wireless communication.

13. The portable endoscope of claim **1**, further comprising a working channel turret integrated with the detachable and interchangeable flexible insertion shaft assembly for aiding said medical procedures.

14. The portable endoscope of claim **1**, further comprising a suction and irrigation control system for controlling flow of fluids during said medical procedures, wherein said suction and irrigation control system is detachably attached to the detachable operator control section assembly.

15. A method of adaptably driving a flexible insertion shaft assembly of a portable endoscope using an adaptable drive transmission system of said portable endoscope, comprising the steps of:

attaching said flexible insertion shaft assembly to the portable endoscope, wherein said attached flexible insertion shaft assembly is connected to a plurality of cable wires;

obtaining angulation properties of the attached flexible insertion shaft assembly by a detachable operator control section assembly;

selecting a gearing ratio for said adaptable drive transmission system by angularly displacing a shifter plate within the portable endoscope, wherein amount of said angular displacement is based on said angulation properties and determines said selected gearing ratio;

providing an angular displacement input for controlling the attached flexible insertion shaft assembly by an operator using a steering lever;

converting said angular displacement input to linear motion using a rack and pinion drive system by an angulation and deflection gear system connected to said steering lever, wherein amount of said linear motion obtained relative to the angular displacement input is determined by the selected gearing ratio; and

converting the linear motion to a pulling force on said cable wires, wherein amount of said pulling force is based on said amount of the linear motion;

whereby the attached flexible insertion shaft assembly is adaptably driven by the pulling force.

16. A portable endoscope kit with component parts capable of being assembled in the field, comprising:

an operator control section assembly;

a plurality of flexible insertion shaft assemblies, wherein a first flexible insertion shaft assembly from said flexible insertion shaft assemblies is configured for an endoscopic purpose different from a second flexible insertion shaft assembly from the flexible insertion shaft assemblies, wherein each of the flexible insertion shaft assemblies comprises an elongated body with a flexible distal end and a proximal end, wherein each of said distal ends and each of said elongated bodies are configured for insertion into an internal cavity of a body of an organism, and said proximal end of each of the flexible insertion shaft assemblies is configured for selectable engagement between the proximal end and said operator control section assembly, wherein the operator control section assembly is configured to engage the proximal end of any one of the flexible insertion shaft assemblies, wherein said flexible distal end of each of the flexible insertion shaft assemblies is locally bendable, and wherein each of the flexible insertion shaft assemblies and the operator control section assembly are configured so that the operator control section assembly selectably controls said local bending of the flexible distal end of the flexible insertion shaft assembly when said flexible

insertion shaft assembly is in said selectable engagement with the operator control section assembly; and

an internal cable wire control system integrated with the operator control section assembly, wherein said internal cable wire control system utilizes an adaptable drive transmission system for controlling orientation and angular position of the flexible distal end using one of principal cable wires and proxy cable wires.

17. The portable endoscope kit of claim **16**, further comprising an optical imaging system and an illumination system.

18. The portable endoscope kit of claim **17**, further comprising an external light source in communication with said illumination system and said optical imaging system, wherein said external light source provides light to the illumination system and the optical imaging system.

19. The portable endoscope kit of claim **16**, further comprising a cable wire switch integrated with the flexible insertion shaft assemblies to engage one of said principal cable wires and said proxy cable wires.

20. The portable endoscope kit of claim **19**, wherein the proxy cable wires are used for controlling the flexible distal end of the flexible insertion shaft assembly in an event of failure of the principal cable wires during a procedure in progress, wherein said cable wire switch disengages the principal cable wires and engages the proxy cable wires.

21. The portable endoscope kit of claim **16**, wherein the adaptable drive transmission system comprises an angulation and deflection gear system comprising gears and gear track subassemblies for matching operator input to scope steering output.

22. The portable endoscope kit of claim **16**, further comprising a neutral lock-out system and a quick disconnect subassembly for facilitating engagement and disengagement of the principal cable wires and the proxy cable wires.

23. The portable endoscope kit of claim **16**, further comprising an image capturing system integrated with the operator control section assembly, wherein said image capturing system comprises one of a plurality of image sensors for capturing and transmitting visual images, wherein said image sensors comprise one or more of a charge coupled display, a complementary metal oxide semiconductor image sensor, and a contact image sensor.

24. The portable endoscope kit of claim **16**, further comprising a working channel turret integrated with the flexible insertion shaft assembly for aiding medical procedures.

25. The portable endoscope kit of claim **16**, further comprising a suction and irrigation control system for controlling flow of fluids during a medical procedure, wherein said suction and irrigation control system is detachably attached to the operator control section assembly.

26. A method of performing an endoscopic examination using a portable endoscope kit, comprising the steps of:

providing said portable endoscope kit capable of being assembled by an operator, wherein said portable endoscope kit comprises an operator control section assembly and a plurality of flexible insertion shaft assemblies, wherein a first flexible insertion shaft assembly from said flexible insertion shaft assemblies is configured for an endoscopic purpose different from a second flexible insertion shaft assembly from said flexible insertion shaft assemblies, and wherein each of the flexible insertion shaft assemblies comprises an elongated body with a locally bendable flexible distal end;

selecting by said operator one of the flexible insertion shaft assemblies based on said endoscopic purpose;

engaging said operator control section assembly and said selected flexible insertion shaft assembly, wherein the operator control section assembly controls bending of said flexible distal end of the selected flexible insertion shaft assembly;

inserting the flexible distal end of the selected flexible insertion shaft assembly into a cavity of a body of an organism;

controlling orientation and angular position of the flexible distal end using one of principal cable wires and proxy cable wires, wherein said principal cable wires and proxy cable wires are controlled using an adaptable drive transmission system; and

bending locally the flexible distal end of said elongated body of said selected flexible insertion shaft assembly by manipulating the operator control section assembly by the operator.

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